Electronics®

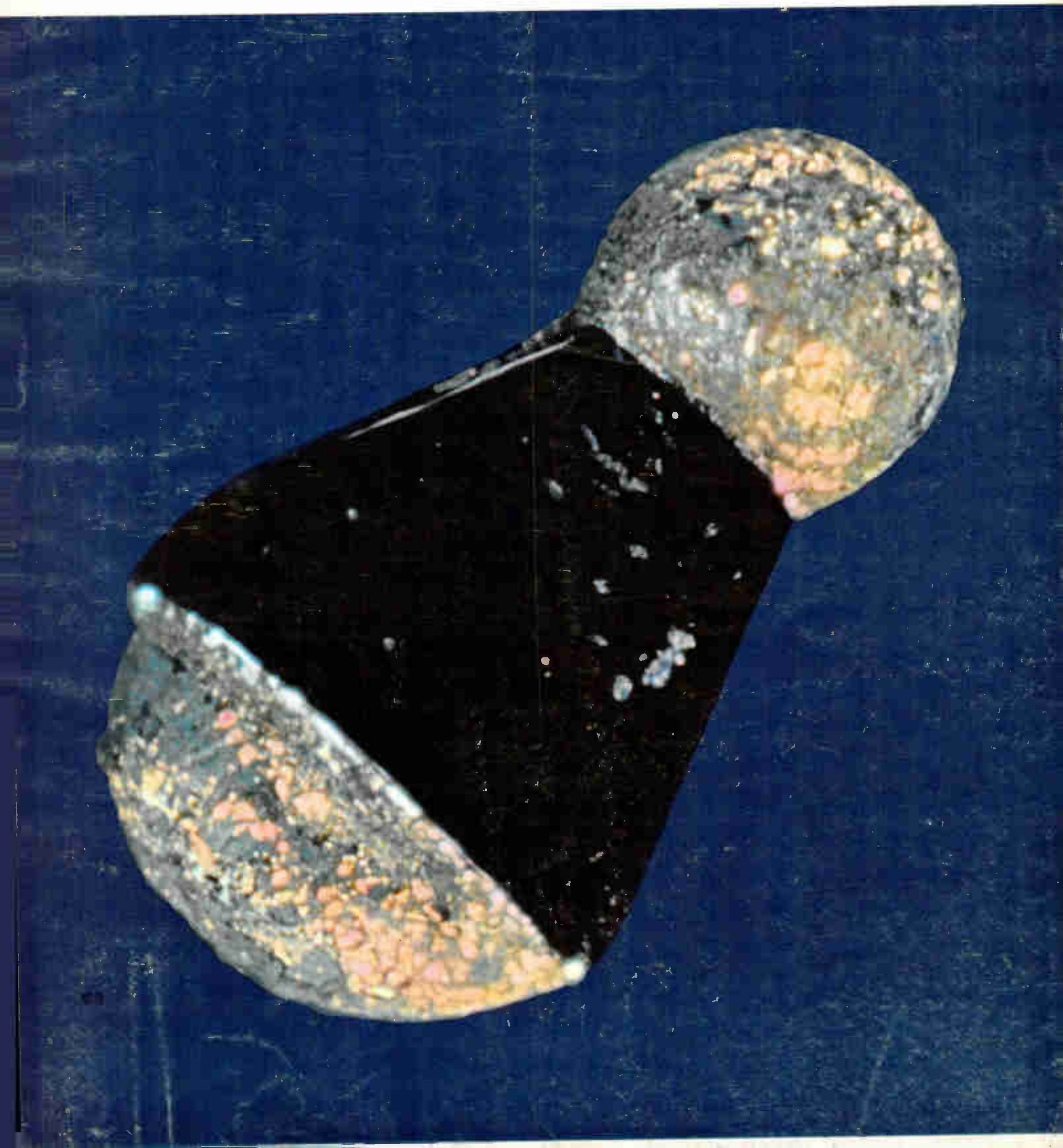
Product planning at IEEE: page 116

Computer aid for nonlinear design: page 140

Understanding logic in integrated circuits: page 149

March 6, 1967
$1.00
A McGraw-Hill Publication

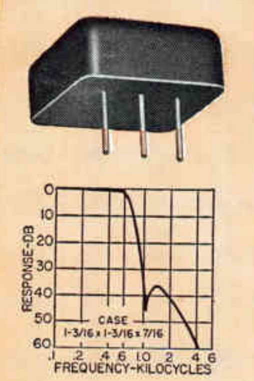
Below: Tapered Gunn device is voltage tunable, page 134



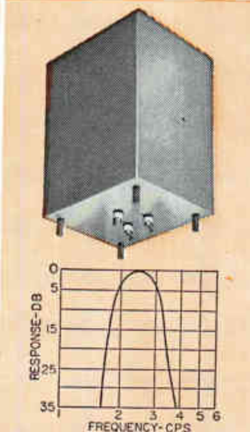
PIONEERS IN MINIATURIZATION

"SPECIAL" CUSTOM BUILT FILTERS

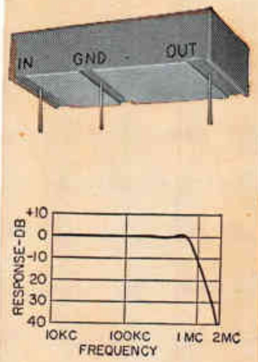
TO YOUR SPECIFICATIONS



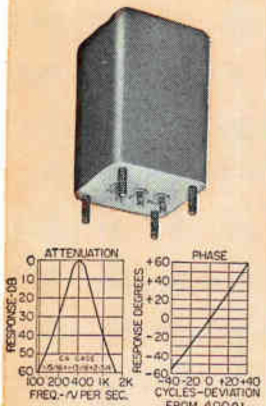
560 — Telemetering low pass filter. Available from 400 — to 70 KC. ± 7.5% band-width flat to 1 db. Attenuation greater than 35 db beyond the 2nd harmonic of — 7.5% frequency. Impedance 47K ohms. MIL-F-18327B. Wt. 0.8 oz.



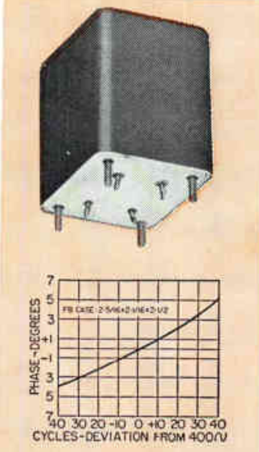
Low frequency band pass filter. Designed for 2.5 cps center frequency. At 2 to 3 cps within 3 db. At 1.5 cps and lower, and 4 cps and higher, greater than 30 db. Source and Load 10K ohms. Size: 4 x 4-11/16 x 6". MA MIL case, MIL-F-18327B.



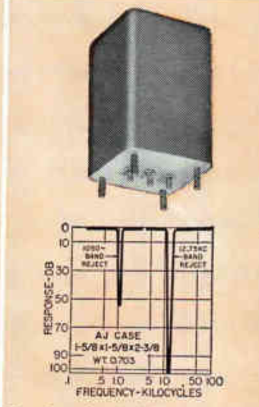
High frequency low pass filter. Zero to 700 KC within 1 db. 1.95 mc to 10 mc 40 db minimum. Source and Load 1000 ohms. Molded flat construction for printed circuit applications. Size: 1 x 2 x ½"; Wt: 1 oz. MIL-F-18327B.



Band pass 400 cycle Gaussian filter. Linear phase response in pass band. Attenuation 380 cps to 420 cps within 0.5 db. 2nd harmonic down 25 db, 3rd harmonic down 45 db. Source and load 5K ohms. MIL-F-18327B Wt., 0.9 lbs.



Minimum phase shift 400 cycle band pass filter. Within ± 1.5 db 370 to 430 cycles, greater than 45 db beyond 1100 cycles. 1K ohms to 100K ohms. MIL-F-18327B; 1 lb.



Band reject filters (two shown). The 1050 ~ filter has 50 db attenuation and is only 3 db at 950 and 1150 cycles. The 12.75 KC filter has more than 100 db attenuation and is only 3 db at 10.8 and 15 KC. Source and load 600 ohms, both are MIL-F-18327B.

ILLUSTRATED ARE TYPICAL SPECIAL FILTERS

RANGE OF FREQUENCIES ON SPECIAL UNITS IS FROM 0.1 CYCLE TO 400 MC.

Over thirty years of experience in the design and production of special filters have resulted in UTC being a first source for difficult units. Present designs both military and commercial incorporate a wide variety of core structures, winding methods, and capacitors to provide maximum performance, stability, and reliability. Fully experienced, top engineering talent backed by complete environmental testing and life testing facilities assure the highest standard in the industry. Full analysis and evaluation of materials are conducted in UTC's Material and Chemical Laboratories. Rigid quality control measures coordinated with exhaustive statistical findings and latest production procedures results in the industry's highest degree of reliability.

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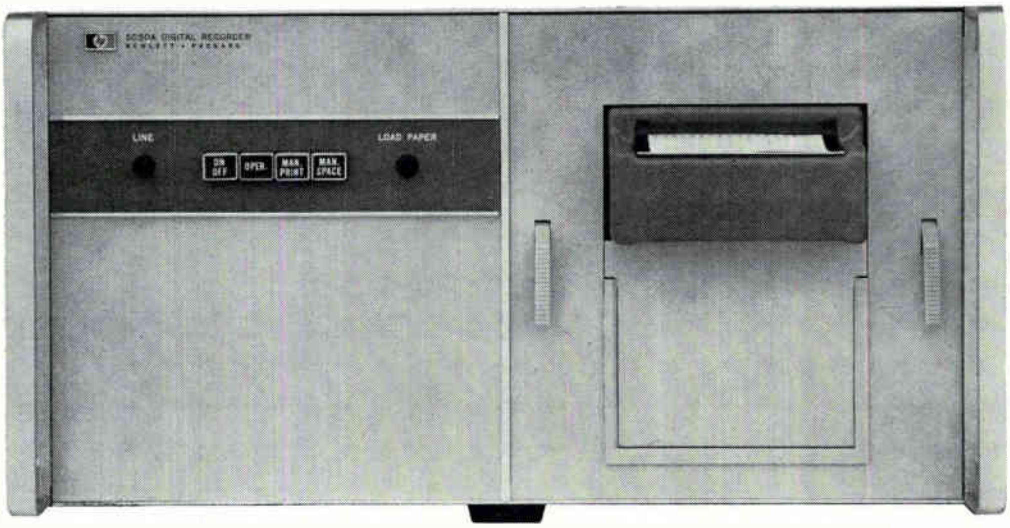
Write for catalog of over 1,300 UTC TOP QUALITY STOCK ITEMS IMMEDIATELY AVAILABLE from your local distributor.

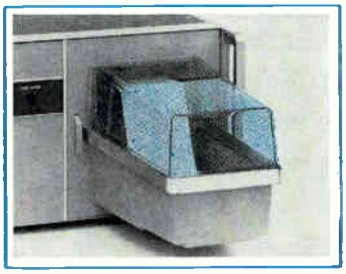
UNITED® TRANSFORMER CO.

DIVISION OF TRW INC. • 150 VARICK STREET, NEW YORK, N. Y. 10013

Circle 900 on reader service card

Introducing 'the strong, silent one.'





The HP 5050A Digital Recorder is no quitter. New mechanical techniques make this 20-line-per-second printer rugged, quiet, economical and simple. For example, there are no rotating electrical contacts for decoding, and no start-stop operation of printwheel and ink ribbon. Instead, photo-electric decoding is used, and the print drum rotates continually against an ink-impregnated roller. Fewer parts lead to increased reliability potential, which is necessary in printers with the 5050A's speed. Zero suppression is available.

The 5050A is quiet, too . . . measured noise is less than an electric typewriter, less than other printers in its speed class. It accepts 4-line BCD data from one or two sources, which can be in different BCD codes. For extra versatility, formats and codes are easily and economically changed by mechanical means without buying new circuitry for driving the printer.

The 5050A can print up to 18 columns at rates to 20 lines per second . . . and without making a lot of noise about it.

Notice the unusual transparent hood. It muffles the sound. It lets you hear yourself think. It keeps your printed records in a neatly folded stack, instead of streaming over equipment, bench and floor. And it stores completely within the recorder when you're not using it.

The 5050A is, of course, fully compatible with other HP solid-state equipment. Price is favorable, too: $1750 without the driving electronics (which are an additional $35 per column).

For more information call your local Hewlett-Packard field engineer or write Hewlett-Packard, 1501 Page Mill Rd., Palo Alto, Calif. 94304; Europe: 54 Route des Acacias, Geneva.

Brief Specifications

Print Cycle Time:	50 msec, asynchronous.
Maximum Capacity:	18 columns, 16 characters each.
Data Input:	Parallel entry, BCD (1-2-2-4, 1-2-4-8 or 1-2-4-2); "1" must differ from "0" by 4.5 V min. to 75 V max.
Reference Voltage:	±150 V max.; both "0" and "1" states are required.
Input Impedance:	Approximately two megohms.
Hold-off Signals:	Both polarities diode coupled, simultaneously available; 10 mA load max. +15 V open circuit from 1 K source −15 V open circuit from 1 K source
Print Command:	+ or − pulse, 6 to 20 V amplitude, 1 V/μsec min. rise time, 20 μsec or greater in width, AC coupled.

HEWLETT hp PACKARD

2561

See new Hewlett-Packard instrumentation at IEEE Show New York Coliseum March 20–23

Circle 1 on reader service card

Electronics

March 6, 1967
Volume 40, Number 5

News Features

Probing the News

Electronics Review

Electronics Abroad

Departments

Technical Articles

I. Design

II. Application

Electronics: March 6, 1967, Vol. 40, No. 5

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Readers Comment

Nothing new under the sun

To the Editor:

In the article "Tv cameras are slimmed down to follow action on sports field" [Feb. 6, p. 103], your Tokyo regional editor described a simplified color television pickup system, made and used by NHK. One essential part of this highly and deservedly praised development effort is a lenticular plate used before the pickup television camera and preceded by a primary color strip filter or dichroic mirror.

It may be of interest that a system using a lenticular plate with a tricolor filter on the pickup side for the purpose of producing color television was published by me in August 1937, in Television and Shortwave World, in a paper entitled:

"A Novel Scheme for Television in Colours."

Victor A. Babits
Vice President of Research
Marshall Laboratories
Torrance, Calif.

Ancient lore

To the Editor:

At the 1967 International Solid State Circuit Conference, after having heard the problems users had with integrated circuits and large-scale integration, I recalled an ancient form of circuitry, now in disrepute, known as DCC.

In this, the user has the following building block characteristics:

Transistors
- Types: PNP and NPN
- Max. voltage: 300 volts
- Max. current: 5 amperes

Capacitors
- Range: picofarads to microfarads
- Max. voltage: kilovolts

Resistors
- Initial tolerance: below .1%
- Range: fraction of an ohm to hundreds of megohms
- Temp. coeff.: 5 ppm
- Note: Resistors are linear and symmetrical

This ancient form requires a minimum investment by the user. All that is required is a workbench and a few hand tools available at the local hardware store. The building

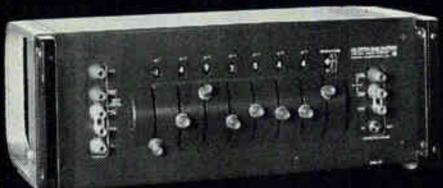
Introducing GR's new...

Standard-Signal Generator with a 9.5- to 500-MHz frequency range and 10-V, cw output behind 50 Ω; or 5 V, modulated, behind 50 Ω. It has automatic output leveling *in all modes of operation* and true single-dial tuning (no trimmer adjustment needed). The generator frequency can be phase-locked to an external standard frequency. Modulation distortion is less than 3% at 80% AM. Type 1026-A Standard Signal Generator . . . $6500.

Sweep and Marker Generator for use with GR Synthesizers. It has nine sweep speeds, from 0.02 to 60 seconds, and sweep excursion is adjustable from ±.001 Hz to ±1 MHz. Generates scope markers for quick calibration of the swept output. The synthesized center-frequency marker and side markers are accurate, stable, and precisely settable. Type 1160-P2 Sweep and Marker Generator . . . $495.

General-Purpose Laboratory Oscillator with its full 10-Hz to 50-kHz range covered by one turn of the dial. No range switch to wear out! This also means no range-switching transients and no ambiguous dial multipliers. Generates both sine and square waves, and can be synchronized to an external signal or can supply a sync signal. Has a calibrated 60-dB step attenuator and a 20-dB continuously adjustable attenuator. Type 1313-A Oscillator . . . $325.

Scanner System to connect up to 100 capacitors sequentially to GR's 1680-A automatic capacitance bridge. Also useful for other scanning applications. Modular construction offers great versatility in the number of input channels, number of lines switched per channel, and line termination. Preserves the three-terminal, guarded connection between bridge and unknown. Digital readout and BCD output of channel identification. Automatic, manual, or externally programmed operating modes. Type 1770 Scanner System . . . $3500 for a typical 50-channel guarded system.



Precision Decade Transformer with 0.2 PPM linearity and easily repeatable settings to 1 x 10^{-9}. Lever switches for easy, in-line readout plus infinite-resolution slide wire (that can be switched out of circuit for calibration). Type 1493 Precision Decade Transformer . . . $1100.

Other new products include the Type 1406 Coaxial Capacitance Standards and several additions to the GR874 and GR900 lines of coaxial equipment. You can see these and many other new GR instruments at the New York IEEE Show, Booth No. 2E26-2E36.

For complete information, write General Radio Company, W. Concord, Massachusetts 01781; telephone (617) 369-4400; TWX 710 347-1051.

Prices apply only in U.S.A.

GENERAL RADIO

Circle 6 on reader service card

blocks can be obtained from a wide number of interchangeable, competing sources and are so cheap that they can be stocked by the user. It gives the manufacturer a much larger value added than integrated circuits or large-scale integration and he can use his own proprietary circuit.

The designer can use DCC blocks in a wide variety of digital logic configurations. The same elements can be used for analog as well as digital applications.

The parts can be readily repaired or changed as all parts are readily accessible.

The design turnaround time can be measured in minutes rather than months.

In case the reader has not guessed it by now, DCC is discrete component circuitry.

Philip D. Goodman
Narberth, Pa.

What's the time?

To the Editor:

It seems to me there's something missing from your report on the Harris-Intertype photographic typesetter [Feb. 6, p. 34], namely: the time required to transfer the text to the magnetic tape, the time required for the computer to justify lines, and the time to convert the crt display to a metal plate.

Surely you would not have us believe that all these steps are completed in 30 seconds.

Clarence W. Metcalf
Engineered Advertising
Stoughton, Mass.

▪ The telephone company supplies its subscriber information to the printer on magnetic tape that serves as an input to the computer typesetter. In 30 seconds, the machine sets each line, justifies it, and produces a complete page on film. Making the printing plate takes a few minutes more. Formerly, the telephone company supplied subscriber names on punched paper tape that ran an automatic linotype machine. Setting a page this way took an hour and a half.

The numbers game

To the Editor:

In the article "Light touch" [Dec. 26, 1966, p. 168], you included some misinformation.

Although you are, of course, at the mercy of manufacturers' exaggerated claims about their sales, this statement of 200 cameras sold with 80% to North American manufacturers is unusual. The general consensus around this country is that Marconi has delivered about 16 cameras and there are firm orders for about 34 more. With 50 cameras ordered in the U.S., this would mean 110 cameras in Canada and since the Canadian Broadcasting Corporation has ordered none of its color yet, this seems very unrealistic.

Generally our information indicates that Norelco and RCA are about equal in color camera sales at around 300 (excluding the earlier 3-tube image orthicon cameras which are no longer being built), GE is somewhere around half this number, and Marconi sales are well below that.

Charles E. Spicer
Vice President-Engineering
Visual Electronics Corp.
New York, N.Y.

▪ Executives at Marconi Co. in London insist they have received orders for 160 Mark Seven color tv cameras from the U.S. and Canada.

People

Northrop Corp.'s Nortronics division means to expand and intensify its efforts in inertial guidance work. It has just named **Helmut Schlitt,** an expert in the field, to the new post of director of advanced development.

Helmut Schlitt

Nortronics already has a capability in airborne digital computers, inertial platforms and gyroscopes. The division's biggest effort at the moment is for the C-5A systems.

Schlitt's plans for Nortronics go beyond the general type of work the division has been doing. "We want to become more systems oriented," he says.

Well rounded. While declining to be specific about his plans, he said they include tactical systems such as low-cost, precision navigation systems, target-location systems, and radars and doppler systems. He added that these are not necessarily all for aircraft.

Schlitt, a native of Germany, comes to Nortronics from Litton Industries Inc. He was vice president of new product technology at Litton's Guidance and Control Systems division, Woodland Hills, Calif., and was also in charge of its space science laboratory in Beverly Hills, Calif., where he directed work on plasma engines and space suits.

He holds many patents in the field of inertial guidance and is credited with development of the case-rotation concept for gyros.

In his new job, Schlitt is in charge of Nortronics' advanced avionics laboratory, the inertial systems applications group (marketing), and the commercial navigation systems group.

Although some electronic equipment makers do produce their own integrated circuits—or at least maintain an in-house capability—most still buy on the open market. But in the view of **William J. Mac-**

People

Donald, the new president of a small Burlington, Mass., company, Film Microelectronics Inc., the number of companies with an in-house IC capability will soon rise sharply. Film Microelectronics is counting on this trend; it specializes in selling or leasing do-it-yourself hybrid IC production facilities.


W. J. MacDonald

"The threat to equipment makers without an in-house capability is that they will be contributing less and less to their own equipment as time goes on," says MacDonald, a 41-year-old engineer.

Subtractive process. The do-it-yourself approach employs printed-circuit board techniques and etching to produce a passive network of resistors and conductors. It is a subtractive process. Starting with a resistor-conductor board that has already been coated with layers of metallic material, the circuit maker selectively etches to remove the unwanted portions, leaving the desired pattern of resistors, capacitors and interconnections.

"If a device maker needs 20,000 circuits a year, or fewer, he should be using hybrids," MacDonald claims. "Development costs vary from $100 to $10,000 for a hybrid circuit, but it costs at least $50,000 to develop a monolithic IC."

He sees an increasing market in commercial applications, including television and hearing aids. The company recently bid on a new device proposed for installation on the wheels of automobiles to sense motion and trigger antiskid equipment.

MacDonald got where he is because the company did not grow faster. Film Microelectronics was founded in 1964 as Mallory-Xerox Corp., a joint venture of P.R. Mallory & Co. and the Xerox Corp. Xerox quickly bought out Mallory's interest and operated the company as Electronic Films Inc. until December 1966, when it offered to sell the business to MacDonald, then chief engineer.

PATENT NO. 3117260: THE DIFFUSION ISOLATION TECHNIQUE

Meetings

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.***

Lectures on Glass in Electronics, New York State Science of Technology Foundation; Polytechnic Institute, Troy, New York, **March 28-29.**

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

Advancing Technology & Purchasing Management Workshop, Institute of Science & Technology; University of Michigan, Ann Arbor, Mich., **March 29-30.**

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.**

Rubber & Plastics Industries Technical Conference, IEEE; Sheraton-Mayflower Hotel, Akron, Ohio, **April 3-4.**

Call for papers

Union Radio Scientific Internati Meeting, IEEE; Ottawa, Canada, 22-25. **March 15** is deadline for mission of abstracts to George clair, department of electrical gineering, University of Toronto, ronto 5, Canada.

Electrochemical Society, Lumin cence Session; Dallas, Texas, May 12. **March 31** is deadline for subm sion of abstracts to Paul Goldb General Telephone & Electronics L oratories Inc., 208-20 Willets P Blvd., Bayside, N.Y. 11361.

Symposium on Adaptive Proces IEEE; Chicago, Oct. 23-25. **Apri** is deadline for submission of abstra to Lloyd Benningfield, Sixth Sy posium on Adaptive Processes, U versity of Missouri-Columbia, Colu bia, Mo.

Symposium on Microelectron IEEE; the Colony Motor Hotel, Louis, Mo., June 19-21. **April 1** deadline for submission of papers Dr. Remo Pellin, Inorganic Chemic Division, the Monsanto Co., North Lindberg Blvd., St. Louis, 63166.

Computer Conference, IEEE; C cago, Sept. 6-8. **April 10** is deadl for submission of abstracts to S Yau, Department of Electrical En neering, Technological Institu Northwestern University, Evanst Ill., 60201.

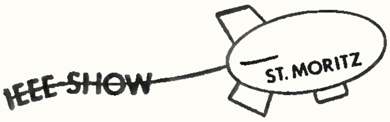
Winter Meeting, American Society Mechanical Engineers; Penn-Sherat Hotel, Pittsburgh, Pa., Nov. 12- **April 15** is deadline for submissi of abstracts to T.V. Sheehan, progra representative, Brookhaven Nation Laboratory, 81 Cornell Ave., Upto N.Y. 11973.

Fall Joint Computer Conferen American Federation of Informati Processing Societies; Convention Ce ter, Annaheim, Calif., Nov. 14-1 **April 17** is deadline for submission papers to Mr. Larson, 1967 Fall Joi Computer Conference, P.O. Box 4 Costa Mesa, Calif. 92627.

Conference on High-Frequency Ge eration and Amplification, Cornell Un versity, Aug. 29-31. **May 1** is dea line for submission of abstracts Conference Committee, School Electrical Engineering, Cornell Un versity, Ithaca, N.Y.

* 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.

WIN THE BROOKLYN BRIDGE!

Every March, rumblings of wanderlust begin to stir within the breast of every true electronic engineer. It is time for the IEEE convention. It is time once more to bend one's lance against the Visigoths of New York: waiters, cab drivers, mods on Bleeker Street, the maitre d' at 21, bilious brokers of theater tickets, the subway and just plain people who use words like "chic," "fabulous" and "devastating."

EVERYBODY WINS

In honor of all those beautiful people, simple of soul, broad of brow, and intrepid of heart, who stem from the provinces, Microdot is offering a genuine, invalid DEED OF TRUST TO THE BROOKLYN BRIDGE printed on equally invalid parchment. Or, if you prefer, Microdot will send you a handsome, invaluable booklet entitled NEW YORK DIETARY LAWS or How to Eat Dinner at the King Henry IV Without Floating a Loan from Chase Manhattan. Nothing to do.

You only get one of these, so choose carefully. There is a way you can get both. Patient reading will tell you how.

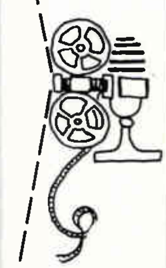
THE BEST CONNECTIONS IN NEW YORK! (PL. 5-5800)

Microdot makes connectors, as a matter of fact, the best microminiature coax connectors in the industry. Whether you're talking about the some 6000 standard off-the-shelf items or the high density, multi-pin MARC 53, Microdot has some rather surprising answers to connector problems. Of course, some of you will not have the advantage of exposing yourselves to the invectives of the hotel clerk in the St. Moritz for the IEEE show. Don't be sad. This is what you would have seen.

LEPRA/CON is Microdot's newest ultraminiature series of coax connectors. The screw-on has an OD of only 1/8 inch with a mated length of only one inch. Packaging can be reduced by as much as 50%. New versions of the LEPRA/CON include the slip-on, multipin and rack and panel based on the TWIST/CON concept. See below.

TWIST/CON is a concept as much as a product . . . the most economical microminiature pin and socket in the history of electronics. TWIST/CON permits high density packaging of contacts on .050″ centers, up to 420 contacts per square inch.

There are also the Microcrimp, Golden Crimp, Mini-Noise coaxial cable and those 6000 standards we were talking about.



MARC 53 is the world's smallest, high-performance circular connector with as many as 61 crimp contacts in a tiny 15/16 inch receptacle shell. "Posilock" push-pull coupling mates easily with no danger of damage and eliminates accidental disconnect. "Posiseal" guarantees an interfacial seal. *The new rear-insertable version of the MARC 53 is a revolution—field assembly without special insertion or extraction tools.* We will have a sound color film at the St. Moritz during IEEE which explains all about the MARC 53.

SEE US AT THE ST. MORITZ!

Microdot will not have a booth at the IEEE show. Instead it has set up a Bessarabian Harem at the St. Moritz, one of the finest combined inns and watering holes in the world. Here, any of you making the trek to Gotham can get all the hot Microdot news first hand. And while you are there you can pick up (free!!!!) at the St. Moritz BOTH your Brooklyn Bridge Deed and your copy of the New York Dietary Laws. By the way, we did say it was a watering hole.

MICRODOT INC.

Microdot Inc., 220 Pasadena Avenue, South Pasadena, California 91030

Dear Mr. Microdot:

☐ Please send me my personal Deed of Trust to the Brooklyn Bridge. I can understand people leaving Brooklyn to come to New York. But *going* to Brooklyn?

☐ Although I am a personal friend of David Rockefeller and could get a Chase Manhattan loan easily, I still want my free copy of the New York Dietary Laws.

NOTE: Only one of the above is available per person unless you visit the Microdot Pasha's suite at the St. Moritz in New York. Both will be sent only to those people who state in 25 words or less (1) why they are a hardship case and (2) why Microdot makes the best connectors in the world.

☐ Send me information on all those things like MARC 53 and TWIST/CON, etc. I am going to New York, but I have better things to do.

Name ____________

Title ____________

Firm ____________

Address ____________

City ____________

State ____________ Zip ____________

MARC 53, Posilock, Posiseal, TWIST/CON, LEPRA/CON, Microcrimp, Golden Crimp and Mini-Noise are registered trademarks of Microdot Inc.

Meeting preview

Optics topics

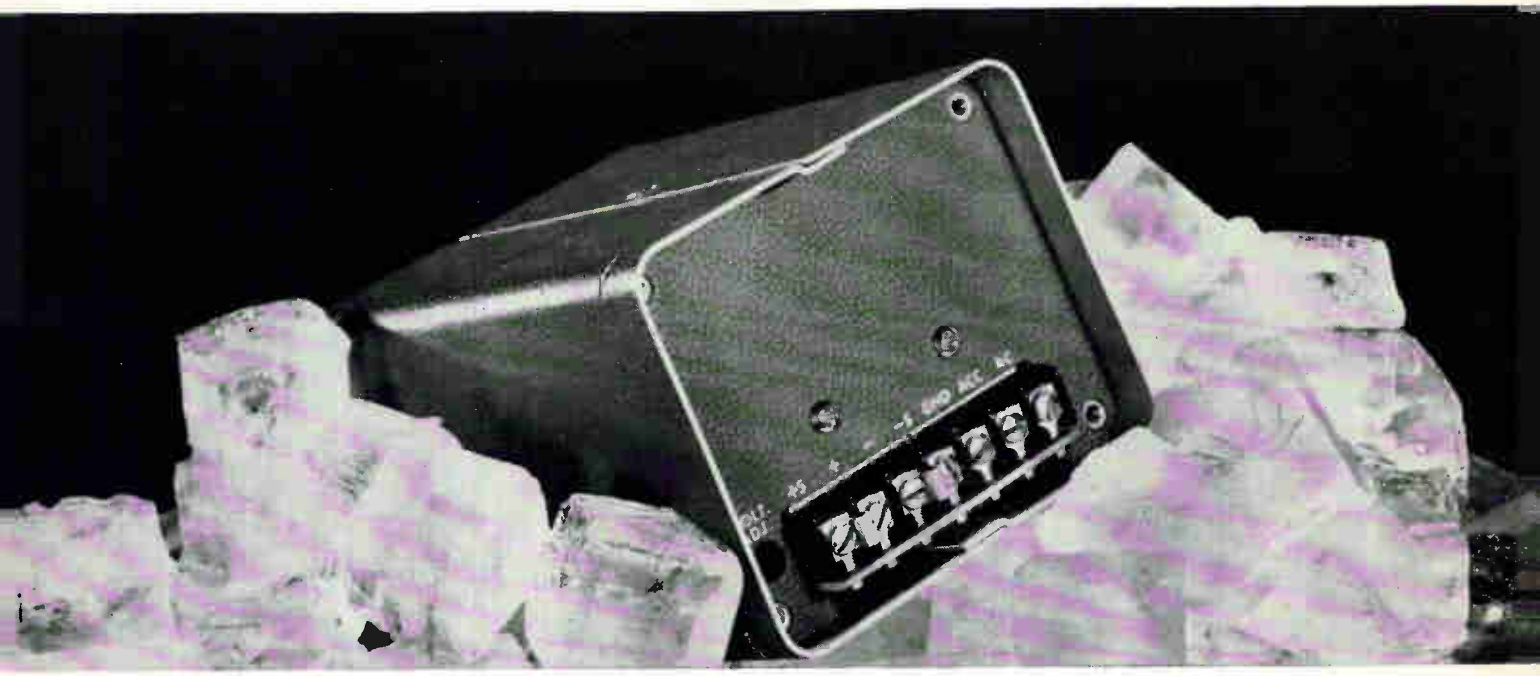
An optical recorder that may compete with magnetic tape in certain applications, real-time holographic techniques, and a single-frequency argon laser are among the advances to be discussed at the three-day Symposium on Modern Optics to be held at the Waldorf-Astoria Hotel in New York City beginning March 22. The session is sponsored by Brooklyn Polytechnic Institute, the IEEE and the military.

The recorder is a multichannel electro-optical device for pulsed signals being developed by Columbia University's electronic research laboratory for the Defense Department. Far smaller than conventional signal-processing equipment, the recorder is designed to save hours of computing time by processing signals optically. The recorder—currently working with 24 channels—is the first to convert multichannel parallel electric signals into optical signals that can be recorded on film. Moses Arm, the Columbia lab's supervisor, says that this recording technique will be used in telemetry, communications, and medical electronics systems. The recorder will be installed in existing radar systems in early 1969.

Real-time 3-D. Techniques for producing both magnified and real-time holograms that can be viewed continuously without requiring the development of a photographic plate will also be discussed. Theoretically, the combination of the magnification and holographic techniques will produce a "holoscope"—a real-time hologram that magnifies the subject. Such a system would permit the viewing of an entire volume of material rather than just the single plane upon which the conventional microscope can focus.

Among the laser work to be discussed will be an argon laser developed for NASA by Donald Caddes of Sylvania Electronic Systems, Mountain View, Calif. It's slated for installation in an optical radar system for tracking launch vehicles. The laser employs supermode control to convert output to a single frequency; it radiates in the blue-green portion of the spectrum.

new disciplines in DC



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HP's new SLOT Series of DC Regulated Power Supplies have a constant voltage output, screwdriver adjustable ±10%. Using four nuts imbedded in end plate, modules can be mounted inside instrument or on standard 19" rack panels available from hp. Barrier strip has terminals for AC input, DC output, and remote sensing.

Design insures operation to 50°C without derating or added heat sinks. Internal construction employs no cables, hand-soldered connections, or component encapsulation — units are fully serviceable. Stock models, available on a short-delivery basis, are listed below. The area below each curve at the right indicates limits of ratings available on special order.

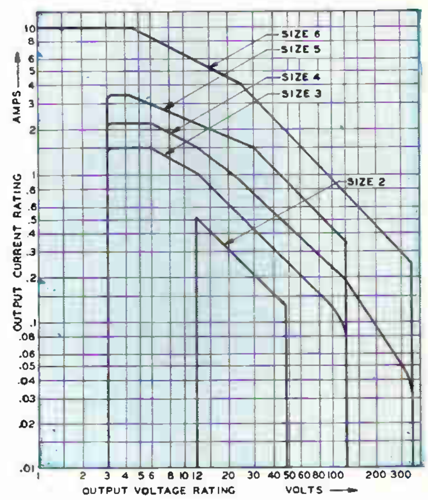
STOCK MODELS

Output Voltage	Output Current	Package Size	Model Number	Price Qty. 1-9
6V ± 10%	0-3A	5	60065A	$100.
12V ± 10%	0-1A	3	60123A	79.
12V ± 10%	0-2.2A	5	60125A	100.
24V ± 10%	0-1A	4	60244A	88.
28V ± 10%	0-1.5A	5	60285A	100.

DIMENSIONS

Module Size	Mounting Surface	Length
2	3⅜" x 4⅛"	4⅛"
3	3⅜" x 4⅛"	6"
4	3⅜" x 5⅛"	6"
5	3⅜" x 5⅛"	7⁵⁄₁₆"
6	4¼" x 5⅛"	11"

Load Regulation, 0.05%; Line Regulation, 0.05%; Ripple, less than 0.006% or 1 MV RMS, whichever is greater • Transient Recovery Time, less than 25 μ sec to within 10 MV • Short-Circuit-Proof, Current-Limited Output • No Overshoot on Turn-On, Turn-Off, or AC Power Removal • Operating Temperature, 0°C to 50°C; Storage — 40°C to +85°C



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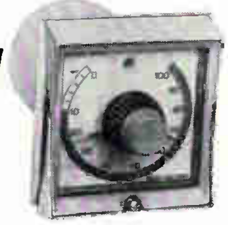

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CA100

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ELECTROMECHANICAL DUAL-FUNCTION TIMER

HG100

The Man from E.A.G.L.E.* *presents two samples that show the range in his bag of timing tricks. The CA100 solid state timer provides split-second control of continuous, high-speed, "on-off" cycles from 3 to 2000 times a minute. Housed in Eagle's famous Cycl-Flex case, the CA100 can be plugged in and taken out in seconds. Solid state circuitry eliminates moving parts, makes this timer great for dusty, dirty locations. At the other extreme the HG100 electromechanical dual-function timer does the job of two ordinary timers. With a single, easily-set dial it provides adjustable "on" and "off" time periods for cycles ranging from 30 seconds to 60 hours. It gives you unmatched ease of adjustment without setting cams or changing gears.*

For detailed descriptions of one or both of these timers, get our CA Series Bulletin 322 and our HG Series Bulletin 320. Write Eagle Signal Division, E. W. Bliss Company, 736 Federal Street, Davenport, Iowa 52808; or call (319) 324-1361.

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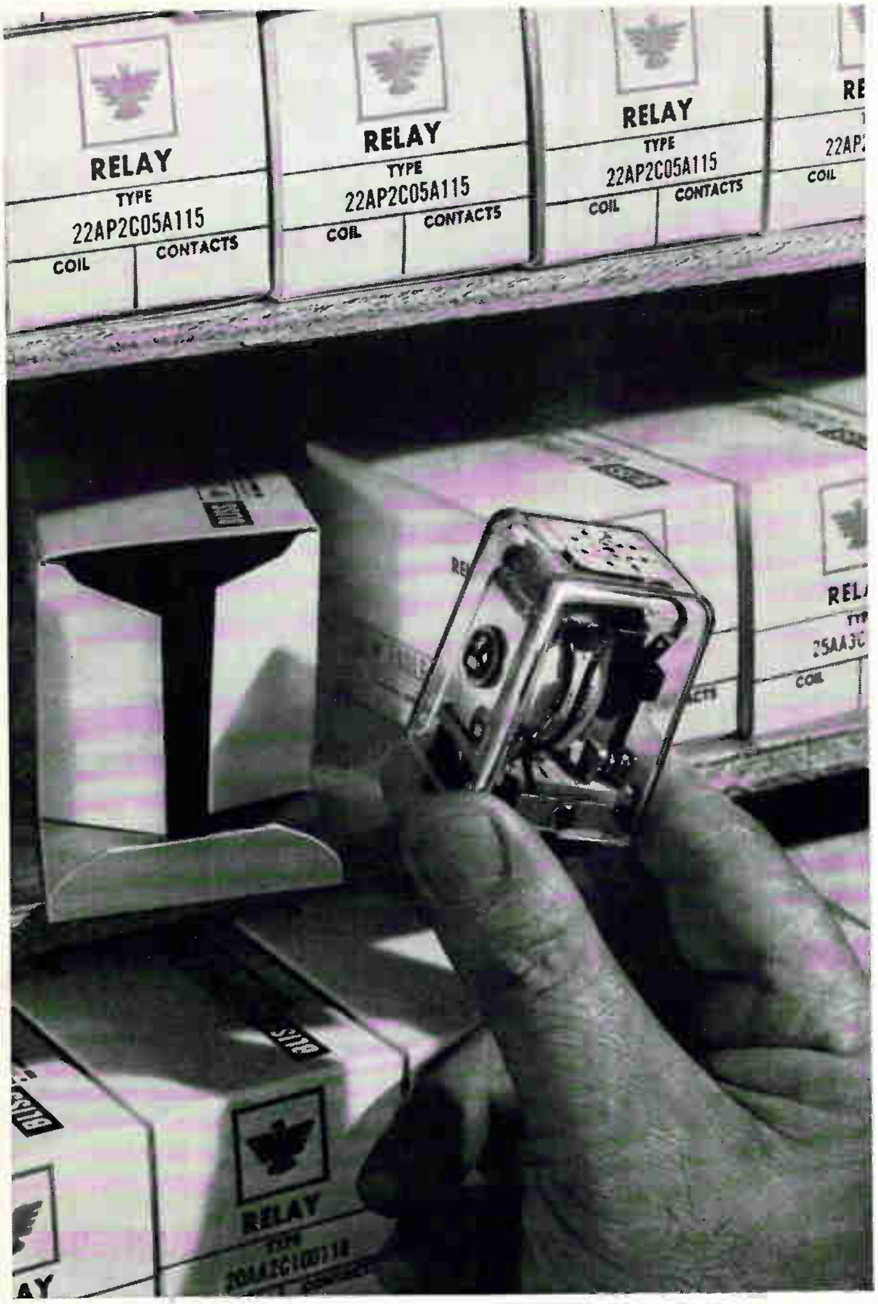
For information on CA100 Timer circle reader service number 18.

For information on HG100 Timer circle reader service number 19.



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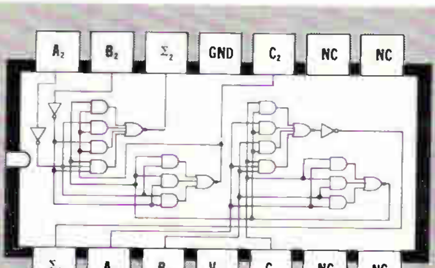
Five new complex-function ICs . . .

Cut costs, simplify designs and improve reliability . . . use these new Texas Instruments Series 74 TTL integrated circuits in your digital electronic systems.

Cut costs two ways. First, you pay less per circuit function than when buying conventional ICs. Second, you save on connectors, circuit boards, inventory, and assembly costs . . . since fewer packages and less area is required. Net result . . . you can often realize over-all savings in excess of 50 percent!

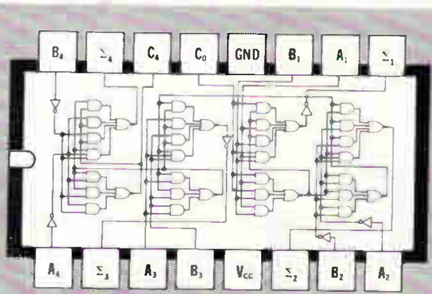
You simplify designs because TI has already done a lot of the work for you. These devices, which are fully compatible with



SN7482N DUAL ADDER

- Cost savings of 26% over two single IC adders.
- 15 nsec serial carry through both additions.
- Provides the Σ_1 of A_1 and B_1, and the Σ_2 of A_2 and B_2, including appropriate carry manipulations.

Circle 497 on Reader Service card for data sheet.



SN7483N QUAD ADDER

- Saves 41% over four single IC adders.
- 30 nsec serial carry through four additions
- Provides the Σ_1 of A_1 and B_1, the Σ_2 of A_2 and B_2, the Σ_3 of A_3 and B_3, and the Σ_4 of A_4 and B_4, including appropriate carry manipulations

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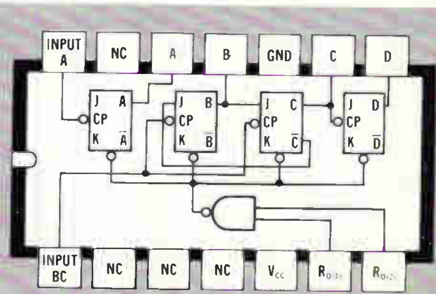

SN7492N DIVIDE-BY-12 COUNTER

- Saves 19% over four separate IC flip-flops and gating.
- Operates at 15 MHz.
- Frequency divides by twelve, six, three, or two.
- Simultaneous independent operation of divide-by-six and divide-by-two sections.

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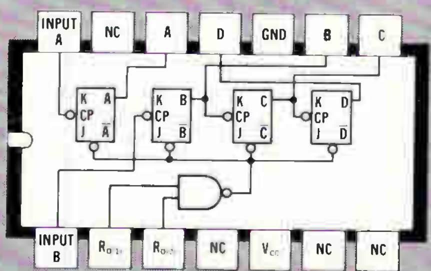

SN7493N FOUR BIT BINARY COUNTER

- Saves 16% over four separate IC flip-flops.
- Operates at 15 MHz.
- Ripple through operation provides frequency division by sixteen, eight, four, or two.
- Simultaneous independent operation of divide-by-eight and divide-by-two sections.

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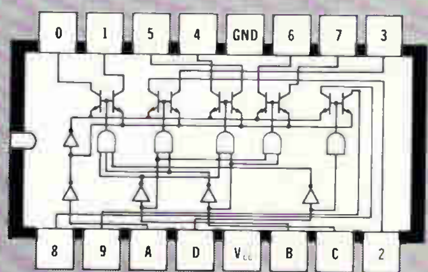
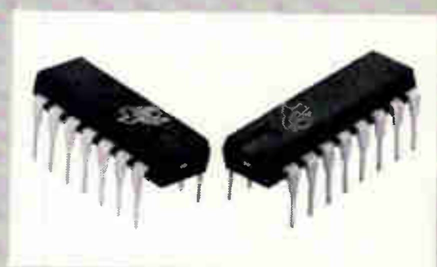


SN7441N BCD-TO-DECIMAL DECODER/DRIVER

- Saves 23% over separate IC decoding circuits and driver transistors.
- High-voltage output (65 volt guarantee) transistors directly drive gas-filled readout tubes.
- BCD inputs provided for use with SN7490N decade counter.

Circle 501 on Reader Service card for data sheet.



MOLDED PLUG-IN PACKAGES

All Series 74 TTL integrated circuits — including these five new complex functions — are available in TI's popular molded plug-in package. A new 16-pin configuration (right) is orovided for circuits requiring more than 14 pins. Both packages have pins located on standard 100-mil centers. These packages provide highest reliability and greatest ease of handling at lowest possible cost.

Find out how TTL complex-function integrated circuits from Texas Instruments can fit into your programs. Ask your local TI Sales Engineer, or write us at P.O. Box 5012, Dallas, Texas 75222

here's how they can work for you!

all other Series 74 integrated circuits, will enable you to develop new systems faster, at reduced expense.

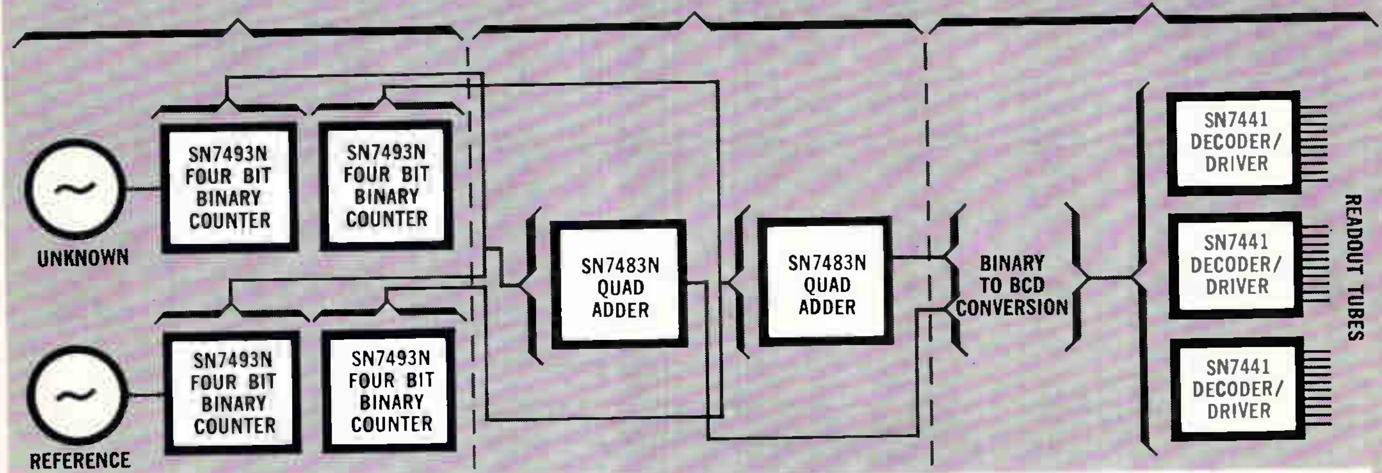
You also improve system reliability — because the increased circuit complexity per package means fewer soldered joints and plug-in connectors.

How can these new TI complex-function ICs work for you? For illustration, we have designed the frequency-measuring subsystem shown below, and compared it with a similar subsystem using conventional ICs. The savings realized here will give some idea of what you may expect.

PROBLEM:
To measure unknown frequency by comparing with known reference frequency and displaying difference frequency.

SOLUTION:

(A) count both frequencies | **(B) subtract the two frequencies** | **(C) decode and display the difference**



With new TI complex-function integrated circuits:

(A)	(B)	(C)
YOU SAVE...	YOU SAVE...	YOU SAVE...
16% in IC costs	19% in IC costs	23% in IC and transistor costs
75% in number of packages	87% in number of packages	93% in number of packages
168 soldered connections	178 soldered connections	196 soldered connections

HERE'S HOW...

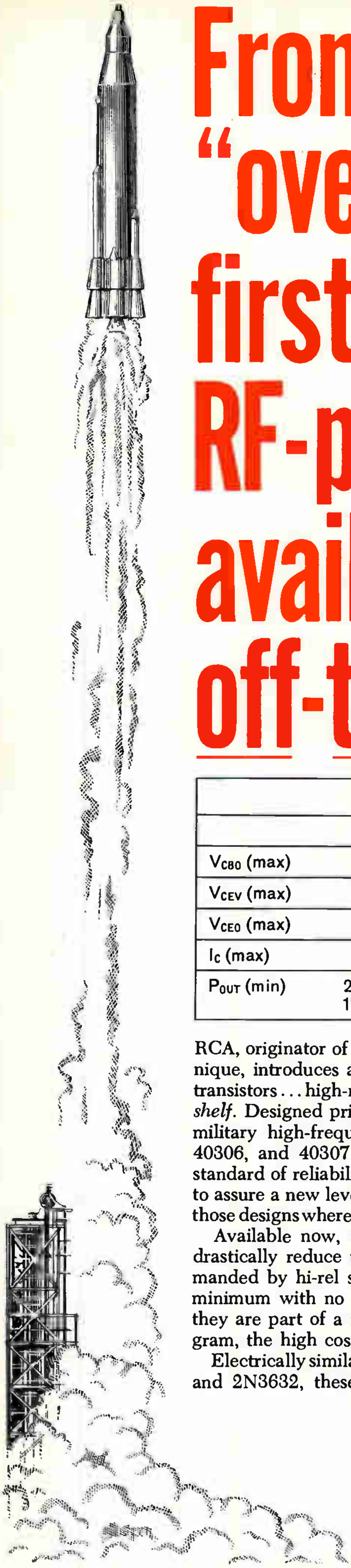
With new TI complex-function integrated circuits, you require:

(A)	(B)	(C)
Four SN7493N four bit binary counters	Two SN7483N quad adders connected to subtract	Three SN7441N BCD-to-decimal decoder drivers
56 pins are to be soldered	32 pins to be soldered	48 pins to be soldered

With conventional integrated circuits you would require:

(A)	(B)	(C)
16 single flip-flops	12 quad two-input gates	Three dual four-input gates
224 pins to be soldered	2⅔ triple three-input gates	Six triple three-input gates
	210 pins to be soldered	1½ quad two-input gates
		30 driver transistors
		244 pins to be soldered

TEXAS INSTRUMENTS
INCORPORATED



From RCA "overlay"... first high-reliability RF-power transistors available off-the-shelf

RATINGS FOR RF SERVICE				
	40305	**40306**	**40307**	**Units**
V_{CBO} (max)	65	65	65	Volts
V_{CEV} (max)	65	65	65	Volts
V_{CEO} (max)	40	40	40	Volts
I_C (max)	1.0	1.5	3.0	Amperes
P_{OUT} (min)	2.5W @ 175 MHz	7.5W @ 100 MHz	13.5W @ 175 MHz	

RCA, originator of the revolutionary "overlay" technique, introduces another new concept in rf-power transistors . . . high-reliability units *available off-the-shelf*. Designed primarily for critical aerospace and military high-frequency applications, RCA 40305, 40306, and 40307 transistors go beyond the high standard of reliability established by RCA "overlay" to assure a new level of confidence . . . confidence for those designs where device failure cannot be tolerated.

Available now, these three "overlay" transistors drastically reduce the time and effort normally demanded by hi-rel specs . . . response time is kept to minimum with no delivery problems. And because they are part of a formal RCA high-reliability program, the high cost of "customizing" is eliminated.

Electrically similar to RCA types 2N3553, 2N3375, and 2N3632, these hi-rel devices are designed to meet MIL-S-19500. (Hi-rel selections of "overlay" types 2N3733, 2N4012, and 2N4440 are also available.) Each transistor is subjected to strictly controlled pre-conditioning tests including:

- Fine Leak, 1 x 10^{-8} cc/sec/max.
- Gross Leak, 70 psig, 16 hours min.
- Acceleration Test (2006 of MIL-STD-750, 10,000 G, Y_1 axis)
- Temperature Cycling (MIL-STD-202)
- Power Age (168 hours)
- X-ray Inspection, RCA Spec 1750326

For more information on RCA's "overlay" high-reliability capability, consult your RCA Representative. For technical data on 40305, 40306, and 40307, write: RCA Commercial Engineering, Section IN3-1, Harrison, N.J. 07029.

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Editorial

Credibility gap in hiring

There are more job openings for electronics engineers than there are engineers available and seeking to fill them. That's the conclusion of Electronics' annual survey of employment which begins on page 211. To hear the recruiters tell it, a good engineer with the right specialization can pick a top notch spot anywhere in the country.

But the survey produced one alarming note: fewer and fewer engineers believe what companies tell them about their jobs and their futures. In spite of—or maybe because of—the tantalizing descriptions in advertisements that would have applicants believe that the job is the way to wealth, power, prestige, and paradise, a credibility gap has opened. One executive of a personnel agency reported that some of his engineer applicants were insisting that companies guarantee the jobs will still exist in a year.

The disenchantment with what recruiters promise is part of a bigger picture of business's sagging reputation. Not too long ago, a study at Harvard University concluded that the brightest undergraduates don't want to work in private industry. The students associate industry with some distinctly distasteful characteristics, mainly exaggerated advertising whose claims are overstated or overdramatized, products that are delivered new but in unworkable condition, and unfilled promises of services. So, instead, they seek jobs at nonprofit foundations or in government agencies. An IBM executive complains that his company can't hire the cream of a college graduating class because the top students prefer nonindustrial work.

Fear of being drafted has caused some young engineers to go to work in industry when they preferred other work, but clearly their motivation is the poorest possible.

Unhappily, a lot of companies have earned this distrust. They have hired willy-nilly for a short-term project, completed the work, and promptly laid off the engineers. Then they've gone out and hired a batch of new technical men for a new project. Or a few companies have stockpiled engineers on the chance that they would receive a big contract. When the project went to another company, they promptly dumped the engineers they had so recently hired. Practically none of these defense-business-oriented companies were interested in cultivating long-time engineering employees, training engineers to keep pace with technology, or planning growth to build a solid enterprise.

Too often, a company has jumped on a technical fad, hired a lot of engineers to pursue it, then discovered the company had no management or marketing ability in this area so the executives closed down the entire new operation, throwing the engineers onto the street without warning.

At too many companies engineers have become expendable, like paper clips, staples, and typewriter ribbons. Now management is beginning to pay for this sloppy attitude and haphazard hiring practice.

Not enough companies can boast, as Hewlett-Packard Inc. did in an advertisement last month, that it has never had a layoff. Steady employment has not come easy to this progressive and profitable instrument company. It takes careful planning, painful patience, intimate knowledge of technical trends, aggressive product planning, and superb management. The company may have missed participating in one or two technical areas because its management couldn't be sure the developments wouldn't be just passing fancies, but it is represented in most of the important product lines.

The credibility gap makes hiring more difficult, but there is even a more important aspect that should concern the industry. If an engineer doesn't trust a company enough to go to work for it, will he trust its products in a critical application that could cost him his job? The answer clearly is no.

Thus electronics companies have several urgent reasons to improve their reputations—and quickly. The best method is not with a public relations campaign to improve the image, a favorite ploy in the 60's. What's needed are realistic hiring practices, a business-like approach to planning the company's future, a willingness to train the company's technical people so they can keep pace with technological advances, and a determination to tell the truth about job prospects, product performance, and the company's future.

Some electronics companies have already reached the point where they cannot hire good engineers because their reputations are so bad and they have trouble selling their products. Unchecked, the credibility gap can sink a company.

Electronics Newsletter

March 6, 1967

Litton plans two computers with MOS arrays

Litton Industries is designing two experimental computers based on large-scale arrays of metal oxide semiconductor integrated circuits. Both are in the early stages of development; the more advanced design has recently received financial support from the Air Force.

One machine is essentially a complex of digital differential analyzers that can perform such limited tasks as solving for trigonometric functions. Designed for aircraft navigation, it could be applied to automatic tool control. The other machine, planned as either a backup or replacement for the differential-analyzer unit, uses MOS arrays to perform logic and memory functions. Its design, more advanced and more along the lines of a general-purpose computer, could be expanded to handle target recognition or fire control.

Both designs depend heavily on the development of highly reliable, easily reproducible MOS arrays. Litton has asked Philco-Ford and General Instrument to prepare experimental circuits.

The two circuit makers are acting as consultants to Litton. Both received specifications for the production of a limited quantity of test arrays designed to be quickly tested with a single probe. Litton's plan is to determine quickly the expected yield (the number of usable functions on an array) that will result from the still-infant MOS technology.

For the more advanced machine, called a block-oriented computer, Litton engineers haven't decided whether to use single or two-layer metalization to interconnect the circuits within the wafers.

The major reason for turning to the MOS arrays is reduction in cost, size, and power needs. It's estimated that the price of a production-model MOS computer would be about a tenth the cost of a computer using bipolar devices; the size would be reduced by a factor of 5 to 10 and the power needs would be cut by a factor of from 100 to 1,000.

Scr's power rises but prices hold

The power-handling capability of low-cost silicon controlled rectifiers is continuing to rise, making them more attractive for use in consumer appliance. Motorola Semiconductor Products has just introduced an 8-ampere, 600-volt scr—one of a series of four plastic-encapsulated types. The scr's, 2N4441 through 2N4444, are rated at 8 amperes root-mean-square forward current and have blocking voltages ranging from 50 to 600 volts. Typical gate current is 10 milliamps. In quantities over 100, they cost from 80 cents to $3. General Electric's C106 series of plastic-encapsulated scr's cost about the same. However, the highest power unit in GE's line, which has probably had the giant share of the consumer scr market, is rated at 2 amperes, 300 volts.

Patent reform hits a snag in court

Just as the Administration's patent reform bill was being sent to Congress late last month, a Federal court handed down a ruling that threatens to stir up a new controversy over patent jurisdiction.

The bill, containing sweeping proposals to end the long and costly court battles, calls for ultimate jurisdiction by a regional court. But the U.S. Court of Claims, ruling in behalf of Technograph Printed Electronics, said a patent judged invalid in one court case can be brought up in another case.

Technograph, whose main business is to exploit its patents and licenses, had lost its battle for back royalties on printed circuits from Bendix [Electronics, Nov. 2, 1964, p. 23]. Now the firm has been given the green light to sue the Government, as purchaser of circuits, and others over the same patents as in the Bendix case. **Outlook: the controversy is likely to embroil the Supreme Court as well as Congress.**

Peak laser pulses top billion watts

Peak powers greater than a billion watts have been achieved with an experimental two-stage Raman-effect laser that uses reverse pumping. The work, done at Gaithersburg, Md., by the International Business Machines' Federal Systems division, has produced pulses as short as ⅓ nanosecond. Although the in-house effort is a long way from application, IBM believes an optical system based on the development could enable precise tracking of orbiting spacecraft.

FAA will test "inexpensive" anticollision unit

A new proximity-warning system, designed by the National Co. of Melrose, Mass., will be flight-tested this spring by the Federal Aviation Administration. **The system is being considered for use by planes flying the North Atlantic routes.**

National's design is hardly a full-fledged collision-avoidance system, but it can warn a pilot if another aircraft comes within 60 nautical miles in any horizontal direction and within 1,500 feet in either vertical direction. **It'll cost considerably less than the estimated $50,000 unit price of a collision-avoidance system,** which would use either cooperating ground stations or highly accurate time-frequency techniques.

With an expected accuracy of within 1 mile, the National system is adequate to maintain safe separation between planes flying over the ocean. For the dense overland routes, better accuracy is needed.

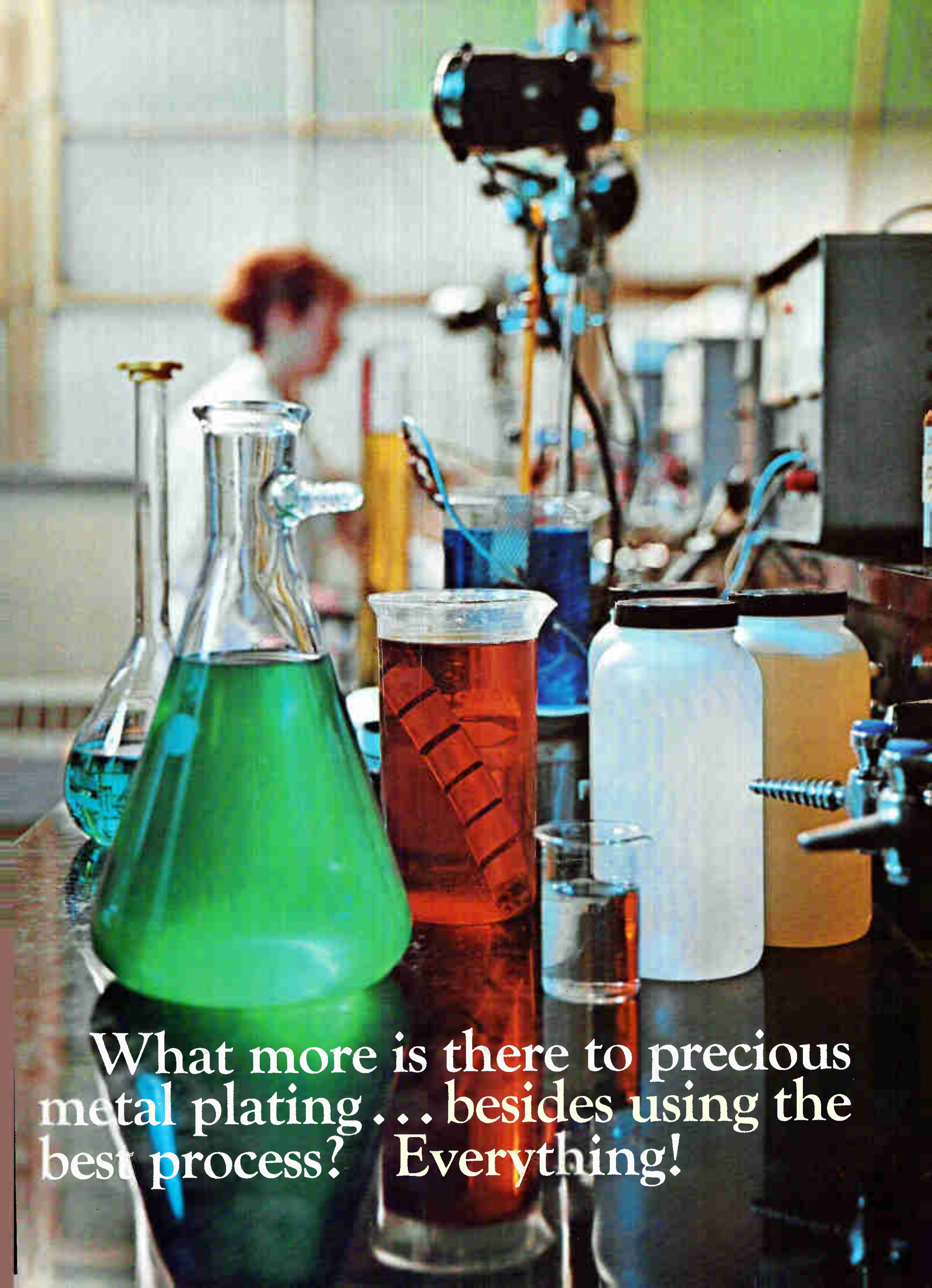
Production woes beset Philco-Ford

Though it is not yet out of trouble with its integrated-circuit calculator (see story on p. 31), the Santa Clara, Calif., operation of the Philco-Ford Corp.'s Microelectronics division **has a new worry with one of its major programs in bipolar integrated circuits.** Because of production difficulties, the plant has been temporarily suspended as a qualified source on the National Security Agency's classified R-13 program. Santa Clara was making milliwatt resistor-transistor logic for the project. **According to insiders, unless the suspension is lifted, the plant will have to lay off a large percentage of its 1,200 employees.** Although Philco-Ford executives have admitted having a problem, they say no layoff is now planned. Nearly 60% of Santa Clara's output is in bipolar IC's.

The troubles are in the deposition of aluminum metalization. **If the suspension on the Santa Clara plant continues, Philco-Ford will shift all its bipolar production to a sister plant in Lansdale, Pa.,** which currently is also producing circuits for the security agency project. Ironically, Philco had wanted to switch bipolar production there a year ago, but the agency opposed the idea.

Transit bids

The Westinghouse Electric Co. was the apparent low bidder for the train control and communications portion of the San Francisco area's rapid-transit system. The bid, for $26.2 million, must now be studied to make sure it meets specifications. Official word is expected March 23.


What more is there to precious metal plating . . . besides using the best process? Everything!

"We don't disappear once we sell you the process."

If precious metal electroplating could be learned from a set of textbook rules, half the need for service would vanish.

But since electroplating is a dynamic, living thing, a blend of skill and science, optimum results depend on more than just a process.

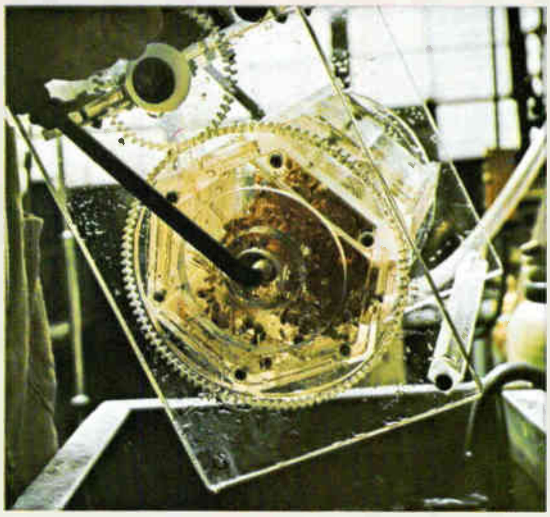
That's why Sel-Rex offers a "total approach". One that guarantees consistent reliability. Maximum production.

Such an approach *starts out with* the best process for your product. (Sel-Rex probably has the best process for you because Sel-Rex has the greatest number of precious metal electroplating processes.)

And if we don't have a process that's just right for you, we'll develop one.

You'd expect that from the company that developed the first bright gold, the first acid gold, and the first non-cyanide gold processes for industry.

Prototype Plating Service



Bring us your product, and we'll conduct process studies for you aimed at satisfying your specifications. (Last year we were involved in evaluating *over 5000* high-reliability electroplating applications.)

Whether you have an in-plant plating operation or a job shop, we'll help you select a process and we'll run a sufficient number of samples to prove out the process.

We'll recommend the proper type of plating equipment, supply it if you need it, provide information on plating procedure and process control, and offer technical information on the maintenance of the bath.

If you've re-designed a product and it's not going through the cycle properly, our prototype plating service will check it out for you.

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Once you're set up and running, we'll help you continue running properly—with preventive maintenance.

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While all this is going on, we'll also serve you indirectly through continuing research; and we'll make available to you the results of our new knowledge.

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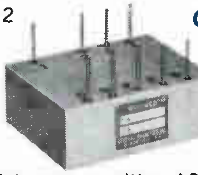

The algebraic sum of two magnetic squaring blocks feeding a switching Demodulator, delivers the indicated DC analog output. Input and output data may be either AC or DC, depending on system requirements

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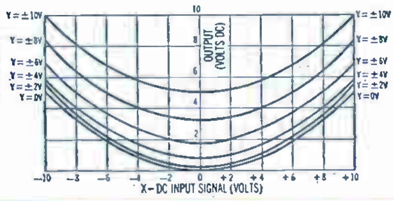

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Wide Band Width
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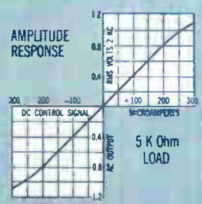

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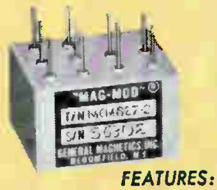

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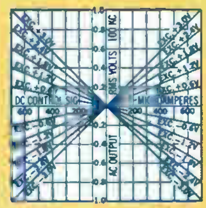

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Low Milliwatt Power Consumption
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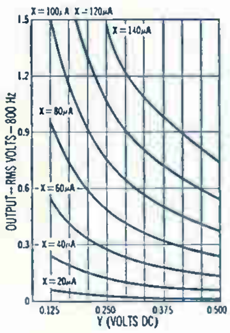

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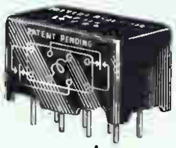
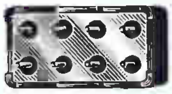
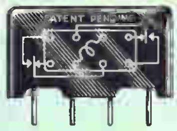
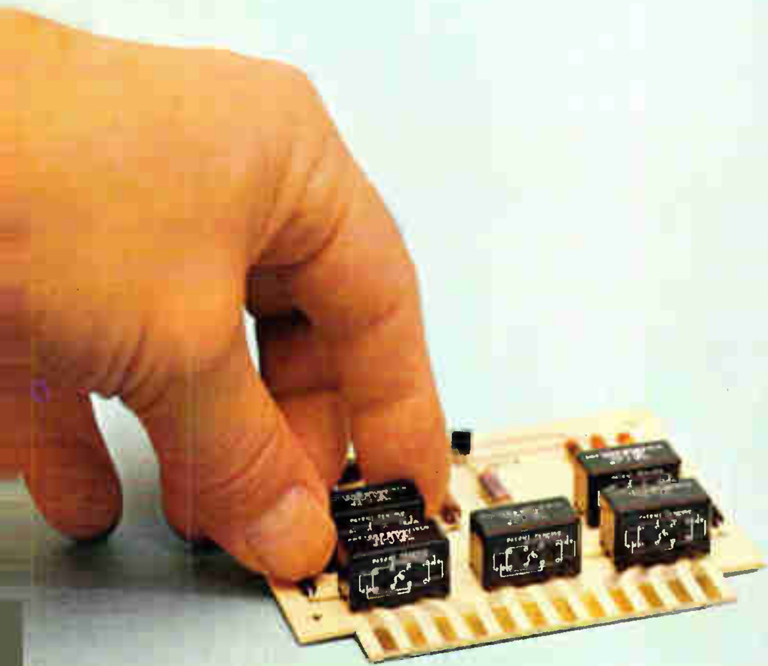
NEW! A commercial relay this  small with 2-ampere dpdt contacts. Printed circuit or socket terminals.  Has Lexan dust cover. This design bonus from our aero/space program is ideal for tape recorders, desk-top computers,  copying machines, television cameras, alarm systems, etc., etc., etc., etc., etc.



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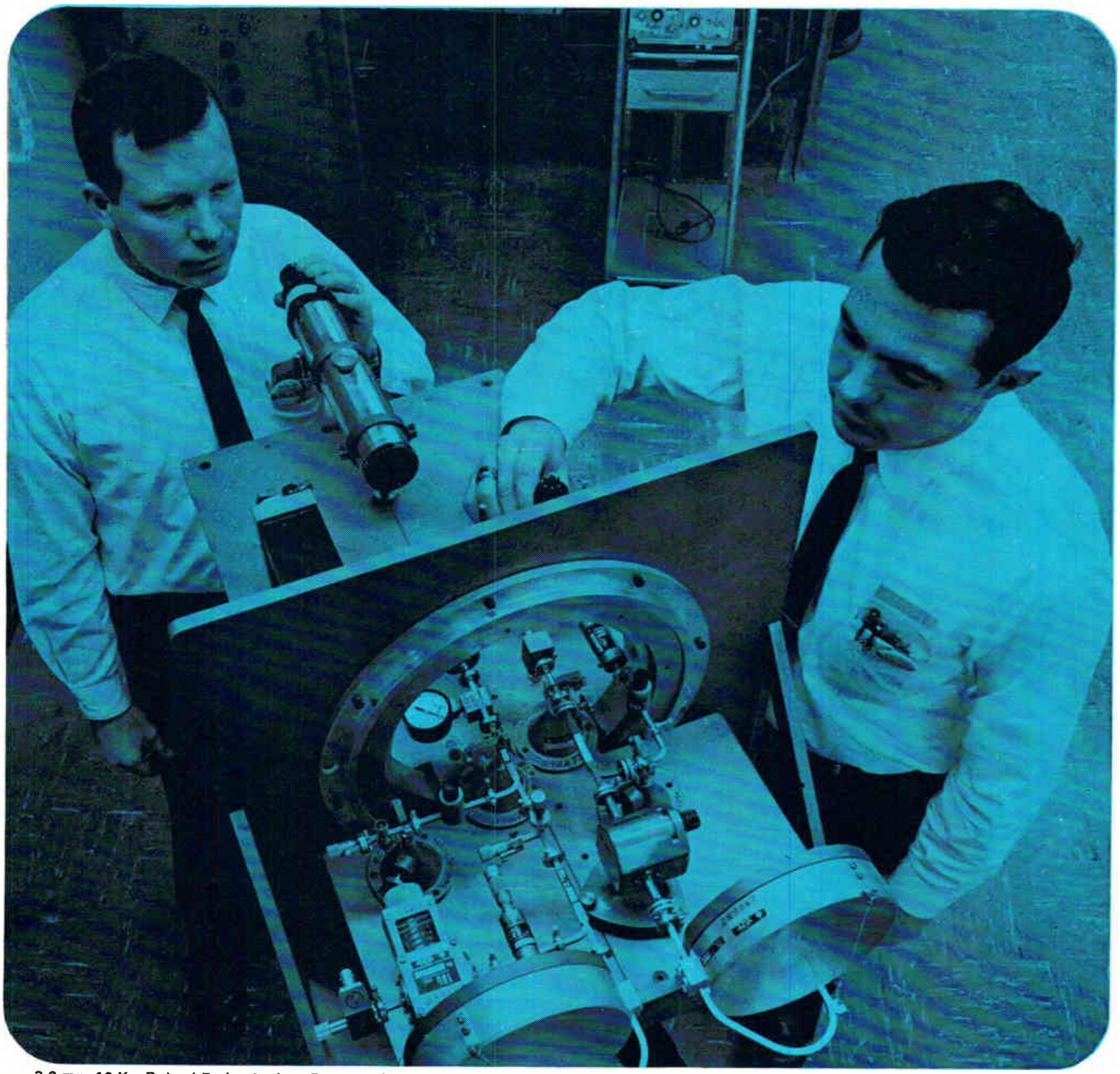

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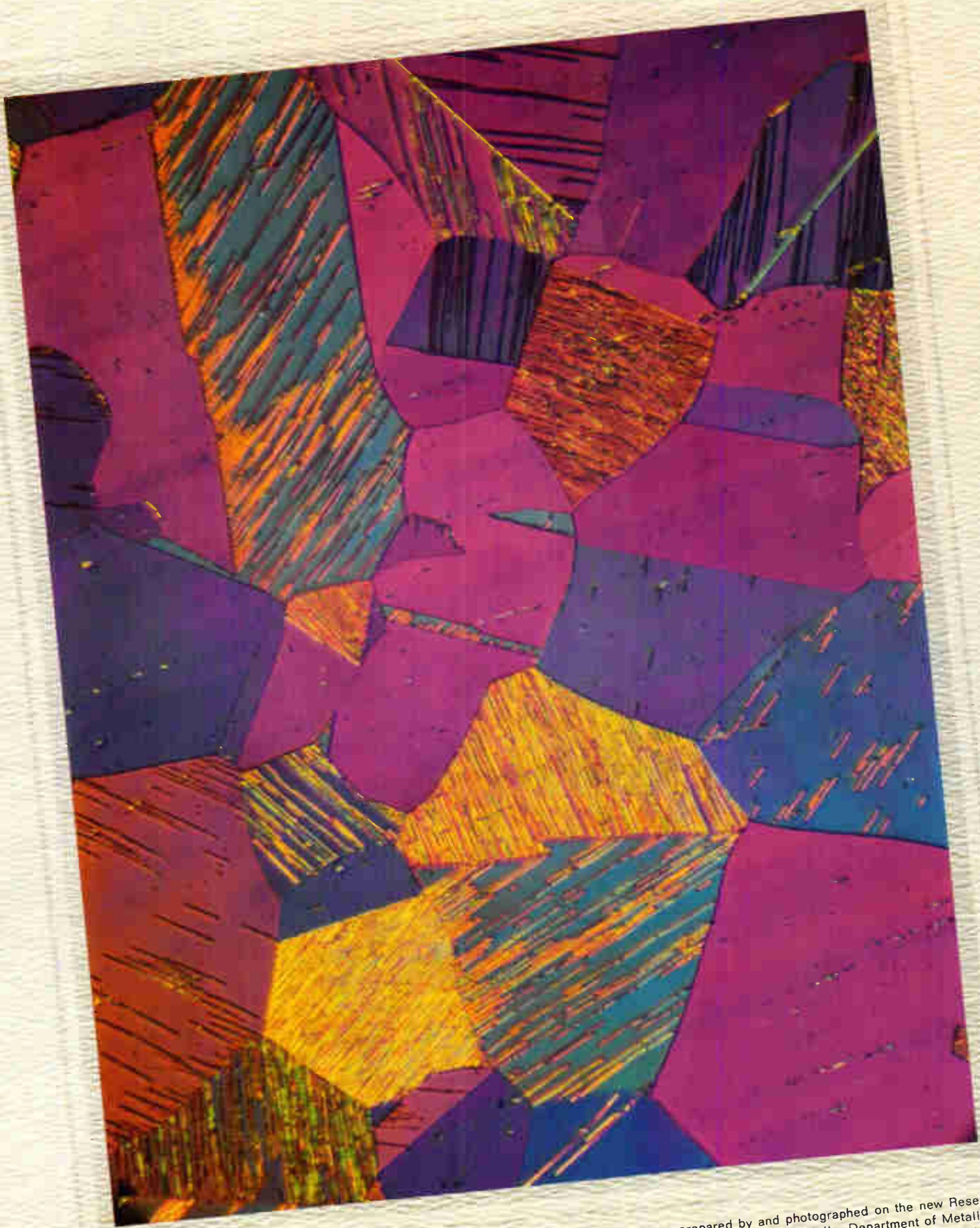

Specimen: Austenite (6% manganese, 1% carbon, 93% iron). Rolled, quenched in brine from 2000°F. Etched with Vilella's reagent. Original magnification: 100×.

Specimen prepared by and photographed on the new Research II Metallograph by Prof. Joseph R. Vilella, Department of Metallurgical Engineering, School of Mines, University of Pittsburgh.

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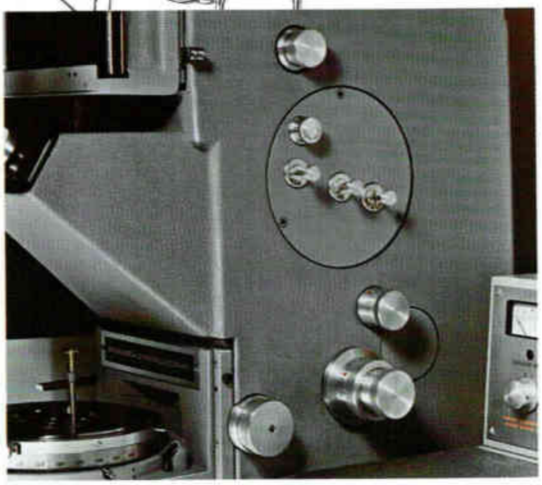

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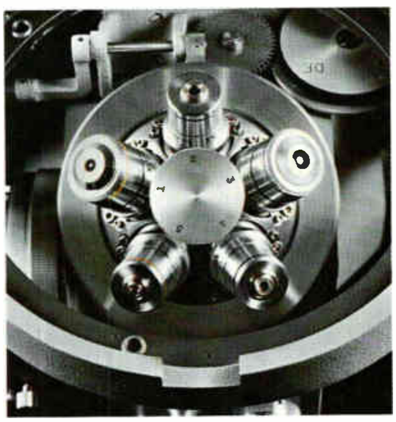

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FREQUENCY RANGE: 5 Hz to 150 kHz. Frequency is determined by two plug-in circuit boards, each of which contains two or four (depending upon frequency) resistors and two capacitors. Plug-in frequency determining boards for any particular frequency in the above range can be ordered from PAR or the user can change frequency by changing the resistors and capacitors on the two plug-in circuit boards. A front panel vernier adjustment functions as a fine frequency control.

SIGNAL INPUT CHARACTERISTICS: Single-ended input of 10 Megohms shunted by 30 pF. Selectivity characteristic is that of a parallel resonant circuit with a Q of approximately 10.

SENSITIVITY: 100 μV to 50 mV rms full scale in a 1, 2, 5 sequence. Output X10 monitor position increases meter sensitivity by factor of 10 on any range.

FILTER TIME CONSTANT: 1 mS to 30 seconds in a 1, 3, 10 sequence and EXT position. 6 dB/octave roll-off rate.

OUTPUT: ± 10 volts full scale, single-ended with respect to ground.

PRICE: $765.00.
Export Prices approximately 5% higher, (except Canada).

Model 121 is continuously tunable throughout its entire operating frequency range. It provides the versatility required for use in many sophisticated research applications. Illustrative specifications are:

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SIGNAL INPUT CHARACTERISTICS: Single-ended input of 10 Megohms, shunted by 20 pF. Adjustable Q from 5 to 25 over the entire frequency range.

SENSITIVITY: 10 μV to 500 mV in 1, 2, 5 sequence. Output X10 monitor position increases meter sensitivity by factor of ten on any range.

FILTER TIME CONSTANTS: 1 mS to 100 sec. in 1, 3, 10 sequence and EXT. position. 6 or 12 dB per octave roll-off.

OUTPUT: ± 10 volts full scale, single-ended with respect to ground.

VOLTMETER MODE: Internal demodulator reference signal derived from signal to be measured. Unit operates as average responding AC voltmeter with overall sensitivity unchanged.

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PAR PRINCETON APPLIED RESEARCH CORP.

Electronics Review

Volume 40
Number 5

Companies

Follow the leader

Even in a business as used to management raids as the semiconductor industry, the grabbing of five top executives of giant Fairchild Semiconductor by little National Semiconductor Corp. is startling.

In fact, National's chairman, Peter Sprague, seemed a bit overwhelmed after hiring Charles E. Sporck, former general manager of the Fairchild Camera & Instrument Corp., division, and naming him president. As an added windfall, four of Sporck's cohorts at Fairchild followed him to National. They are: Pierre Lamond, integrated circuit manager; Fred Bialek, director of international operations; Roger Smullen, IC manufacturing manager; and Floyd Kvamme, marketing product manager for IC's.

Fairchild wasted no time in trying to repair the damage, appointing Tom Bay, its Instrumentation division manager, to head the Semiconductor division.

Described by Sprague as the latest in a series of moves to strengthen and expand the Danbury, Conn., semiconductor firm, he said the addition of the Fairchild group is expected to have a negative effect on company earnings initially, but is part of a four-to-five-year growth plan. "Right now, we have a lot of chiefs and only a few Indians," Sprague commented.

Asked if the five Fairchild executives were hired as a group, Sprague noted that Sporck "is pretty much of a leader and when it became known that he was leaving, the others asked to come with him." He called their arrival late last month "somewhat of a surprise."

As to definite plans regarding the group, Sprague said they had not been accurately worked out as yet. But the additions do mean that National will expand its hybrid-integrated-circuit operations in Danbury and monolithic-IC work in Santa Clara much faster. After it firms up plans, National will seek new financing, Sprague said.

Other recent additions are Ken Davis, West Coast sales manager for Texas Instruments Incorporated; Ken Moyle, leader of an integrated circuit development group at the Hewlett-Packard Co.; and John F. Hughes, a financial vice president at the Perkin-Elmer Corp. Davis will become marketing manager of National, and Hughes will become chief financial vice president.

All of this talent, except for Hughes, is currently clustered at National's Santa Clara, Calif., operation at what used to be called Molectro, Corp., before National bought it year and a half ago. Molectro employs about 50 persons.

National's main business is in discrete components, although it recently introduced a line of its own linear IC's. The company holds licenses from Fairchild. "Our plans are not completed in terms of what circuits we will make," Sporck said. "Planning is our first step."

Jack F. Hegarty, National's president for the past six months, will take over Danbury operations and product marketing, according to Sprague.

Both Fairchild and Sporck said that the parting of the ways was friendly. "The reason we left," Sporck said, "was that the attraction of working with a small company was just too great."

Fairchild group vice president Robert N. Noyce says the loss of five top men won't hurt Fairchild's operations. "You ask me how I am and it's a little like 'aside from that, how did you like the play, Mrs. Lincoln," he grinned. "And to be honest, last week I did feel a little low. But Fairchild is not just a few people; we're not scraping the bottom of the barrel for talent."

Computers

Soft hardware

For years the Stanford Research Institute has been studying ways of organizing integrated circuits in standardized arrays that could be used as computer building blocks. Theory may soon become practice with a plan to program the functions of IC arrays by external electrical signals.

The institute is now seeking funds to fabricate experimental computers with arrays. A 64-cell model array was designed by Sven Wahlstrom of the institute's computer techniques lab. Each cell will have a working structure, or "base," of 13 logic gates, plus 13 flip-flops that will be switched on or off by programing signals to control data flow through the arrays and processing by the logic circuitry.

One cell, for example, might be set up as a NAND gate with any number of inputs up to seven. Several cells would then be combined to form a subsystem, such as an adder. The flip-flop could later be switched by a new program to form another type of logic function, or the other functions could be programed into duplicate arrays.

In the past, the institute's scientists have concentrated on cellular arrays organized by cutting or adding wiring, an approach that resembles the methods IC manufacturers are now using to make large-scale arrays. The institute has also studied such techniques for altering arrays as shining light through a mask onto photoconductive switches in the array. But the new design is the most flexible yet

—the array's function can be controlled through only two leads.

MOS for more cells. Wahlstrom and an associate, Bruce Clark, have decided to use metal-oxide-semiconductor circuitry. Layout is simple, Clark explains, and the small size of MOS devices allows large arrays—probably larger than 64 cells per chip in the future. Several semiconductor companies near the Menlo Park, Calif., lab have checked the design and found it feasible for production, Wahlstrom says. Clock cycle will be 2 megahertz, slower than most logic circuitry but fast enough for good computers.

Single-chip arrays are needed to fit the building-block concept. If mass-produced, the blocks would be far less expensive than custom arrays made with fixed wiring, Wahlstrom notes; custom arrays can cost as much as $30,000, depending on the number of computers made. Wahlstrom thinks the standardized arrays might cost as little as 5% as much as custom arrays, though over-all systems savings wouldn't be that great. If fewer than 500 computers were built in a production run, the savings would be significant, he says.

Programs for chips. Programing the building blocks would add little to system design costs, Wahlstrom believes. As the computer is designed, the logic designers would list cell logic functions and record them in code on magnetic tape. When the computer is turned on, the tape would be the initial input to the computer, setting up the functions.

Because logic IC's require power to retain switch positions, the program tape would have to be rerun each time the computer is turned off and on, or standby power would have to be provided by a battery during the time the computer is turned off.

The control circuits would operate like an X-Y switching matrix, using one set of input signals for X and another for Y. These signals would enter the array as serial bit streams and would be passed on to the cells by a cluster of input circuits at one corner of the chip. They initially go to the cell in the corner of the chip farthest from the input. That cell decodes the signals that set its switches, and this decoding and switching process then works back, cell by cell, to the input. Clear paths for reprograming signals can be left in the array.

Communications

Phone-a-train

Before the year is out, rail travelers will be able to make telephone calls while zipping along at speeds of up to 160 miles an hour from New York City to Washington, D.C. Telephone booths are being installed on Budd Co.-built cars to be put into service by the Pennsylvania Railroad in the first test of advanced data links planned for rapid-transit systems [Electronics, Jan. 23, p. 59].

Expected to start in October, the test will be one in a year-long series of Northeast Corridor demonstrations sponsored by the Office of High-Speed Ground Transportation (soon to become part of the newly formed Department of Transportation). The Northeast Corridor is the high-traffic-density sector from Boston to Washington, where improved rail service is sought.

The Pennsy, prime contractor for the New York-to-Washington test run, will use 30 electric-powered parlor and snack-bar cars equipped for phone service — actually, a radio-telephone setup.

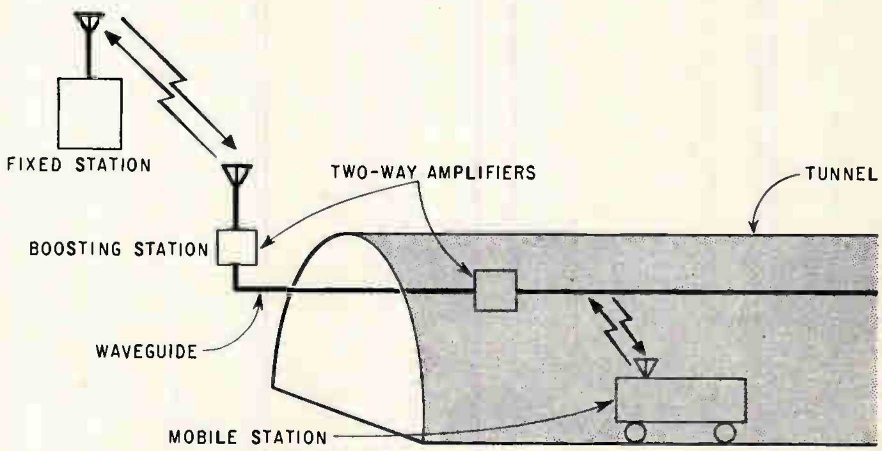
No cross talk. The American Telephone & Telegraph Co. will provide the radio-telephone service. Sixteen Government frequencies—8 mobile and 8 wayside—in the 400-megahertz band will be used. Each channel will be 100 kilohertz wide, and a 1-Mhz separation between transmit and receive bands will prevent cross-talk.

Fifty-watt transmitters and receivers will be included on the telephone-equipped cars. There will be nine wayside stations, each with a 300-watt transmitter, a receiver and an antenna. These stations will be from 35 to 40 miles apart and will link the mobile equipment with a central operator in Philadelphia.

Down the tracks. As a train nears the range limit of the wayside transmitter carrying a signal, a wayside coil—essentially a magnetic triggering device—will automatically shift the signal at the same frequency to the next wayside station.

The General Electric Co. is providing the mobile equipment and Motorola Inc. is making the wayside station gear, both as AT&T subcontractors. Bell Telephone Laboratories, an AT&T subsidiary, is to supply the amplifiers and waveguides to carry signals through the two tunnels near the Baltimore terminal.

A "leaky" waveguide consisting of two parallel wires is expected to overcome the problem of signal attenuation in the Baltimore tun-



Passengers will make phone calls from trains—even while under a tunnel.

nels. Two-way amplifiers may be placed along the waveguide as needed, and a two-way amplifier at the tunnel portals will boost the signal for relay either to the train or a wayside station.

A communications consultant estimates the cost of the mobile and wayside hardware at between $1 million and $1.5 million.

Routing. To make a call, a passenger deposits a coin in the pay phone to reach a Philadelphia operator who can connect him with any phone system in the country. Incoming calls will also be routed through the Philadelphia system.

Amplitude-modulated voice signals generated at the telephone handset are converted into frequency-modulated, single-sideband signals before reaching the train transmitter. The transmitter relays the signals to a wayside station; from there they go by land line to Philadelphia and are converted back to a-m at the switchboard. Similarly, incoming signals are converted to f-m at Philadelphia and sent by wire to a wayside station that beams them to a train. They are converted to a-m after reception.

Manufacturing

Testing on the run

Sylvania Electric Products Inc. is betting a half-million dollars that production volume of monolithic integrated circuits has reached a point where automatic in-line testing and sorting will pay off in reliability and orders.

Sylvania, a subsidiary of the General Telephone & Electronics Corp., has put the $500,000 into a computer-controlled system now undergoing final tests at its semiconductor division headquarters in Woburn, Mass. Two more systems are in the works—one is to be installed in May.

Called Mr. Atomic, for multiple rapid automatic test of monolithic integrated circuits, the Sylvania system is the industry's first automatic in-line tester-sorter. It will be used on Sylvania's entire circuit production output. Within the next month, the division will also install a commercially produced automatic probe for testing dice prior to assembly.

The market push. These are part of a quadrupling of Sylvania's IC facilities since August 1964, when Alvin B. Phillips left Motorola Inc. to become the general manager of the integrated circuit operation at Sylvania.

Phillips is setting his sights on third or fourth place in IC production within the next year. Presently, the company ranks about fifth or sixth. Phillips' optimism is based on the 100% testing of d-c parameters at four temperatures, plus a-c switching tests at room temperature. "This would be close to impossible without Mr. Atomic," he says.

Mr. Atomic's four temperature-controlled d-c test chambers and one switching test station are designed in-line with an automatic mechanical feed and regulated by a digital computer. An operator leads the circuits into plastic pallets, which take either TO-5's, flat packs or dual in-line plug-in packages. The dispensing rack presents a new circuit to the tester every 2.2 seconds. It takes a circuit 25 minutes to go through the entire system. During that time, 60 d-c characteristics are probed in each of the temperature chambers and 20 a-c tests are made at room temperature, for a total of 260 tests.

Circuit warmer. As each circuit enters the first chamber, with a 75° C ambient temperature, it is automatically inserted into a wheel-type holding device, designed in such a way that the circuit travels 180° to the test position. The time required to reach this point insures that the chip, case, and junction will have stabilized at the test temperature. Two probes contact each of the 14 leads on the package, one is the test probe and the other a sensor to signal the system that electrical contact has been established. A circuit that fails this contact-sensing test is automatically sorted into a bin for future reinsertion.

The circuits move on to other chambers of 125°C and −55°C. The computer memory stores the results obtained at each temperature.

After completion of d-c tests, the IC is moved to the fifth test station for the switching tests. Here, as in d-c testing, the circuit is "worse case" tested. Rise time, fall time, turn-on delay, and turn-off delay are all verified to each circuit's specification.

After the switching test, the circuit's performance is reviewed by the computer and a decision is made on its limits. The circuit then goes into one of 20 sorting bins where it is stored until removed by the machine operator.

Because the system can't handle all the a-c tests, some tests are made off-line. This is particularly true for J-K flip-flops, where from 30 to 35 a-c tests are required. According to John C. Blackie, engineer in charge of test equipment, as much as 25% of all a-c testing is done off-line.

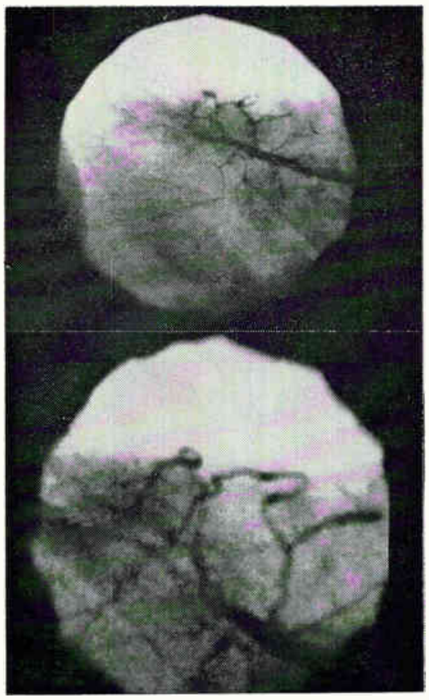
In the system, 700 circuits at a time are run through the machine and each is allocated a slot in the computer memory. To reduce the amount of information the computer has to retain, the test limits are divided into performance bands. The memory keeps track of the bands and sorts the circuits accordingly into groups of devices that are suited for specific applications.

Computer control. "The bands are adequate for sorting," says Blackie, "but the computer keeps other quality-control types of information that can be read out."

The second Mr. Atomic will be a copy of the first. But No. 3 is being designed with a different concept: to test functions instead of circuit parameters. "It will ripple through a truth table in maybe 100 microseconds," says Blackie, "moving through all possible logic combinations."

Parameter testing, he points out, is limited. But a simple gate can have as many as 250 possible logic combinations. "We'll hit the circuit with most all of them, and any leakage is bound to show up," says Blackie.

Functional tests will require



Researchers study X-ray motion picture taken with new Picker equipment. Image, of main trunk of a coronary artery, is magnified three times (photo on left). Top photo shows same section enlarged only 1½ times, the best that could be achieved previously.

ing on and off the primary or secondary power but Picker uses a grid effect. A grid control turns the electron stream on and off with square-wave pulses, resulting in a higher-energy X ray leading to shorter exposure times. In fact, says Vahjan, the exposure time can be as low as 0.5 millisecond.

The X-ray's square-wave control is pulse-width modulated. To operate, the set is adjusted for the density required on the film. The amount of tissue to be penetrated by the X rays determines the exposure time and therefore the total energy of the beam. This closed-loop control provides a uniform density on the film independent of the patient or his position.

The next step, says Dr. Zimmerman, will be to perfect the equipment so surgeons will be able to take X rays as they operate and get an almost instantaneous view of their work.

Employment

Raiding the Pentagon

Back in the 1950's, the Defense Department and the high-paying "think factories" it employs raided college campuses for gifted professors. The lure was money. But in recent years the pendulum has swung the other way. Using the same bait—money—the nation's colleges have been busy raiding the Pentagon and its "think tanks."

Faculty pay scales have risen sharply in the past few years and, as an added incentive, lucrative consultant positions for moonlighting professors have been on the upswing. The result: a professor earning $25,000 a year—which is on a par with a top-rated think-tank researcher—is almost sure to be able to pick up another $15,000 to $20,000 as a consultant.

Eye for an eye. Among the first to feel the squeeze are the same defense agencies and semi-independent research groups which raided the campuses a decade ago. And those most difficult to keep are the personnel trained in systems analysis and computer technology.

Although the greatest competition is coming from colleges, industry and other Government agencies—where the systems approach is becoming increasingly fashionable—also are grabbing their share of scientists whom the Pentagon once had merely for the asking.

Examples of what has been happening:

- The deputy directorship of the Pentagon's Advanced Research Projects Agency—hardly a sinecure or a dead-end to a scientific career—went unfilled for six months before the Pentagon latched on to Peter Franken, a laser expert, last month.
- The Institute for Defense Analyses reports that top scientists and engineers are rejecting its job offers 30% to 40% more often than was the case a year ago.

Says Gordon MacDonald, the institute's vice president for research: "We're finding an increased reluctance on the part of first-rate people to commit themselves to defense problems, at a time when we very badly need their help on major systems decisions being made."

Among the institute's projects are antiballistic missile defense and the new generation of intercontinental ballistic missiles.

MacDonald and Lawrence J. Henderson Jr., vice president in charge of the Rand Corp.'s Washington office, cheer the keen competition from universities even though it poses problems. They feel those returning to the campuses from defense and the think tanks will show the schools the need to train more systems men, thus eventually raising the supply to meet the demand.

Moral stand. Do their objections

Up to 72% smaller than MIL-C-25C paper capacitors!

MIL-C-19978B/2 reduces capacitor size drastically—down to .125" diameter by ½" long. At the same time electrical characteristics are upgraded sharply.

MIL-C-19978B/2 hermetically sealed mylar* capacitors are available now from TRW with immediate delivery in production quantities.

- REDUCED SIZE—35% to 72% smaller than MIL-C-25C.
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- CAPACITANCE CHOICE—.001 mfd through 10.0 mfd.
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These capacitors—when designated TRW Type 693—are available to high reliability specifications, and in custom capacitances and tolerances beyond the range of MIL-C-19978B/2.

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TRW CAPACITORS

Circle 51 on reader service card

program your Tektronix Type 561A or 564 oscilloscope for DC-to-15 MHz applications

Here's new convenience for many Type 561A or 564 applications.

You can program the Tektronix oscilloscope for 6 measurement setups—using the new Type 263 Programmer and the Types 3A5 and 3B5 Automatic/Programmable Plug-In Units.

PUSHBUTTON PROGRAMMING

In this mode, both plug-ins can be programmed using the Type 263 Programmer, which accepts up to 6 plug-in type program cards. Each program card, after initial set-up, establishes the plug-in control functions required for a particular test or measurement . . . with actual measurements made conveniently from the CRT display, as usual. Any number of programmers can be cascaded for applications requiring pushbutton control of more than six measurement set-ups. In REMOTE PROGRAMMING mode, the deflection factor is 10 mV/div to 50 V/div and sweep range is 5 s/div to 10 ns/div.

Programmable Functions: **from Type 3A5**—V/div, 10X probe indication, and AC, AC Trace Stabilized, or DC coupling, by program card jumper connection . . . vertical positioning by program card potentiometer setting; **from Type 3B5**—Time/div, X10 or X100 magnifier, trigger mode with coupling, and trigger slope, by program card jumper connection . . . horizontal positioning, trigger level, and magnifier delay, by program card potentiometer setting.

AUTOMATIC SEEKING

In this mode upon SEEK command from the probe or the plug-ins, the oscilloscope automatically presents an optimum display. The SEEK command to the plug-in units automatically adjusts the time and amplitude settings and automatically checks the trigger logic—switching to auto trigger mode, if not correctly triggered, to present a stable display whenever possible. Indicators on the plug-ins light automatically to show the time and amplitude settings. Measurements can then be made quickly and accurately from the CRT display. In AUTOMATIC SEEKING mode, the deflection factor is 10 mV/div to 50 V/div and sweep range is 5 s/div to 0.1 μs/div.

MANUAL OPERATION

In this mode, both plug-ins are controlled conventionally. Indicators on the plug-ins show the time and amplitude settings. In MANUAL OPERATION mode, deflection factor is 1 mV/div to 50 V/div (5 MHz bandwidth at 1, 2 or 5 mV/div and 15 MHz at 10 mV/div to 50V div) and sweep range is 5 s/div to 10 ns/div.

Type 263 Programmer (complete with 6 program cards)	$325
Type 3A5 Automatic/Programmable Amplifier Unit	$760
Type 3B5 Automatic/Programmable Time-Base Unit	$890

Oscilloscopes which accept both Automatic/Programmable Plug-Ins:

Type 561A Oscilloscope	$500
Type RM561A Oscilloscope	$550
Type 564 Storage Oscilloscope	$875
Type RM564 Storage Oscilloscope	$960

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Circle 53 on reader service card

If your blip is a blooper, you'll know it in 10 seconds.

Once you start using Polaroid Land film, you'll wonder how you and your oscilloscope ever got along without it.

In 10 seconds, you get an on-the-spot record. You can study it, attach it to a report, send it as a test record along with a product shipment, or file it for future reference.

You have a choice of 5 films for oscilloscope recording.

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

And for extremely high-speed oscilloscope recording, there's Polaroid PolaScope Land film [a roll film, Type 410].

It has an A.S.A. equivalent rating of 10,000. It can discover traces too fleeting for the human eye: such as a scintillation pulse with a rise time of less than 3 nanoseconds.

Because these films are so sensitive, you can use small camera apertures and low-intensity settings. Every shot is a sharp, high-contrast image that's easy to read.

To put these films to work on your scope, you need a camera equipped with a Polaroid Land Camera Back.

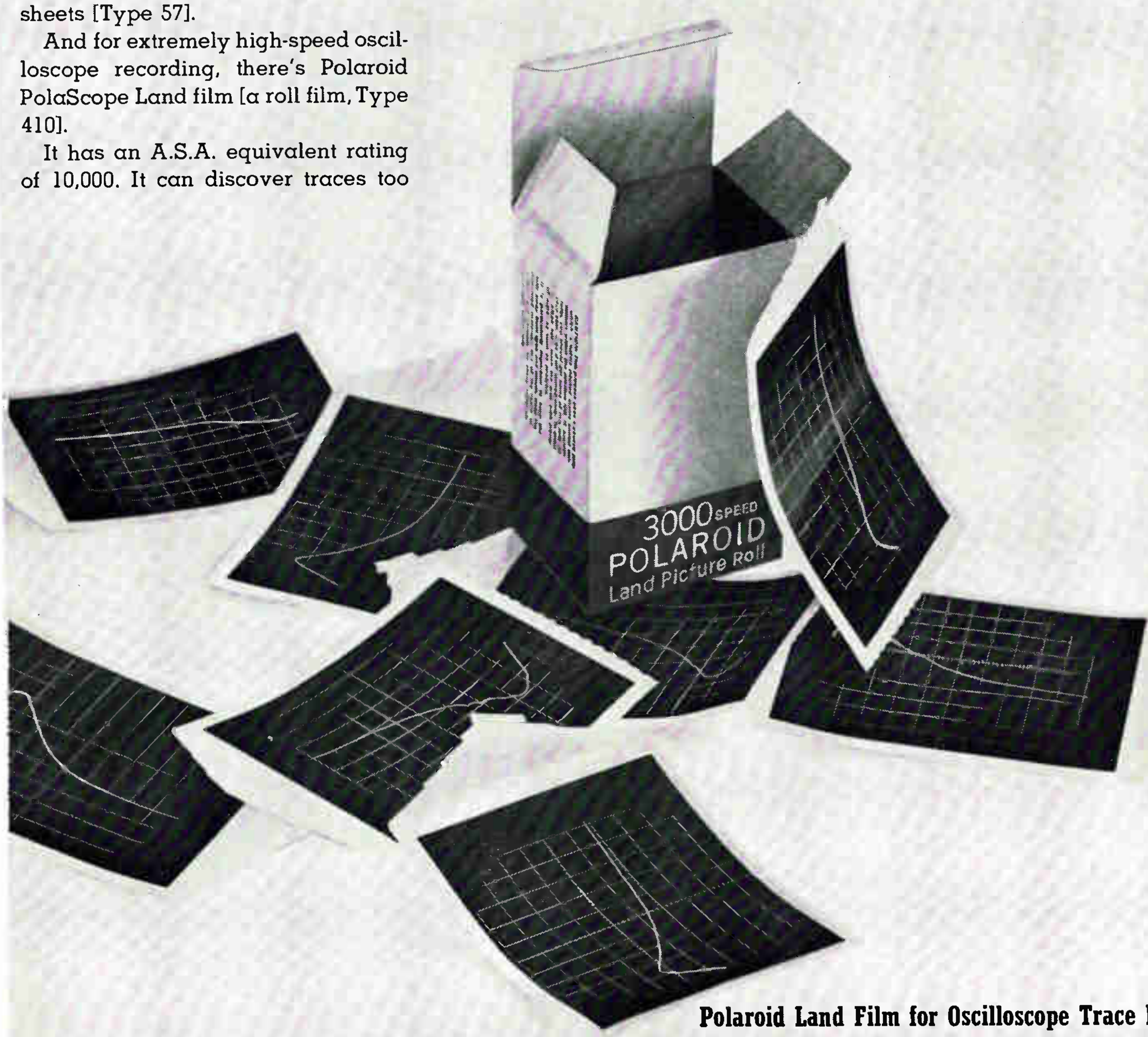
Most oscilloscope camera manufacturers have one.

For instance: Analab, BNK Associates, Coleman Engineering, EG&G, Fairchild, General Atronics, Hewlett-Packard and Tektronix.

You can get the full story by writing to Polaroid Corporation, Technical Sales Department, Cambridge, Massachusetts 02139 [or directly to the manufacturers mentioned above].

About the only thing we can't tell you is how to keep your blips from being bloopers.

"Polaroid" and "PolaScope"®



Polaroid Land Film for Oscilloscope Trace Recording.

Tony DeBerardis likes green eyes, freckles and buck teeth...but he just can't stand crooked knees.

Tony will be the first to admit that not everybody likes buck teeth.

Freckles, yes. Green eyes? O.K. . . .

But buck teeth . . . ?

When it comes to knees, though, Tony likes them the same way you do. Because, when you're Product Assurance Manager at Unitrode you *know:* Either your diodes have sharp, crisp knees, or you simply don't have the ability that's built into every Unitrode to handle avalanche current, whether surge or continuous.

So Tony's got to be fussy. He knows controlled avalanche is just one of the qualities he's responsible for assuring. And when you're testing diodes that are designed to deliver an entirely new level of performance and reliability, you've got some "assuring" to do.

Of course, *entirely new* is the key phrase there. And it's easy enough to say. But when we say it, we mean just that.

Because the Unitrode diode was developed from the ground up. With entirely new design. With entirely new methods of construction. The metallurgical bond that joins the silicon between the two terminal pins 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.

Because the pins are bonded over the full face of the silicon die, heat due to surge is carried away quickly from the silicon into the terminal pins. So even the smallest Unitrode diode can take a surge of 600 amps for one microsecond, and the big ones can take 4000 amps.

Nevertheless, we try not to ever forget that people like Tony DeBerardis are more important than any process. After all, they're the reason we can virtually guarantee: Unitrodes don't fail. Ever.

Maybe the work your company is doing could profit from diodes with this kind of reliability. It doesn't cost anything to find out.

We'll be glad to send you complete information and samples. We're at 580 Pleasant St., Watertown, Mass. 02172. Telephone (617) 926-0404. TWX (710) 327-1296.

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Circle 57 on reader service card

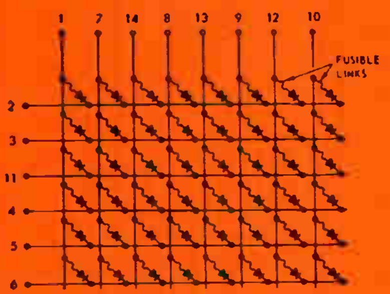
Radiation's popular dielectrically isolated matrices provide an unusual degree of flexibility. (1) RM-30 Matrices contain 48 active devices per chip. (2) A fusible link in series with each diode permits unlimited matrix patterns to be formed. And (3), circuits can be combined to produce an almost infinite variety of size configurations.

In addition to flexibility, Radiation 6 x 8 Matrices offer the increased reliability of monolithic construction. Size and weight requirements are slashed through reduced package count. Further, cost of matching, testing and assembly of discrete diodes is eliminated.

Production has been expanded to guarantee fast shipment of matrices "customized" to your exact requirements. In fact, most orders are shipped on a 24-hour basis.

A new low-cost RM-134 design in a ceramic dual in-line package is available in volume at a unit price of less than $5.00—and can be supplied to any code configuration requested.

Write for data sheets on the entire line of Radiation Monolithic Diode Matrices. *Worst-case limits* are included, as well as all information required by design engineers. We'll also be glad to supply our new manual, Monolithic Diode Matrix Technical Information and Applications. For your copy, request publication number RDM-T01/A01 from our Melbourne, Florida office.



BEFORE "CUSTOMIZING"

Radiation 6 x 8 Monolithic Diode Matrices* (typical limits)

Characteristic	Symbol	RM-30	RM-31	RM-34 RM-134†	Unit	Test conditions ($T_A = +25°C$)
Forward drop	V_F	1.0 0.7	1.3 0.75	1.0 0.7	V	$I_F = 20$ mA $I_F = 1$ mA
Reverse breakdown	BV_R	60	60	50	V	$I_R = 100\,\mu A$
Reverse current	I_R	7	25	70	nA	$V_R = 25$ V
Reverse recovery	t_{rr}	7	11	30	ns	$I_F = 10$ mA to $I_R = 10$ mA
Crosspoint capacitance	C_{cp}	1.9	1.9	2.0	pF	$V_R = 5$ V; f = 1 MHz
Coupling coefficient	I_{CL}	20	20	20	μA	See data sheet

*Supplied in T0-84 packages. †Supplied in ceramic dual in-line package.

All Radiation integrated circuits are dielectrically isolated.

RADIATION INCORPORATED

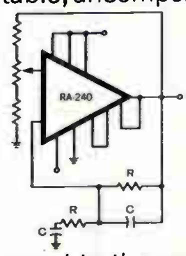
MICROELECTRONICS DIVISION

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.EL 03, Melbourne, Florida (305) 723-1511, ext. 554

Circle 62 on reader service card

State of the design art

The flexibility of Radiation IC Operational Amplifiers is illustrated by the circuit below. Here, the RA-240 is used in the design of a highly stable, uncompensated Wien bridge oscillator which is virtually unaffected by temperature variations.



Using the RA-240, engineers may select a wide range of RC combinations without regard to the active element of the circuit. Frequency of oscillation (up to 500 kHz) is defined by:

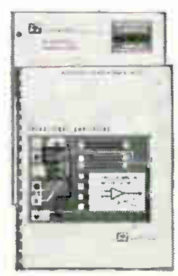
$$f_o = \frac{1}{2\pi RC}$$

Stability and versatility of our Radiation Operational Amplifiers is made possible through advanced dielectric isolation and thin film over oxide technology. Further information will appear in our ELECTRONIC DESIGN advertisement of March 15.

Radiation's line of IC operational amplifiers opens the door for integration of systems requiring high-performance analog circuitry. These amplifiers provide the ideal 6 dB per octave high frequency roll-off required for unconditional stability in operational feedback connections *without* use of external compensation . . . even in the critical unity gain configuration.

Three types are immediately available in T0-84 flat packages: general-purpose, broadband, and high-gain amplifiers.

Write for data sheets. *Worst-case limits* are included, as well as all necessary design information. We'll also be glad to send you our new manual, Operational Amplifier Technical Information and Applications, ROA-T01/A01. Contact our Melbourne, Florida office for your copy.



Circle 63 on reader service card

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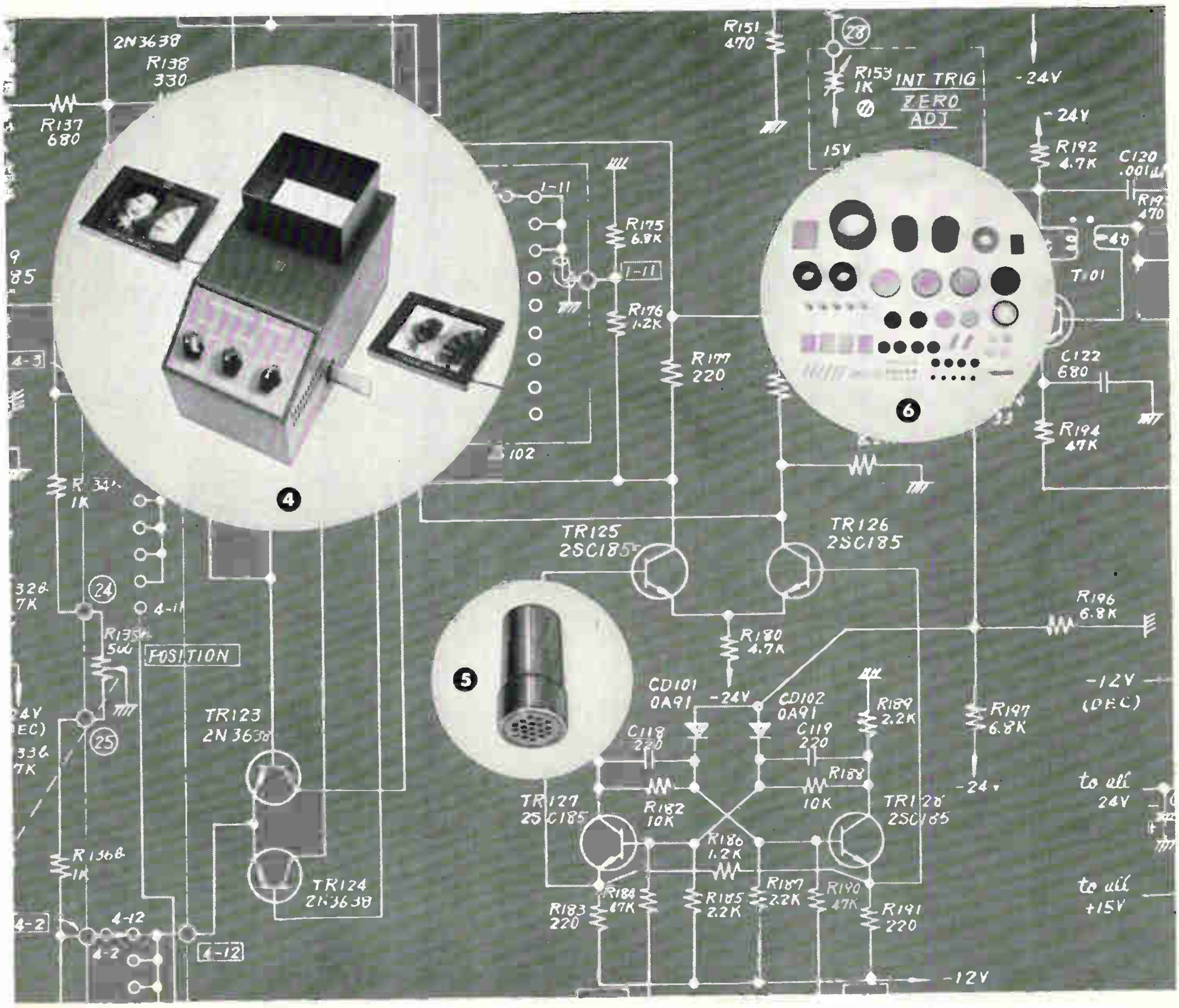


Washington Newsletter

March 6, 1967

GE wins contract to develop a radar for Nike-X system

A contract to develop one of the five Nike-X antiballistic missile system radars has been won by the General Electric Co. The award will be announced after price negotiations are completed between GE and the prime contractor, Western Electric Co., the manufacturing arm of AT&T. GE will develop the phased-array perimeter-acquisition radar that will be used for long-range area defense if the antimissile system is deployed. The company already has a contract for the beam-forming subsystem of the Nike-X multifunction array radar.

GE edged out Bendix Corp.'s Radio division in the competition for the latest order, although Bendix was the only bidder to have built a prototype—the AN/FPS-85 at Eglin Air Force Base [Electronics, June 27, 1966, p. 133]. Bendix opted for the FPS-85 frequency in its bid, though Western Electric had asked for a different frequency. However, after GE was selected, Western Electric is said to have changed the perimeter-acquisition radar frequency to conform with the Bendix FPS-85.

Burroughs submits low bid for FAA's digitizer subsystem

Burroughs Corp. is the apparent winner of a contract to develop and build the common-digitizer portion of the Federal Aviation Administration's National Airspace System. The company was low bidder for the radar and beacon processing subsystem for the semiautomated traffic control program, a contract that will total either $16 million or $22 million, depending on the number of units initially ordered. The award, to be announced shortly by the FAA, will cover production of either 111 or 177 digitizers.

FCC will test use of tv frequencies by radio operators

The Federal Communications Commission will begin tests next month to see if it can assign commercial television frequencies to mobile-radio operators. The FCC is confident the feasibility trials will show that these new users can take over unused tv channels in the vhf area.

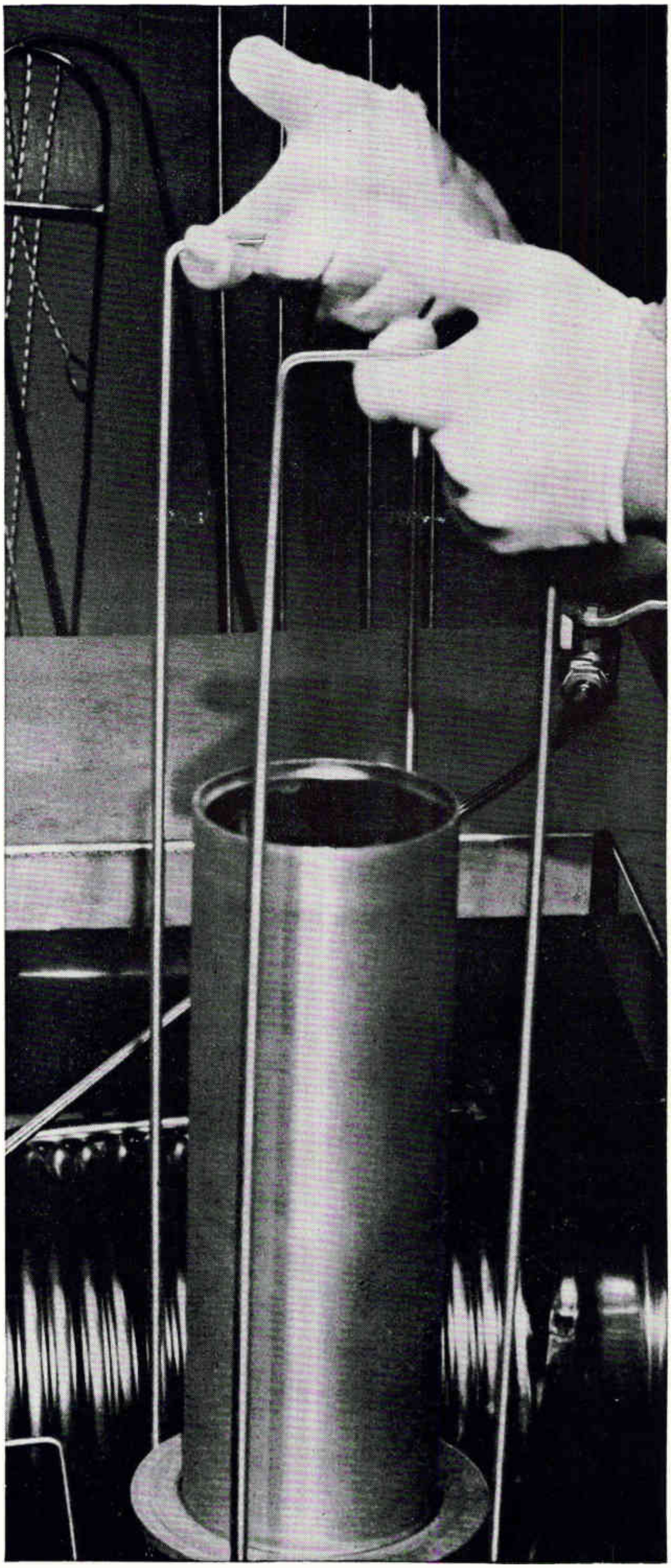
In the test, transmitters at various locations around Washington, D.C., will send 25-kilohertz-bandwidth signals over unused Channel 6 (82 to 88 megahertz). If the test transmissions don't interfere with tv reception on Channels 5 and 7, the FCC will be able to allocate the frequencies to mobile-radio users in Washington. In order to make similar assignments in other cities, however, the agency would have to hold new tests to gauge local conditions.

Television broadcasters oppose such sharing, maintaining that they were given exclusive use of the spectrum they were allocated.

IBM aims to make space-tv lasers of gallium arsenide

Researchers at IBM's Federal Systems division are working to develop arrays of gallium-arsenide injection lasers for a system to transmit real-time tv pictures from a spacecraft to earth at interplanetary distances. Other work on a laser link for NASA has incorporated such gas devices as the Hughes Aircraft Co.'s ionized argon laser and Sylvania Electric Products Inc.'s carbon-dioxide laser [Electronics, Feb. 20, 1967, p. 25].

IBM's quantum electronics department at Yorktown Heights, N.Y., has been studying ways to phase a number of gallium arsenide lasers to yield a 10-watt data link able to transmit a million bits per second. Researchers have succeeded in phasing the lasers—just how many IBM won't say—



TEST BOARD BEFORE...

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New Solutec system cleans PCB's faster, more economically than ultrasonics or vapor degreasing

You can improve your productivity, cut your investment in cleaning equipment and get more uniform results by switching to the Solutec method of printed circuit board cleaning. It's a simple process, requiring only one cleaning solution and generating no fumes, films or toxicity problems.

If it takes you more than three minutes to clean a board — whether you use ultrasonic, vapor degreasing or manual methods — you need more information about the Solutec "hydrogen scrubbing" system! It removes tenacious contaminants by generating hydrogen bubbles on or near the surfaces of parts being cleaned. In the presence of "Hydrochemex," a proprietary activated alkaline detergent, the bubbles actually scrub surfaces clean.

How clean? Clean enough to accept electroless copper plating after less than three minutes of processing. The Solutec system also gives you excellent wetting action for subsequent soldering operations.

In addition to the scrubber and its detergent solution, Solutec offers a complete line of board processing chemicals — deoxidizers, strippers and electroless copper solutions. Start cutting your board cleaning time and cost today: send this coupon for more information.

THE SOLUTEC Model 900 is a bench-type hydrogen scrubber. The device is also available in larger capacities for production line use.

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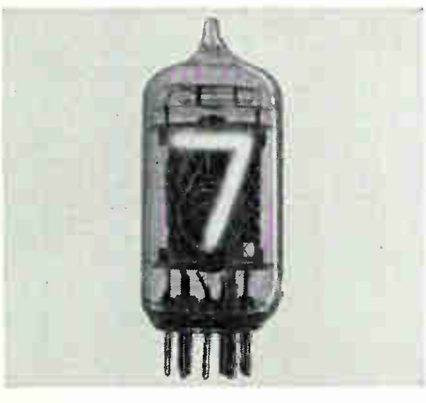
New Raytheon Projectoray* Tube produces more than double the light output of standard projection-type cathode ray tubes. The tube's light output is 30,000 foot lamberts, which results in a light level of 15-foot lamberts on a 3′ x 4′ lenticular screen.

The tube's expected minimum operating life is 500 hours — 20 times the life of a standard projection tube.

The Projectoray's high light output and long life are due to its novel design. The design incorporates liquid cooling of the phosphor backplate. This allows the phosphor to be energized with a very intense electron beam. At high beam levels, very high peak light output is obtained. The light image is projected through a 5″ optical window in the face of the tube. The electron gun is set at an angle to the phosphor and the deflection system compensates for keystone effects.

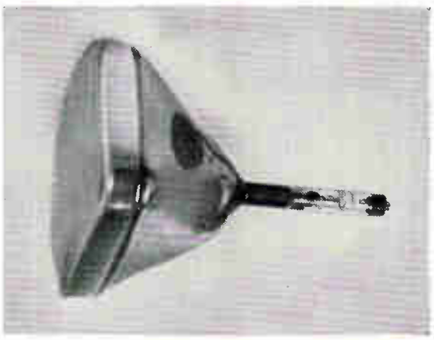


Datavue* Side-View Tubes. New Type CK8650, with numerals close to the front, permits wide-angle viewing. These side-view, in-line visual readout tubes display single numerals 0 through 9 or preselected symbols such as + and − signs. Their 5/8″-high characters are easily read from a distance of 30 feet. Less than $5 each in 500 lots, they also cost less to use because the bezel and filter assembly can be eliminated and because their mating sockets are inexpensive.

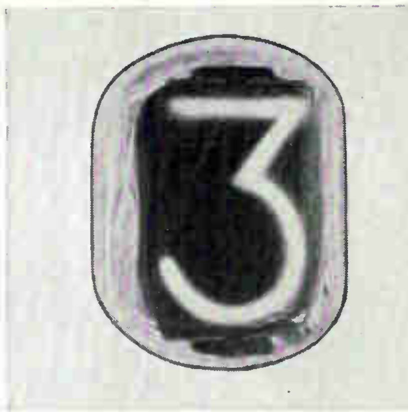
Recording Storage Tubes. The miniature tubes shown here are Raytheon's single-gun (CK1516) and dual-gun (CK1519). They provide high resolution, long storage, and fast erase capability.

Raytheon electronic input-output storage devices feature the above capabilities and immediate readout. Information can be written and stored by sequential techniques or by random-access writing. Complete, gradual or selective erasure is possible.

Raytheon storage tubes are readily available for applications in radar scan conversion, slow-down video, signal processing, signal enhancement, time delay, and stop motion.



Dataray* Cathode Ray Tubes. Raytheon makes a wide range of industrial CRTs —including special types—in screen sizes from 7″ to 24″. Electrostatic, magnetic, and combination deflection types are available for writing alphanumeric characters while raster scanning. All standard phosphors are available and specific design requirements can be met. Combination deflection or "diddle plate" types include CK1395P (24″ rectangular tube), CK1400P (21″ rectangular), and CK1406P (17″ rectangular).



Datavue* End-View Tubes. These tubes are easily read in high ambient light — do not wash out like other displays. Erroneous readings due to segment failure do **not** occur because the characters are fully formed. Raytheon Datavue End-View Tubes fit existing sockets and conform to EIA ratings. Models include round (CK8421) and rectangular (CK8422). Ultra-long-life types are designed for 200,000 hours or more of dynamic operation.

Send Reader Service Card for literature on the:

Symbolray CRT	491
Projectoray CRT	492
Datavue Indicator Tubes	493
Recording Storage Tubes	494
Dataray CRTs	495

Or call your Raytheon regional sales office. Or write to *Raytheon Company, Components Division, Quincy, Mass 02169.*

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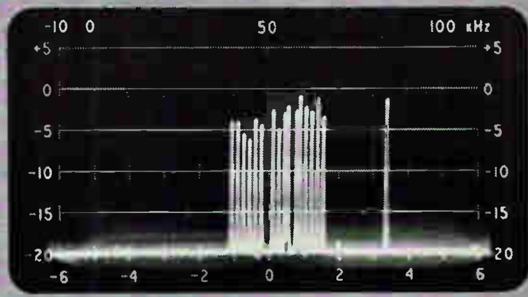
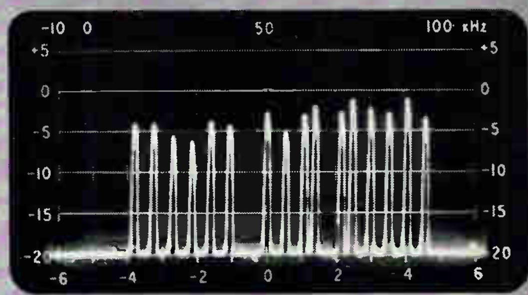
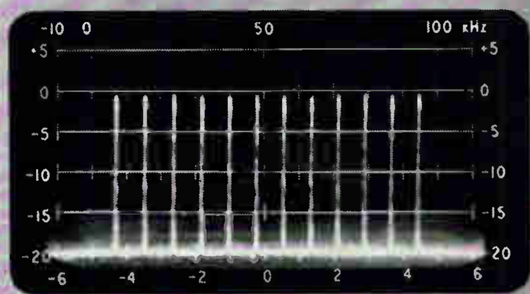


Three L-3 carrier channels shown in 12-kHz sweep width mode: teletype signals on center channel, 2600-Hz "on hook" tone on right channel, left channel idle.



Center channel above expanded to 3.6-kHz sweep width mode: 17 teletype carriers, 1 missing, 2 showing "mark space" information.



Complete N-1 carrier system shown in 120-kHz sweep width mode. Slope is 0 db, all carriers present, channels 2-13, high group.

Sierra brings to light... dark deeds in the underworld of high-density carrier systems

You'll spot them all with lightning speed on Sierra's Model 360A Spectrum Display Unit: Overload, noise, crosstalk, carrier leak. The communications disrupters!

Tracking automatically across the tuning range of a companion frequency selective voltmeter (shown above, Sierra's Model 128A), Model 360A presents an expanded view of selected frequency segments on a high-resolution, swept-band CRT display. Sweepwidths of 120 kHz or 12 kHz display thirty- or three-channel segments of the multiplex baseband. A 3.6-kHz sweep position narrows the view to one voice channel, resolving approximately 30 Hz at 3 db down from a carrier peak and 60 Hz at 40 db down. The voltmeter indicates precisely the frequency and amplitude of any displayed signals.

Price of the Model 360A is $2,450. The bulletin sheds further light on the matter. Write Sierra, 3885 Bohannon Drive, Menlo Park, California 94025.

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Fluorine is such an active element that, until 1886, it had never been successfully separated from its compounds. When isolated, it combines immediately with water, many metals and even glass. Finally Henri Moissan, a French chemist, fabricated containers of a platinum-iridium alloy, the most inert metals known. By cooling his equipment to slow down fluorine's activity, he managed to capture some free fluorine. In 1906, he received the Nobel prize in chemistry for his achievement.

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Adlake Mercury Wetted Relay — Application Data

Measurement of "Dynamic Contact Noise" for Low Level Signal Applications

Adlake AWCS 26000 Series Relay— 2 Switch Form C

In small signal applications, such as computers, telemetric systems, strain gauges, etc. generated emf. within the system's relays must be taken into account.

Dynamic Contact Noise is a "coined" phrase used to indicate an undesired generated emf. upon contact closure. It is the result of mechanical oscillation of the armature—caused by the impact of the armature on the stationary contacts — sweeping the coil flux.

Typical illustrations of this noise are shown in the oscillograms, with the relay being driven at nominal voltage in the test circuit shown below. The frequency and amplitude are integral functions of system bandwidth and coil drive conditions.

The slight ripple seen at the end of each trace is not noise, but due to resolution of test equipment and test circuit.*

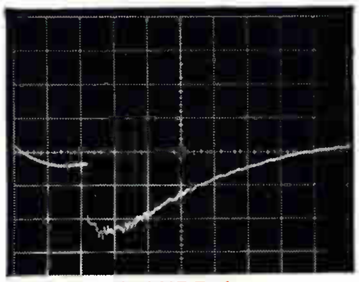


FIGURE 1

Horizontal Deflection	1.0 ms/cm
Vertical Deflection	20 μV/cm
Systems Bandwidth	.06—60 Hz.

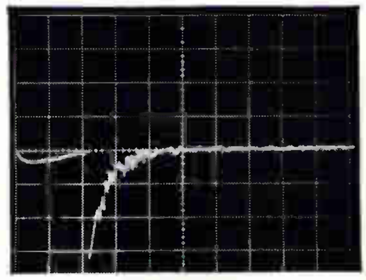


FIGURE 2

Horizontal Deflection	1.0 ms/cm
Vertical Deflection	100 μV/cm
Systems Bandwidth	.06—600 Hz.

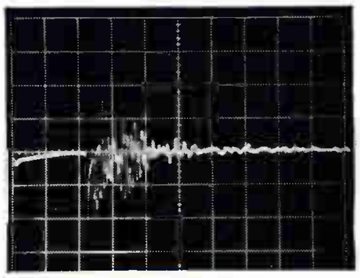


FIGURE 3

Horizontal Deflection	1.0 ms/cm
Vertical Deflection	200 μV/cm
Systems Bandwidth	.06—6K Hz.

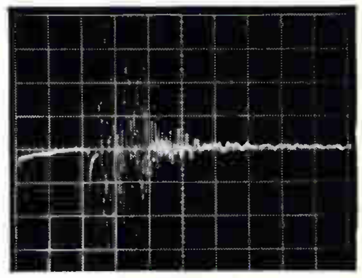
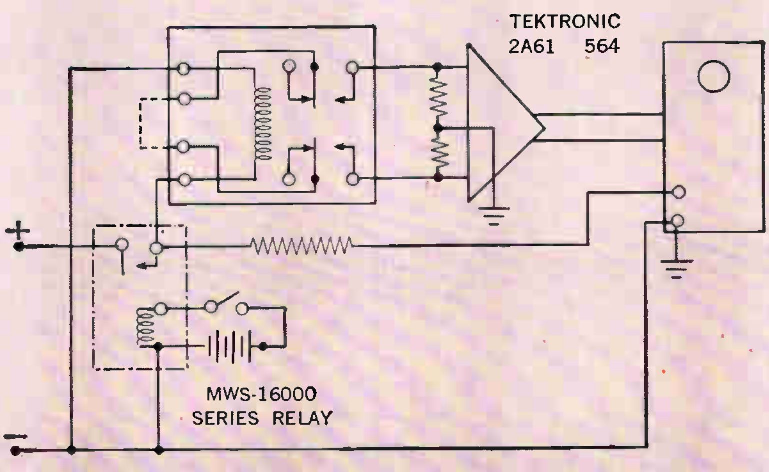


FIGURE 4

Horizontal Deflection	1.0 ms/cm
Vertical Deflection	200 μV/cm
Systems Bandwidth	.06—60K Hz.

TEST CIRCUIT



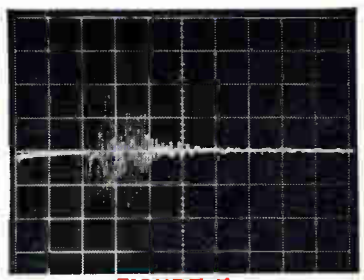


FIGURE 5

Horizontal Deflection	1.0 ms/cm
Vertical Deflection	500 μV/cm
Systems Bandwidth	.06—100K Hz.

* If you have a problem regarding relay applications to a particular system our engineering staff is ready to help you. Contact Mr. Le Roy Carlson, Chief Project Engineer.

Backed by sound research and disciplined engineering, Adlake applies the industry's broadest line of mercury displacement and mercury wetted relays to the creative solution of design circuit problems. However unique or special your application, Adlake can assist you in developing it. For prompt, personal and knowledgeable attention to your relay needs, contact the one source that is the complete source in the mercury relay field. Contact Adlake today for catalog and further information.

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Words about wines

It has occurred to us that a good product—like a good wine—gains far more renown from what its users say about it than from what its makers say about it. Therefore, in this column we eschew the temptation to discuss that over which we labor in our own vineyard, and instead bring you each month some random thoughts on the science of making wines and the art of enjoying them.

* First, a comforting thought for the wine lover who is aware of the value of the grape as a gentle tranquilizer, but who worries lest its nourishing effect on his psychical well-being is offset by any threat to his physical welfare. Rest easy. There is sound medical evidence that—among wine's many salutary effects—it may be useful in prevention or treatment of coronary problems. (But if it increases your appetite and you over-eat, that's another problem.)

* Wine-making is as old as history. You'll find more than 150 references to it in the Bible (including a number counseling its temperate use). The more recent history of wine still has a religious flavor. *Vitis vinifera*, the Old World grape, was first introduced in California—where 80% of U. S. wine is made—by the Spanish missionaries in 1769. Much wine is still produced today in monastic surroundings.

* The spirit of inquiry leads many Americans to make their own wine at home, under a law that lets heads of households make 200 gallons for personal use. It is an official tribute to wine's unique status as a food. Most of the results are so unusual they are quietly trickled down the drain after a few months. Write to us for a how-to bulletin if you have hopes of doing better.

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You will taste samples from fifteen different wineries. To obtain your free pass and program for this delightful event, contact your Union Carbide Semiconductor distributor, representative, or factory sales engineer, or stop by the Union Carbide exhibit (Booth 3J06-3J16) at the IEEE show.

Note of Interest: Whether or not you can join us for the wine tasting in New York, you are also invited to join the intellectually curious who will be following our current series of advertisements appearing each month in *Scientific American.* The first in this series is reprinted at left. (Use reader service card to request the wine bulletin offered in the advertisement.)

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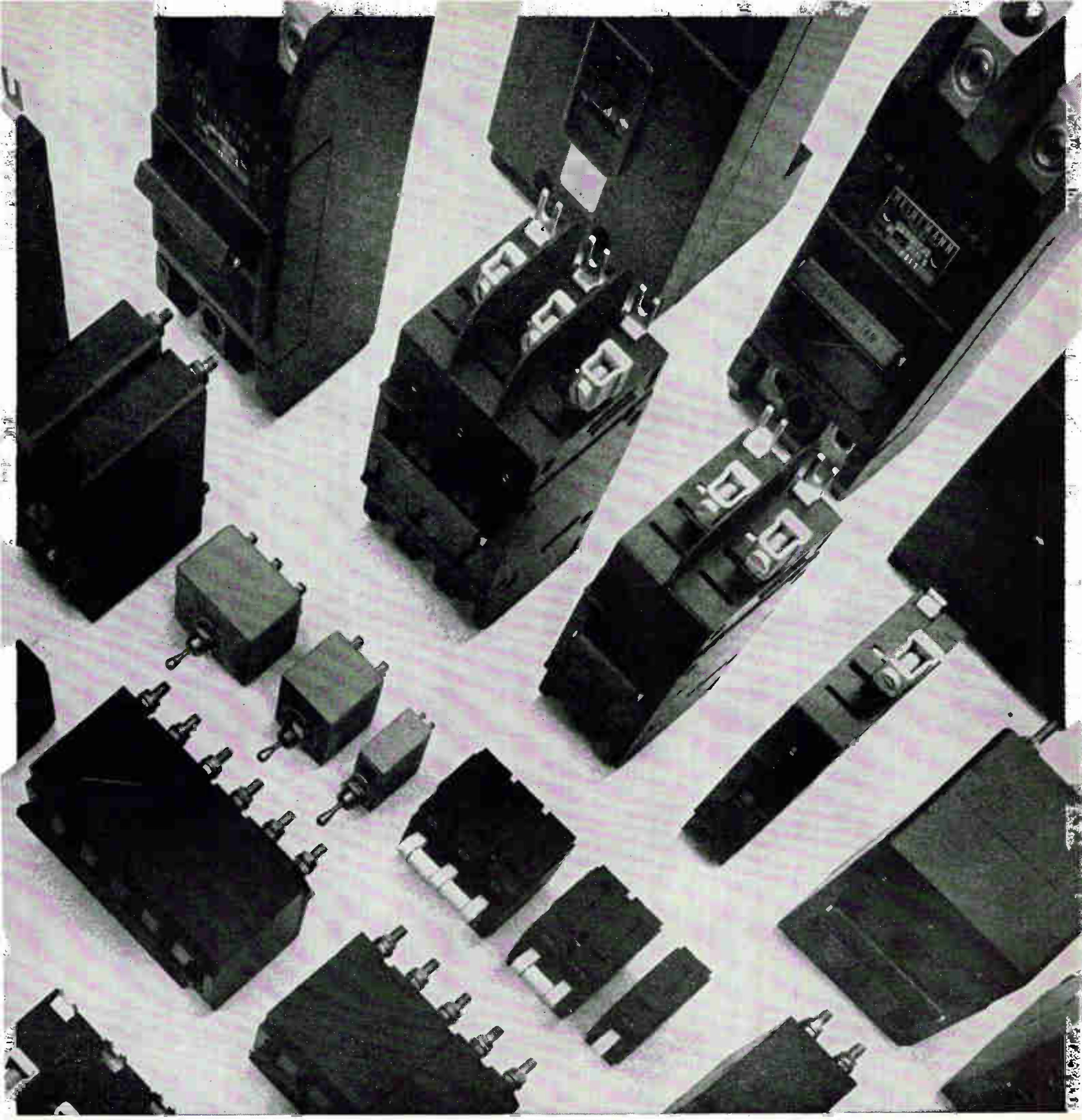

Over 60% of all Heinemann hydraulic-magnetic circuit breakers produced each year are rather odd in one way or another.

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The fact is, we have an extensive roster of options for you to work with when you want really tight overload protection. Current ratings in any integral or fractional value, from 0.010 to 225 amps. A choice of several time-delay characteristics or instantaneous trip. A selection of special-function internal circuits — relay-trip, shunt-trip, etc. A broad array of models, from one to six poles, from subminiature on up.

The cost of a job-matched Heinemann breaker will probably be a good bit less than you would expect. The reason is simple enough. 'Specials' are our specialty—60% every year.

If you've got a knotty protection requirement, get in touch with us. For a starter, try our Bulletin 302; it covers our entire line of breakers. We'll put a copy in the mail as soon as we hear from you. Heinemann Electric Company, 2626 Brunswick Pike, Trenton, N.J. 08602.

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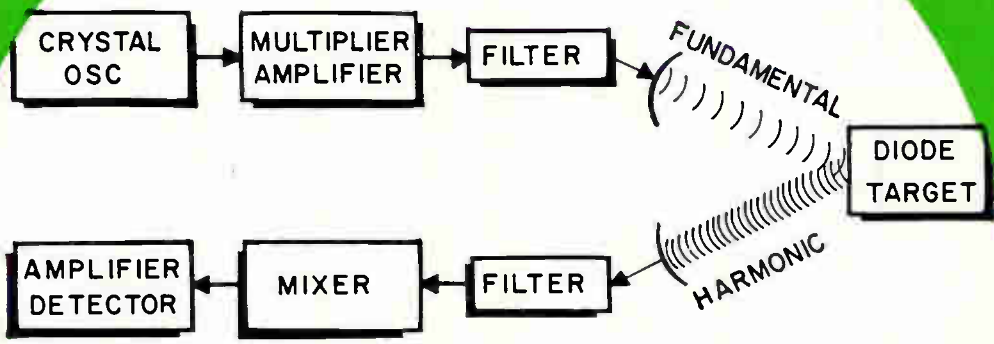

Can a diode in free space generate harmonics?

YES—and it's the basis of a new communications & navigation system from Microlab/FXR!

Everyone knows that diodes generate harmonics—in a circuit! But perhaps you didn't know that diodes can be made to do this in free space—without any attached circuitry or power source.

Microlab/FXR has applied this principle to a new Diode Interrogation, Communication and Navigation System*. This is a harmonic radar system, consisting of a Diode Exciter/Receiver plus a passive diode antenna—or a self-focusing phased array where increased range is required—either modulated or unmodulated.

This new Microlab/FXR system can thus detect and communicate with any object (or person) to which the diode is attached. Perhaps even more important, it can positively *single out and identify* any particular target from all others.

Microlab/FXR's new system can well be the answer to heretofore unyielding problems connected with air/sea navigation, flight traffic control, rescue and recovery operations, IFF systems, etc. In other areas, the system can be used for everything from automobile traffic control to aircraft blind landing systems; from bird and animal migratory studies to human medical diagnostics.

Maybe these applications whet your appetite – maybe they fit in neatly with a project you're working on– maybe they give you a new idea for something we haven't thought of. If so, you'll want more information. Just circle the Reader Service Card. Better still, write us directly, at Dept. E-61.

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*patents pending

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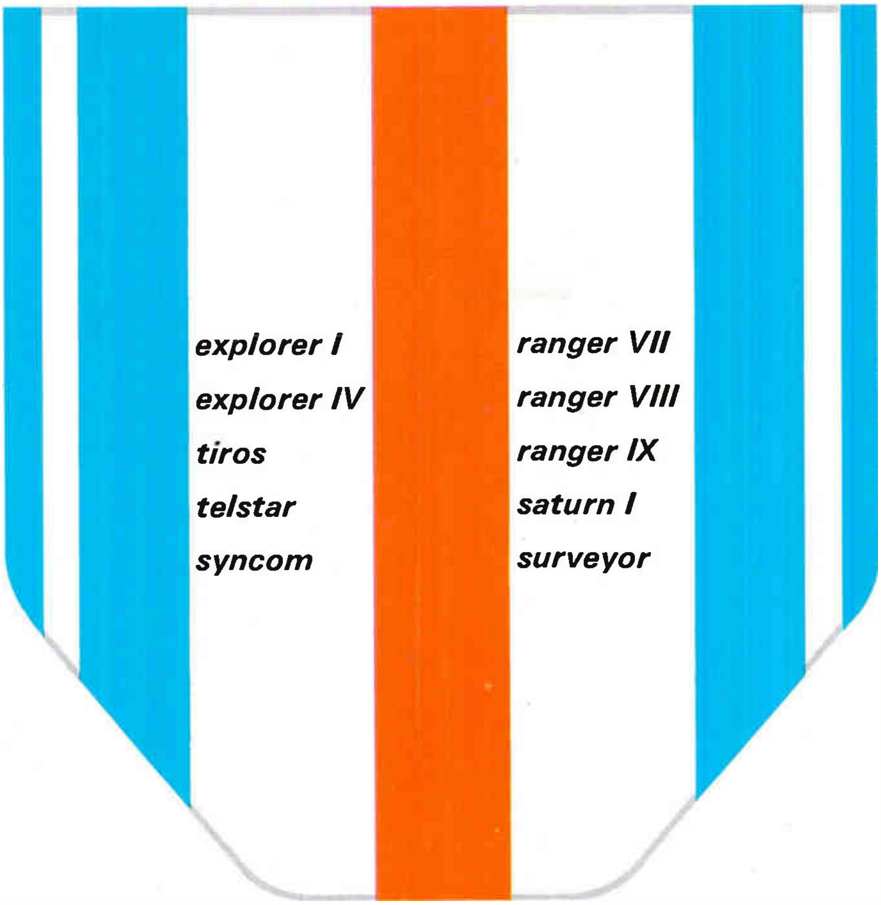

the most honored resistor in the Space Program

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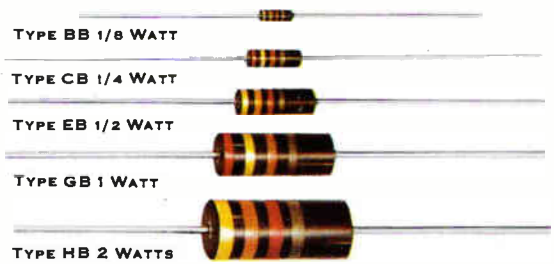
HOT MOLDED FIXED RESISTORS are available in all standard resistance values and tolerances, plus values above and below standard limits. **Shown actual size.**



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Solitron announces

A MAJOR BREAKTHROUGH in Silicon Power Transistors:

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NPN SILICON TRANSISTORS

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Featuring

- ✓ low leakage currents
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- ✓ flat gain curve
- ✓ 15 amp capabilities
- ✓ 145 Watts @ 25°C
- ✓ low output admittance
- ✓ low saturation voltages
- ✓ high reliability

Now — for the first time — a transistor has been developed with the characteristics of low-leakage planar units, combined with resistance to secondary breakdown offered by homogenous devices. The results are Solitron's ISOLTAXIAL NPN Silicon Power Transistors! The ISOLTAXIAL transistors have special construction innovations and processing techniques, and were developed with the high reliability standards associated with Solitron. A few of their many applications include power supplies, audio amplifiers, inverters, converters, relay drivers and series regulators. ISOLTAXIAL transistors are low-cost and packaged in TO-3 and T-61 cases.

Type Number	Pkg. Size	Type Number	Pkg. Size	DESIGN LIMITS			PERFORMANCE SPECS.	
				BV_{CBO}	$V_{CEO\,(SUS)}$	BV_{EBO}	I_{CEX} @ V_{CE} ($V_{EB} = 1.5V$)	
				Volts	Volts	Volts		
				Min.	Min.	Min.	µA (Max.)	Volts
SDT9801	TO-3	SDT9901	TO-61	60	40	12	100	40
SDT9802	TO-3	SDT9902	TO-61	80	60	12	100	60
SDT9803	TO-3	SDT9903	TO-61	100	80	12	100	80
SDT9804	TO-3	SDT9904	TO-61	120	100	12	100	100

ALL TYPES INCLUDE THE FOLLOWING SPECIFICATIONS:
Gain 20-60 @ 5 A
VCE (sat) 0.5 V Max. @ 5 A
VBE (sat) 1.2 V Max. @ 5 A
ft 1.0 MHz Min.

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VALUE

BIG:
11"x 17"
X-Y RECORDER

Now in a bigger chart size—a value-priced Moseley X-Y recorder offering solid-state reliability and the same performance you get from the Model 7035A 8½"x11" X-Y Recorder ($895).

The Moseley 7005A lets you record on an 11"x17" chart for increased resolution. Five calibrated ranges each axis, 1 m V/in. to 10 V/in. High input impedance, floating and guarded input, 0.2% accuracy at full scale. Adjustable zero set each axis. Autogrip care-free electric paper holddown. Electric pen lift. Bench and rack mount model in one. Metric Model 7005AM is also available.

You get all these features for your recording applications for just $1195. For complete information just call your Hewlett-Packard field engineer or write Hewlett-Packard, Palo Alto, California 94304, Tel. (415) 326-7000; Europe: 54 Route des Acacias, Geneva.

BRIEF SPECIFICATIONS

Input Ranges: 7005A 1, 10, 100 mV/in.; 1, 10 V/in.
7005AM 0.4, 4, 40, 400 mV/cm; 4 V/cm

Input Resistance: Potentiometric—1 mV/in. range; 100K—10 mV/in.; 1 Megohm—0.1, 1, 10 V/in.

Accuracy: ± 0.2% at full scale; linearity: ± 0.1% of full scale; dead band: ± 0.1% of full scale.

Model 17108A External Time Base provides 5 sweep speeds either axis 0.5 to 50 sec/in. ($175).

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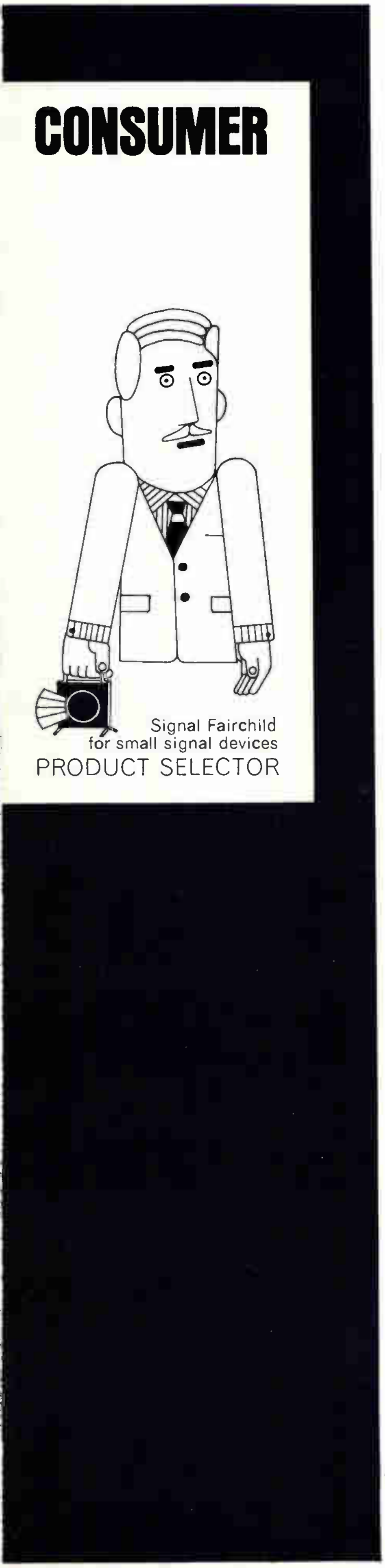

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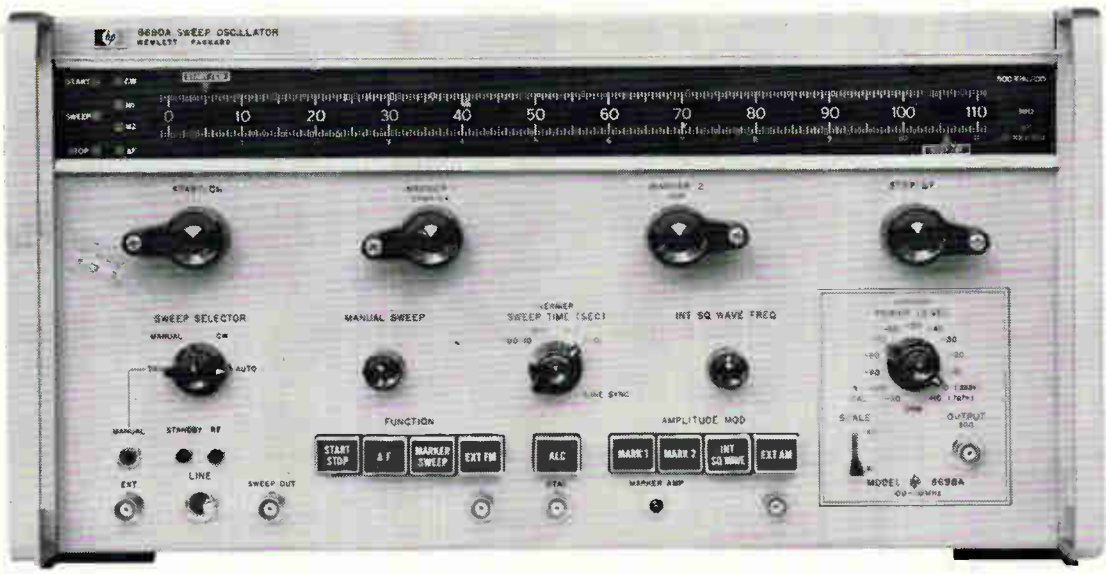
Linear RF Sweeper



Residual FM:
0.1 to 11 MHz <150 Hz peak, 1 to 110 MHz <500 Hz peak.

Frequency Stability:
With temperature: 0.1 to 11 MHz, ±0.01%/°C or ±200 Hz/°C, whichever is greater; 1 to 110 MHz, ±0.01%/°C or ±2 kHz/°C, whichever is greater.

With 10% line voltage change: 0.1 to 11 MHz, ±5 kHz; 1 to 110 MHz, ±50 kHz.

Spurious Signals:
Non-harmonics at least 40 dB below CW output. Harmonics at least 35 dB below +10 dBm CW output.

POWER SPECIFICATIONS

Power Output:
At least +20 dBm max. (2.23 VRMS into 50 ohms). Calibrated power output adjustable in 10 dB steps from +10 dBm to −110 dBm; 10 dB vernier permits continuous adjustment between steps. Source impedance is 50 ohms.

Power Accuracy:
±1 dB + attenuator accuracy (vernier in CAL position).

Attenuator Accuracy:
±1 dB to 70 dB attenuation; ±2 dB to 120 dB attenuation.

Output Flatness:
±0.25 dB (±0.1 dB over any 10 MHz bandwidth).

Price: Model 8698A RF Sweeper Generator, $950.
(Model 8690A Sweep Oscillator, $1550.)

For more information contact your local HP field engineer or write Hewlett-Packard, 1501 Page Mill Road, Palo Alto, California 94304, Tel: (415) 326-7000; Europe: 54 Route des Acacias, Geneva.

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Satellite communications transmitters can now operate broad band using MEC's high power, high efficiency TWT, the M4444. This tube delivers more than 12 kilowatts of c.w. power from 7.7 to 8.4 GHz at efficiencies greater than 35%. For the first time, a TWT matches klystron efficiency while providing 14 times their instantaneous bandwidth!

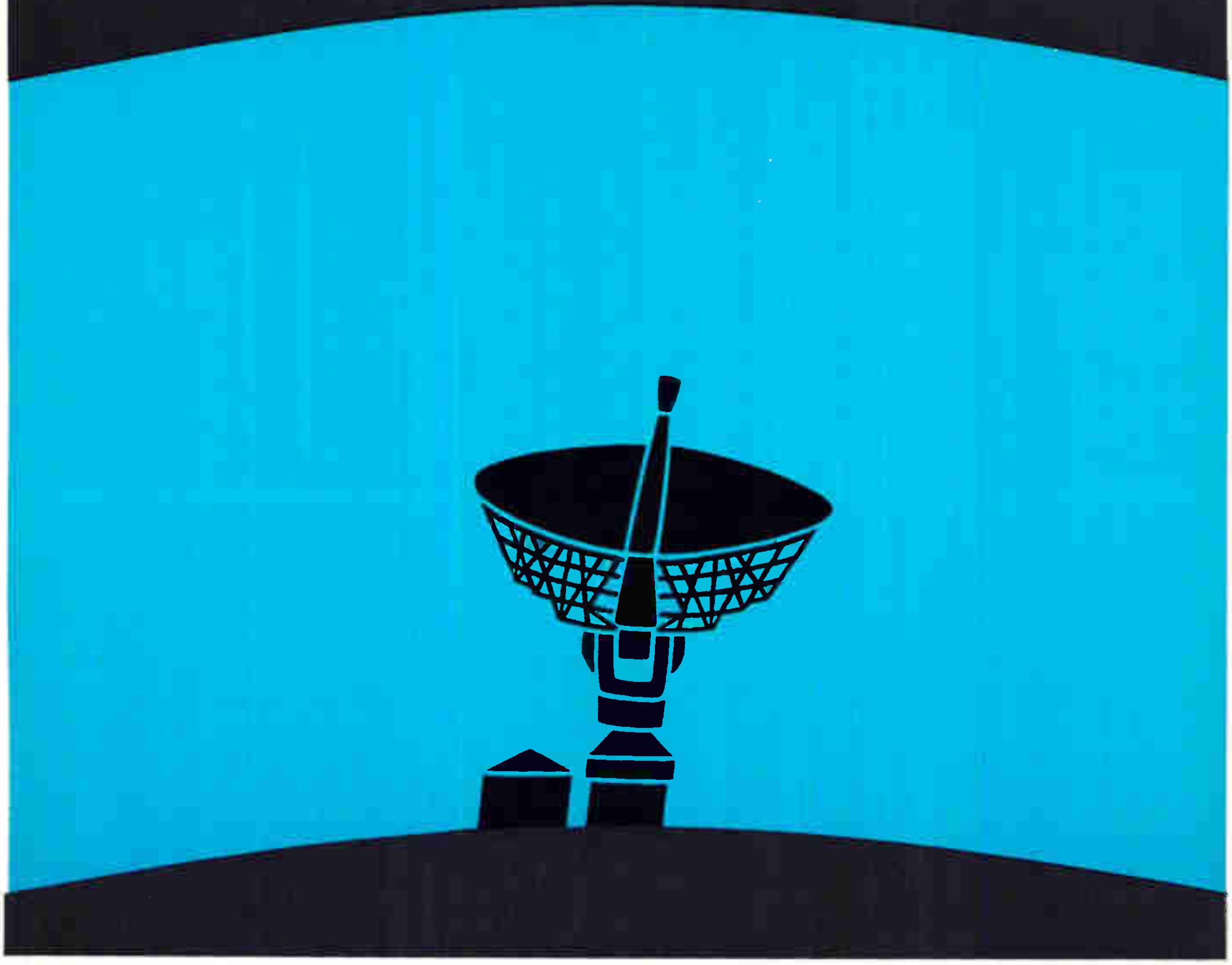
The metal-ceramic construction of the M4444 permits high temperature processing, and its integral ion pump and low cathode current density assure stable, long lived dependability.

A single stage depressed collector minimizes power supply complexity, and broad band operation is obtained at constant beam voltage.

Complete gain, phase shift, intermodulation, power and electrical characteristics are available for the asking. Our technical staff will be pleased to fill in the details on the M4444 or its counterparts in other frequency ranges.

The M4444 is one more example of MEC being first with the best in high power TWTs.

MEC



A new dimension in satellite communications

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Technical Articles

Product planning at IEEE
page 116

This year will see integrated circuits move into a variety of new equipment. In this examination of some significant products to be introduced at the annual show of the Institute of Electrical and Electronic Engineers, the emphasis is on integrated circuits and instruments to test them. The trend in new products shows industry has a continuing interest in reducing production costs.

Worldwide look at the Gunn effect
page 134

The Gunn effect is the best known of the new phenomena that are exciting semiconductor engineers and microwave experts. Except for some production in Europe, however, the Gunn effect is confined to research laboratories. Some newer effects like limited space-charge accumulation now hold greater promise. On the cover is a many-times magnification of a voltage tunable oscillator, built at Bell Telephone Laboratories, that is tapered to allow control of the Gunn effect. The oscillator is about 30 mils long.

Computer-aided design, part 7: Performing nonlinear d-c analysis
page 140

Earlier in this important series, there were extensive descriptions of how a computer can help in design when linear elements like resistors and capacitors are involved. These components require simple models. But nonlinear devices like the transistor and zener diodes require more complex models and procedures. A computer program has been prepared to solve nonlinear d-c problems and statistical, worst-case, and stress analysis.

Integrated circuits in action, part 5: In search of the ideal logic scheme
page 149

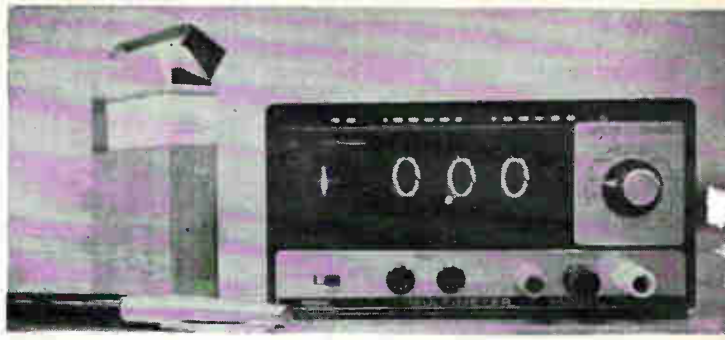
In the brief history of integrated electronics, many different logic schemes have been proposed. The engineer who has to choose one ought to understand the weaknesses and strengths of each.

1. Dilemmas galore—a survey of types of integrated logic
2. Understanding integrated-circuit logic—the engineer has to know how the logic works because specifications are often sketchy
3. Logic IC's don't live alone—the system affects the choice of circuit logic too

Coming March 20

- **How the computer handles transient analysis**
- **Measuring the transconductance of field effect transistors**
- **Computers for research satellites**
- **Glass isolation at work**

Price of meter drops near predicted level



Some scoffed at the prediction four months ago that mass-produced integrated circuits would make possible a $100 digital instrument for measuring voltage and resistance [Electronics, Nov. 28, 1966, p. 88]. Well, it hasn't been done yet, but the Instrumentation division of Fairchild Camera & Instrument Corp. has brought the price of a multimeter down to $249, and claims this is one-fourth the cost of a comparable unit with conventional circuitry.

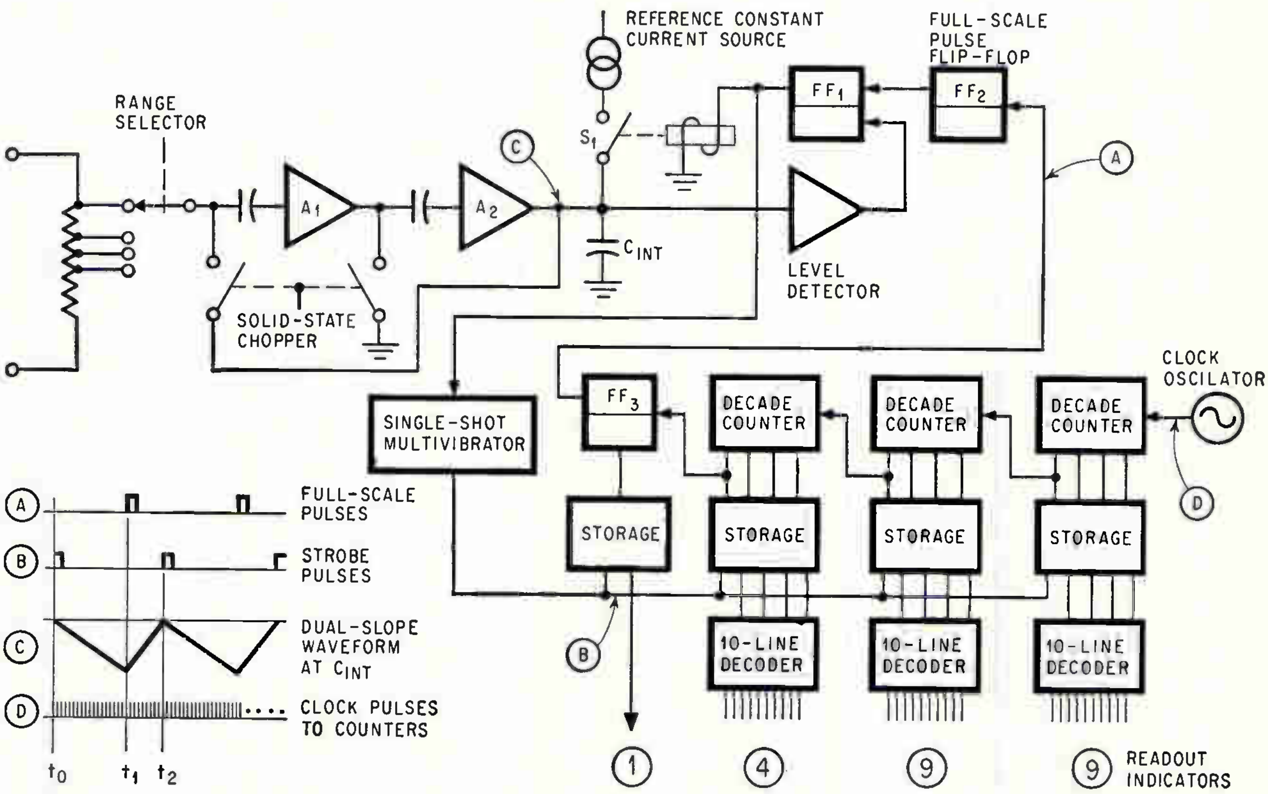
The company says the meter's size and price make it ideal for production-line use, systems testing and calibration, quality assurance, field service and educational applications.

Like the $100 prototype predicted, the Fairchild multimeter uses a dual-slope (up-down) integrating technique for making measurements, but with fewer components. Besides combining the noise-rejection capability of integration with the accuracy and stability provided by automatic comparison to an internal standard, the dual-slope integrating method is better suited to IC's than are other digital voltmeter techniques.

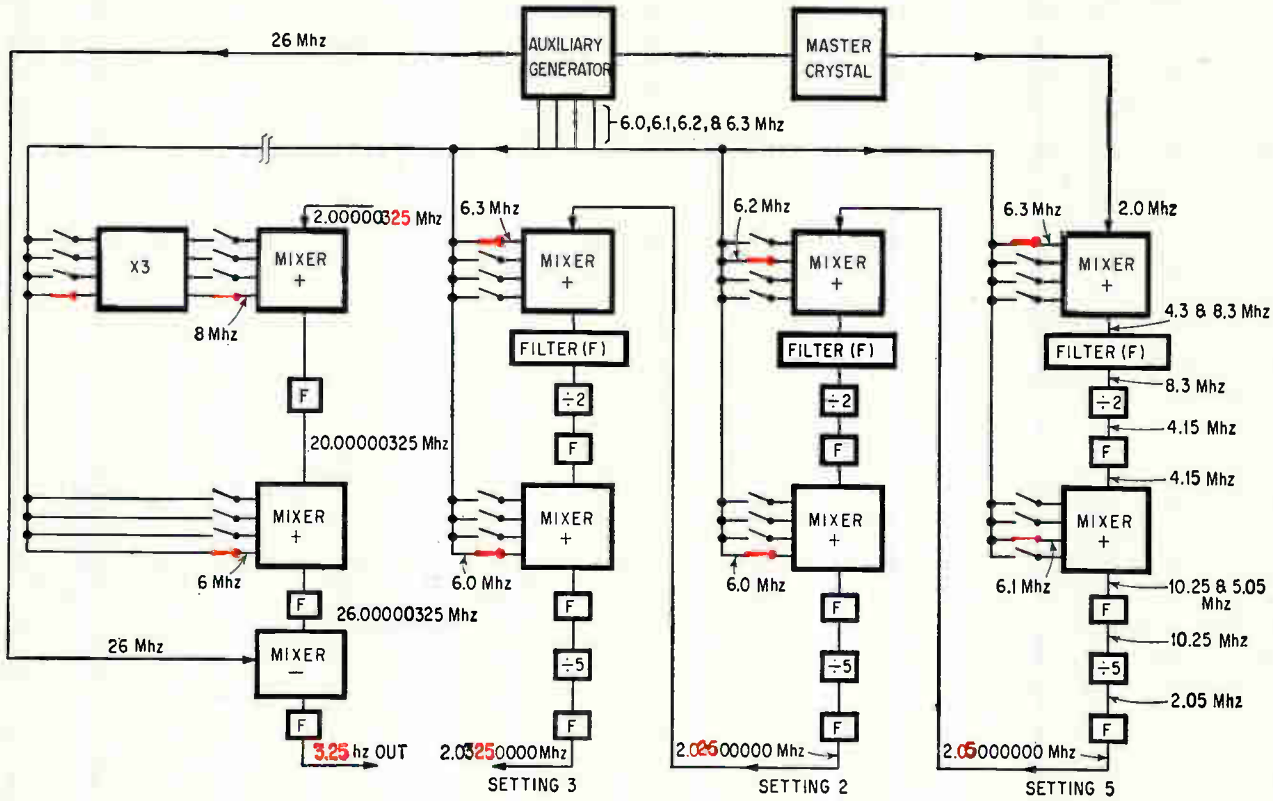
Fairchild's model 7050 uses off-the-shelf IC's for a pair of linear amplifiers and a number of logic elements.

According to the company, the model 7050 can replace not only analog meters and panel indicators but digital voltmeters costing much more. Measured values are displayed on Nixie tubes and are easy to read, even from a distance and at wide angles. The three-digit readout is said to be accurate to within 0.1% of reading. With analog instruments, on the other hand, operator and parallax errors, meter movement wear and aging often reduce their nominal accuracies—1% to 3%, typically. The model 7050 can withstand input voltages up to 1,000 volts d-c on any of its ranges without being damaged, according to Fairchild.

The meter measures d-c voltages from 1.5 to 1,000 v full scale and resistance from 1.5 kilohms full scale to 15 megohms full scale. For voltage measurements, the input is connected directly to the dual-amplifier range selection circuit (below).



To measure voltage, multimeter measures the time required for the constant-current reference to discharge the integrating capacitor to zero volts after it has been charged to an initial value by an input voltage. The level detector senses the moment when C_{int} reaches zero volts and generates a strobe pulse to transfer the count from the counters to the readout and restart the measurement cycle.



Decade modules mix signals produced by crystal oscillator to produce desired output—3.25 hertz in this example. Selecting the desired frequency closes various switch-contacts to feed the proper slave frequencies into mixer. Decimal portion (in color) of each decade's output is shifted one digit to the right as it progresses.

ample, the unit can sweep from 1 Mhz to 1.001 Mhz or from 1 kilohertz to 1.3 khz. The two fixed sweep rates are either 1 hz for monitoring on a recorder or 50 hz for viewing on the scope. As in other synthesizers, an external source can control the vco to frequency modulate the output or to provide other sweep rates. This instrument also makes it possible to amplitude modulate the output frequency derived from either the vco or the crystal. A d-c offset feature permits placing the output signal on a d-c bias level, variable between ±2 volts—useful for testing solid state circuits. An attenuator can vary the output amplitude in 10 decibel steps from -70 db above a milliwatt to 20 dbm.

The instrument can be remotely programed for testing frequency-sensitive devices like narrow band filters, delay lines and amplifiers. In this mode, the synthesizer can derive its output from the crystal source or the vco or a combination of both. Frequencies can be selected in any desired pattern.

The unique doubly-balanced mixer circuits in this unit aid in reducing spurious outputs. Using only diodes, transistor and resistors, they suppress input frequencies about 60 db below the sideband. Eventually, Monsanto expects to fabricate these mixers in a special-purpose integrated circuit.

Specifications

Output frequency	0.01 hz to 1.3 Mhz in 0.01 hz steps
Stability	1 x 10^{-9} per day
Output voltage	2 v across 50 ohms
Spurious signals	80 db below desired output
Harmonic signals	50 db below desired output
Modulation	Amplitude or frequency
Size	5¼ in. high, mountable in 19-in. rack
Weight	Approx. 35 pounds
Price	Approx. $4,000

Monsanto Co., 620 Passaic Ave., West Caldwell, N.J. 07006

'Unusual marriage': Constancy, variation

"It took an unusual marriage to do it," says an official of the Weston-Rotek division of Weston Instruments Inc. The comment by Peter Richman, a vice president of the division, refers to the development of an oscillator that provides both a continuously variable frequency capability and a constant output voltage.

Until now, engineers measuring frequency response have had to choose between these two properties. An instrument with a constant output was tunable in discrete steps only, so that if one continuous tuning was required, one had to learn to live with sizable amplitude changes in the output.

In designing its new oscillator, Richman says, output dividers to provide flexibility when using the instrument in both one-and two-phase applications.

Specifications

Frequency range	9.6 hz to 104 khz
Voltage output	12 v rms
frequency response (flatness)	±0.01% to 50 khz ±0.02% to 100 khz
Total harmonic distortion	0.01% above 20 hz
Frequency stability	0.01% per hour above 100 hz 0.02% per hour from 10 to 100 hz
Price	about $900

Weston-Rotek division of Weston Instruments Inc., 17 Hartwell Ave., Lexington, Mass.

Plug-in modules for blue-collar job

Setting its sights on a new market—bench and production-line instrumentation—Electronic Associates Inc. is offering a low-cost, flexible digital measuring system. The modular instrumentation concept was first exploited by oscilloscope makers.

EAI, which previously had limited itself to costly laboratory-type precision-accuracy units, has developed an instrument built around a universal main frame and a plug-in approach—the main frame for display of the measured variable, the plug-ins to adapt the system for measurements such as voltages, frequency and resistance.

"The modular approach," says Andy Anderson, the EAI Instrument division's marketing manager, "affords maximum flexibility at low cost by enabling the user to mix or match modules according to his particular needs. Previously, if an engineer wanted to measure voltage and frequency, he would buy a voltmeter and a counter—a fairly expensive procedure. This no longer has to be the case." The company's basic display unit, the model 6200, will sell for about $525, including a d-c plug-in. "Other measurement capabilities can be added for as little as $185," says Anderson. The unit contains power supplies, high-speed counting circuits, a display-time generator and numerical readout indicators. Drawer space is provided with wired receptacles for up to two plug-in modules, and a switch that permits the output of either module to be read out eliminates changing modules when more than one measurement is made.

The readout is displayed on Nixie tubes. There are four digits—three full range plus the fourth digit 1 for overranging. An illuminated decimal point is automatically positioned according to the range selected. Display time is variable, from 0.2 second to six seconds; it can also be held. Readout reset is both automatic and manual, and can be done from the front panel. The main frame can be supplied with a data output consisting of binary-coded decimal (1-2-4-8) logic. The unit's dimensions are a compact 7 x 8½ x 11 inches.

The model 6201 voltmeter module provides the system with a means of measuring d-c voltage from 100 millivolts to 1,000 volts full scale in five ranges. The module has automatic polarity selection and pushbutton ranging for fast operation.

EAI's voltmeter module operates on the integrating principle, thereby reducing the system's susceptibility to superimposed noise and hum. The module includes a high-speed solid state chopper to eliminate amplifier drift and reduce circuit time constants. This permits fast response to full-scale input step functions. A built-in calibrating system allows the operator to check the instrument's accuracy— ±0.1% ± 1 digit. The voltmeter module's 10-megohm input impedance is constant over the measuring range.

When the a-c converter module is used with the voltmeter module, the system can measure a-c voltages from 20 hertz to 200 kilohertz. The unit, the model 6204, converts an a-c input to a d-c output voltage proportional to the root-mean-square value of the input sine wave. The module allows the measurement of voltages from 1 volt rms to 300 volts rms full scale.

Specifications

Display readout	4 digits in-line (40% overranging)
Display time	Continuously variable from 0.2 sec to 6 sec
Signal input	0 to 10 Mhz from compatible plug-in module
Voltmeter	
Full-scale ranges	100.0 mv (100 μv resolution) 1.000 v 10.00 v 100.0 v 1000.0 v
Overrange capability	40% on all except 1,000=v range
A-c rejection	80 db at 60 hz 90 db at 120 hz
Conversion time	100 msec
Response time	700 msec to reach 99.9% of value for full-scale step input
A-c converter	
Frequency range	20 to 200,000 hz
Full-scale voltage ranges	1, 10, 100, 300 v rms
Accuracy	± 0.02% to 10 khz, ± 0.3% for 10 to 100 khz, 0.4% for 100 to 200 khz
Input impedance	1 megohm shunted by 30 pf.
Floating input	Enables a-c measurement of signals having ± 500 volts d-c with respect to line ground

Electronic Associates Inc., West Long Branch, N. J.

Integrated circuits

TI backs bet on TTL with two new series

The wave of the future—that's the way Texas Instruments Incorporated views the place of transistor-transistor logic (TTL) in the integrated circuit business.

TI has been backing this conviction with a $5

Series 54 TTL "family" of eight gates and a flip-flop, with 13 nsec propagation delay and 10 new power dissipation.

Prior to this, Litton Industries Inc. had developed the "Phoenix gate" TTL for the Phoenix missile. It contained a multiple-emitter transistor, a device nonexistent in discrete-component circuitry and a key element in TTL work. The logic family, originally called TCL for transistor-coupled logic, was first developed by Pacific Semiconductor Inc., now TRW Semiconductor, Inc.

TI's TTL's are diffused-planar, double-layer epitaxial structures. Circuit construction is similar to DTL layouts, but the input diode gate of the DTL is replaced with the multiple-emitter transistor.

"The diffusion techniques and other manufacturing steps are much simpler for TTL's," Fowler declares. "They actually have fewer component elements than earlier DTL types but they perform more functions."

Specifications

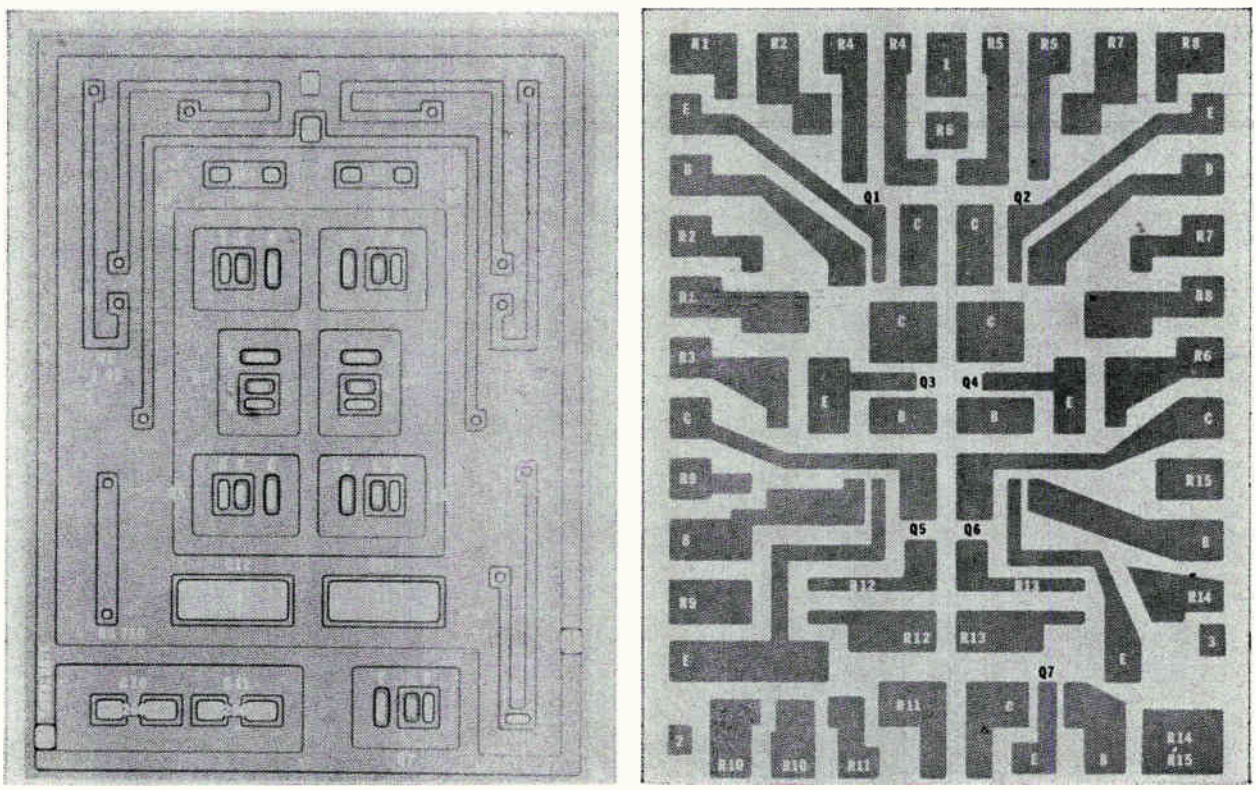
	Series 54H (High speed)	Series 54 (Standard)	Series 54L (Low power)
Propagation delay	6 nsec	13 nsec	35 nsec
Power dissipation	25 mw	10mw	1mw
Fanout	10	10	10
Power supply voltage	4.5 to 5.5 v	4.5 to 5.5 v	4.5 to 5.5 v
Temperature range	Military and industrial ranges on all three		
Packages	Flatpack and plastic	Flatpack and plastic	Flatpack
D-c noise margin	1 v	1 v	1 v

Norden is putting zip in tailored IC service

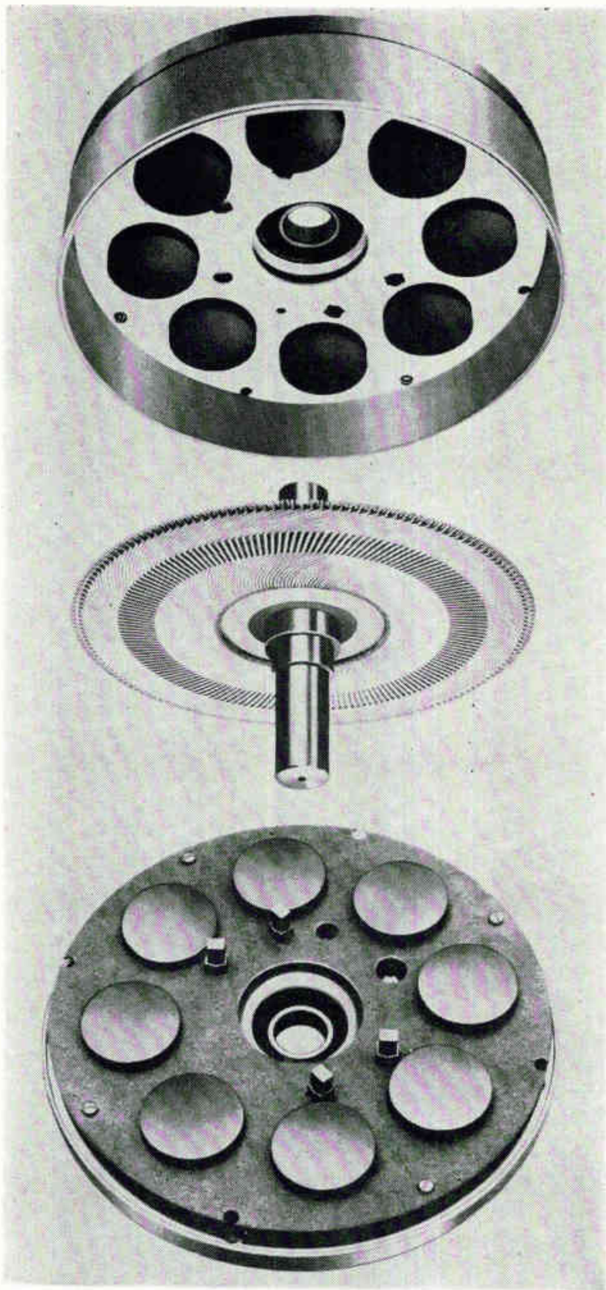
Telephoning an order one day and getting the integrated circuit a day or so later is normal service when buying off-the-shelf IC's. But the Norden division of United Aircraft Corp. offers the same service for custom-made, dielectrically isolated circuits.

Norden can prepare either digital or linear IC's by stitch bonding wires between component elements on chips. Although breadboard chips have been sold by Norden and other semiconductor manufacturers for several years, these, Norden claims, are the first with dielectric isolation.

The isolated elements speed the design work



Master dice breadboard has six transistors and 33 resistors varying in value from 75 ohms to 10,000 ohms. Aluminum bonding pads shown in photo at right are connected to each resistor and to the emitter, base, and collector of each transistor.



Armature for new line of precision motors is stamped from sheet of copper. Flat armature is shown between two sets of Alnico field magnets.

company, Societe Electronique et Automatisme, which holds the basic flat-armature patent. This is the same firm that licenses Printed Motors' parent concern.

Instead of printed circuit techniques, Yaskawa uses mechanically stamped-out armatures for its line of inexpensive d-c motors. These have been sold in large volume for about $5 to $6 each to the automotive industry; precision printed-circuit motors have been selling for 15 to 20 times these prices.

The mechanical armature has one distinct advantage over the printed-circuit design: its basic fabrication approach allows four layers of continuous conductors to be placed on a single armature. The printed circuit approach permits only two layers, one on each side of the insulating copper-clad laminate on which the conductors are etched.

With twice the conductors, each armature should have twice the torque sensitivity. Based on this and the fact that production costs could be lowered, Printed Motors decided to upgrade the mechanical approach for the manufacture of a precision servo motor.

Conductor patterns in the new armatures are stamped from copper sheets by a notching press that can make 700 notches per minute. Two sheets of conductors are laminated and welded at their inner diameters, and two sets of these double-conductor sheets are then laminated together and their outer diameters are welded.

The result: a sturdy structure that doesn't require the support ring for the less rigid armature. In addition, the stamped armatures don't have the thickness variations of the printed circuit armatures, variations due to control problems in the electro-plating process.

Printed Motors has also improved on the low-cost motor design by using:

- Higher flux density Alnico magnets, instead of ferrite magnets.
- Four brushes instead of two, reducing the current density per brush and allowing higher currents in the motor.
- Ball bearings rather than a sleeve bearing, so that the armature turns with considerably less wobble and more concentricity.
- Epoxy-glass insulating materials that can withstand higher temperatures than the copper-clad laminates used in the printed circuit motors.

Specifications

	U9M4	U12M4	U16M4
Power (horsepower)	1/12	1/3	1/2
Torque constant (K_t-ounce-in./amp)	7.0	16.0	31.2
Mechanical time constant (seconds)	.013	.010	.011
Terminal resistance (R_T-ohms)	.8	.75	.79
Inertia (J-ounce-in./sec^2)	.0055	.023	.099
Weight (pounds)	4-1/2	8	16-1/2
Diameter (inches)	4-3/8	5-1/2	7-3/8
Length (inches)	1-27/32	2-7/64	2-9/16
Cost per motor (in quantities of 100)	$77	$94	$140

Printed Motors Inc., 31 Seacliff Ave., Glen Cove, N.Y.

Sputtered oxides form thin-film thermistor

A new low-energy sputtering technique, combined with a multiple-oxide target material, adds a thin-film thermistor to the circuit designer's bag of tricks.

The A-Thinistor, the first deposited-film thermistor, can be attached at a critical area in a circuit to trigger a signal when a predetermined

Subassemblies

Test display uses IR missile scanner

Adapted from a Sidewinder missile technique, an infrared scanner will compete in the fast-developing market for thermal sensing and display devices.

The Sierra Electronic division of the Philco-Ford Corp. sees a broad market, ranging from tests of printed circuit boards to diagnosis of muscle inflammations, for its 710B scanner, which incorporates both direct-viewing and picture-taking capabilities.

Sierra's system uses the output of the Sidewinder device, an indium antimonide cell, to provide two types of oscilloscope display:

- A video display of the subject's infrared radiation, with 10 black-to-white ranges covering temperatures from 2 degrees to 1,200 degrees centigrade.
- A scope tracing that shows i-r energy as a curve derived from the video signal, with the amount of energy determining vertical deflection.

Both types of display, known respectively as C-scan and B-scan, can be shown on one cathode ray tube, but the Sierra console has two scopes because the light levels best for the human eye are less than optimum for cameras. Either scope will provide both types of display.

The Boeing Co. was the catalyst in the development of the 710B, a follow-on to an earlier scanner-plus-scope system that was more suited to laboratory than production-line use. Boeing wanted to test the bonding process in which plastic skin is mated to the aluminum honeycomb used in helicopter rotor blades. The company had been leaning toward ultrasonic testing, but Sierra pointed out that if a heat source were placed behind the blade, bonding flaws would show up as cool spots on the front.

That test is passive, but the system is equally valuable for active testing of components on a printed-circuit board. As diodes heat up, for example, their picture becomes brighter and brighter on the cathode-ray tube. Poor welds are also shown by irregular heat transfer.

In the single-scope system, the operator had to swing the camera away in order to see the crt picture. Not only was this procedure awkward, but the light settings that were best for direct viewing were too bright for picture-taking and they washed out detail. The persistence of the scope that was necessary for a raster scan took five seconds from top to bottom, and did not have enough grey scale for good pictures.

In the 710B, the top scope is coated with P7 phosphor for good persistence, and the bottom with P4 phosphor, which has short persistence but a good grey scale. Both scopes are modified by their builder, Tektronix Inc., Beaverton, Ore.

Infrared scanner developed for the Sidewinder's guidance system nondestructively test solid state components. The output signal . . .

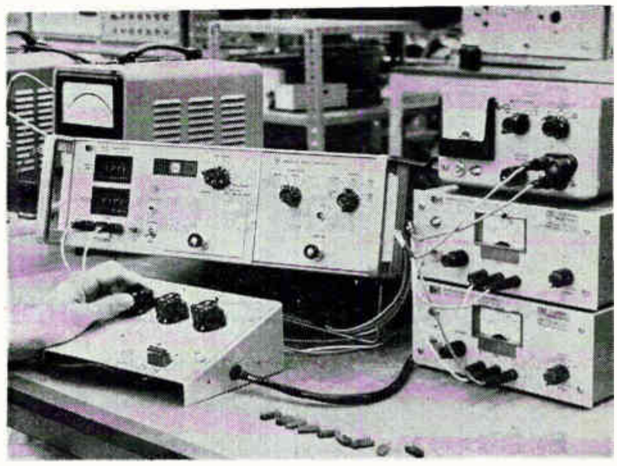
The raster is produced by a mirror that is mechanically rotated at 30 revolutions per second. It is tilted up and down so that a complete 150-line picture is produced every five seconds.

Sierra also offers a "quantizer" that puts thermal contours, analogous to the isometric lines on a weather map, on the scope. The analog traces are digitized into six discrete temperature levels.

The company sees applications in reliability testing and in medical electronics. In solar cell tests, a malfunctioning cell would show up as a cold spot. Subcontractors to the Lockheed-Georgia Co., a subsidiary of the Lockheed Aircraft Corp., are now required to take thermal pictures of circuit boards for reliability testing. The University of Washington medical school will use a Sierra system to study muscle inflammation. The company says that the

. . . from an indium antimonide cell paints a picture with 10 black-to-white ranges on the monitor console's oscilloscope. A built-in Polaroid camera makes a permanent record of the scope's traces.

Fast, low-cost testing with limit comparator



Limit comparator can be used with external test jig for integrated circuits.

"It looked like an instrument we'd be able to use on our own production lines. If we could use it, probably other people could too. So we went ahead and built it."

That, according to one of the design engineers, is the uncomplicated reasoning behind the Hewlett-Packard Co.'s first instrument aimed at the production line—a high-go-low limit comparator for automated testing of electronic components, including integrated circuits. The new production tool marks a departure for Hewlett-Packard from laboratory-type instrumentation.

The high-speed, multifunction model 3434A has a basic price of $1,575 and can be used in sorting, batching and matching components, testing printed circuit boards and cables, and calibrating.

The comparator can handle four types of limit measurements—a-c voltage, d-c voltage, direct current and resistance—against the single d-c voltage measurement available with most analog comparators. Limits can be selected automatically or manually. As many as 12 different sets of limits can be preprogramed and quickly selected by a 12-position rotary switch as test conditions change.

Its versatility and cost make the comparator attractive for automated testing on low-volume production runs of from 50 to 100 pieces. But it is fast enough—at 15 decisions per second—to be used on high-volume lines as well.

The comparator can accept the plug-in function modules Hewlett-Packard has designed for its line of digital voltmeters, as the comparator circuitry uses the same ramp-comparison techniques.

The plug-ins range in price from $40 for the 3441A voltage range selector with 10-, 100- and 1,000-volt ranges, to $575 for the 3444A d-c multifunction unit with voltage, current and resistance functions.

High and low limits can be set separately on the comparator by:

- Dialing thumbwheel switches on the front panel during routine testing.
- Plugging in a preprogramed board on which 12 different pairs of limits are set.
- External binary-coded decimal limits driven by a computer or other programing source.
- Remote analog voltage inputs.

When the comparator is used to test integrated circuits, both the 3444A d-c multifunction plug-in and the preset limit board are needed. The built-in rotary switch brings in bias and signal voltages to the IC test jig, selects the appropriate input and output pins and programs the comparator's 12 sets of test limits. A complete test set (without the jig) would cost $2,375. This includes $225 for the limit program board.

If IC's are to be tested semiautomatically at high speeds, an external scanning switch is needed.

Except for the external analog signals, the limit voltages are produced in digital form and converted to analog form before they're applied to the comparator circuit.

The comparator circuit takes the two input analog voltages and compares them with a +12- to −12-volt ramp. Output pulses appear when the ramp voltage is coincident with the analog voltage, and are applied to the decoding and logic circuits. The time sequence of the pulses yields the proper decision—high, go or low.

Each decision is flashed by colored lights on the front panel. The indication is held until the next limit condition occurs. The decision circuits can also drive floating contact closures, which can be used, in turn, to activate such production-line accessories as parts counters and materials-handling equipment, or a printer. A switchable input filter allows the comparator to operate in a noisy environment.

Specifications

Functions (plug-ins required)
- HP 3441A range selector (d-c voltage)
- HP 3442A automatic range selector (d-c voltage)
- HP 3443A high gain/auto range unit (d-c voltage)
- HP 3444A d-c multifunction unit (d-c voltage, d-c current resistance)
- HP 3445A a-c/d-c range unit
- HP 3446A a-c/d-c remote unit

Accuracy (10-, 100-, 1000-volt ranges)

External analog:	±0.02% full scale
Other modes:	±0.04% full scale

Other accuracies depend on plug-ins

Decision rate

Normal:	fixed at 15 decisions/sec
Manual:	front panel control
Remote:	variable to 15 decisions/sec
Power:	115 and 230 volts ±10% 50-1,000 hertz Approximately 30 watts
Dimensions:	16¾ x 5 7/32 x 18⅜ in. deep
Weight:	18 lbs.
Price:	$1,575 with thumbwheel limit set $225 for limit programer

Hewlett-Packard Co., Loveland Div., P.O. Box 301, Loveland, Colo. 80537

If Q_1 is kept off, the charge on C_1 is maintained until an incoming pulse triggers the circuit and starts the ramp.

Transistor Q_1 is kept off by the conduction to ground through D_1 and Q_5, which back-biases D_2 and prevents base current from reaching Q_1. Transistor Q_5 is held on by Q_3; Q_3 conducts because its base potential is slightly more positive than Q_4's due to the action of R_4, P_2 and R_5 together with R_6 and D_4.

The ramp is started when a positive triggering pulse at the base of Q_5 turns Q_5 off, dropping this transistor's collector voltage to —20 volts and back-biasing D_4. With D_4 off, the base of Q_3 goes more negative than the base of Q_4 because of the action of R_4, R_5 and P_2; thus Q_3 cuts off (holding Q_5 off) and Q_4 turns on.

The turnoff of Q_5 also back biases D_1, so D_2 turns on, starting the Miller effect ramp generator. With D_2 conducting, Q_1 turns on, turning on D_3. Constant current is then provided by Q_1 to linearly discharge C_1, and the output ramp is generated.

When the combinations of currents through R_4, R_5 and P_2 bring the potential at the base of Q_3 to —15.9 volts (or slightly more positive than the base of Q_4), Q_3 turns on, turning Q_4 off and Q_5 on. With Q_5 on, diode D_1 again conducts, back-biasing D_2 and cutting off Q_1. Now that Q_1 is off, diode D_3 is back-biased and Q_2 turns on, rapidly charging C_1 to —16 volts. The cycle is now complete and the circuit is ready to accept the next input pulse.

The slope of the ramp is controlled by P_1 and R_1, which can vary it through a range of 50 to 1 by changing the amount of constant current through C_1.

Ramp height is controlled by P_2 and R_5. The output voltage for the ramp is given by

$$V = V_{out} = \frac{-V_{cc}R_4}{P_2 + R_5} + \frac{V'_{B4}R_4}{R_{equiv}} \qquad (1)$$

$$\text{if } R_{equiv} = \frac{(P_2 + R_5)R_4}{P_2 + R_5 + R_4}$$

where V_{cc} is the —20 volt supply and V'_{B4} is the voltage at the base of Q_4. This equation shows the ramp amplitude to be inversely proportional to P_2 and R_5.

The ramp reaches its maximum amplitude at ground when the combination of P_2 and R_5 is 3 kilohms. With P_2 almost an open circuit, the ramp amplitude is zero volts.

$$\text{The timing equation is: } T = \frac{\Delta V \cdot C}{\Delta I} \qquad (2)$$

where ΔV is the increment of voltage across C_1 and I is the increment of current.

$$\Delta I = \frac{V_{cc}}{P_1 + R_1} \qquad (3)$$

Substituting equations 1 and 3 into 2 yields

$$T = \frac{R_4(V_{cc} - V_{B4})(P_1 + R_1) \cdot C_1}{(P_2 + R_5)V_{cc}} \qquad (4)$$

where

$$V_{B4} = \frac{V'_{BA}(R_1 + P_2 + R_5)}{R_4}$$

Setting $R_2' = (P_2 + R_5)$ and $R_1' = (P_1 + R_1)$ yields:

$$T = \frac{R_4(V_{cc} - V_{B4})(R_1')(C_1)}{(R_2')(V_{cc})} \qquad (5)$$

Equation 5 indicates that the duration of the ramp may be varied by slope control R_1' or amplitude control R_2'.

Pulse-width modulation can be achieved with the circuit by fixing $(P_2 + R_5)$ and connecting the top of potentiometer P_2 to a control voltage V_c. The new timing equation then becomes:

$$T = \frac{R_4(V_c - V_{B4})(R_1')(C_1)}{(R_2')(V_{cc})} \qquad (6)$$

Equation 6 indicates that T is directly proportional to control voltage V_c.

If R_1 is made large enough the circuit will oscillate:

$$f = \frac{(R_2')(V_{cc})}{(R_4)(V_c - V_{B4})(R_1')(C_1)} \qquad (7)$$

and if P_1 goes to a control voltage V_c, then

$$f = \frac{(R_2')(V_c)}{(R_4)(V_{cc} - V_{B4})(R_1')(C_1)}$$

The operating frequency may then be controlled by the same voltage V_c. The resulting output is a train of negative-going pulses and a positive-going sawtooth wave.

IC amplifier serves as stable current source

By Clement S. Pepper

Marine Physical Laboratory
Scripps Institution of Oceanography, San Diego

For less than $40, a stable 185-milliampere current source can be built with an integrated amplifier and a feedback circuit. The circuit has excellent regulation and serves as a laboratory standard for

Constant relay on-time for any input pulse

By Ken Wahl

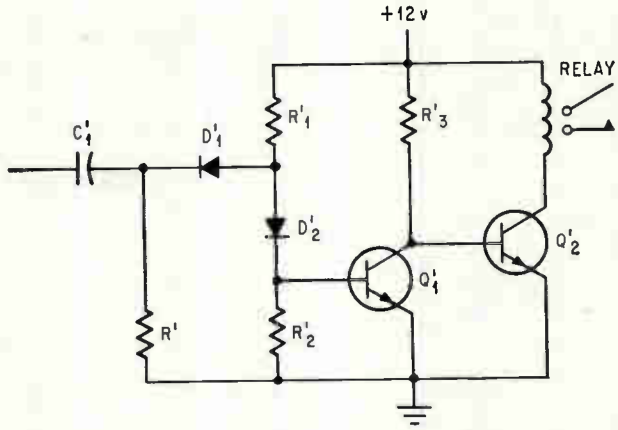
Photo Bell Co., New York City

A monostable relay driver can be made independent of the input pulse's amplitude or duration by feeding back a negative pulse generated by the output circuit. The pulse holds the input transistor off for a predetermined time. The circuit shown below was designed to drive a 4-watt relay momentarily. Since the circuit holds the output transistor in conduction for 25 milliseconds regardless of the input pulse duration, the power to drive the relay is generated without the additional transistor stage normally required for pulse stretching. Thus the circuit's cost is reduced by 25%.

In the conventional high-gain pulse amplifier at the right transistor Q'_1 is normally on, Q'_2 is off and the relay is not energized. When an incoming negative pulse turns Q'_1 off, Q'_2 turns on and the relay energizes. The time Q'_1 is off depends on the pulse duration, pulse amplitude, and the time constant $R'_2C'_1$.

With the modified circuit the relay's on-time is independent of input pulse characteristics. Diode D_3 is normally off and capacitor C_2 is charged to +10 volts.

When a negative input pulse turns Q_1 off, Q_2 turns on and its collector voltage drops to ground. Since the charge on C_1 cannot change instantaneously, the voltage at point A will drop to −12 v which turns on diode D_3, enabling C_1 to charge toward the +12-v supply with time constant R_1C_2.

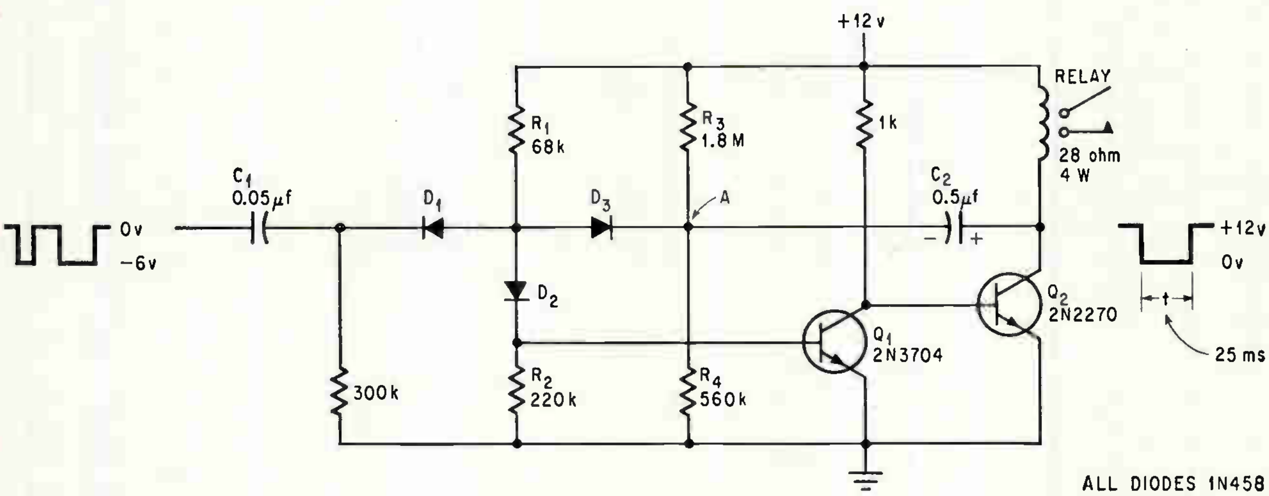


Conventional high-gain pulse amplifier generates output pulses whose duration is determined by the time and amplitude of input pulses together with time constant $R'_2C'_1$.

When the voltage at point A nears +0.6 v, the base of Q_1 turns on, terminating the output pulse and causing the relay to drop out.

The output pulse duration of 25 milliseconds is approximately 0.7 of the time constant R_1C_2, since C_1 stops charging when point A becomes slightly positive, far below the charging potential of +12 v. Resistors R_3 and R_4 are large with respect to R_1 so their contribution to the charging (and hence to the timing) is negligible; they are in the circuit to provide back bias for D_3 when the circuit is in its stable state. The relay's on-time can be adjusted by replacing R_2 with a potentiometer.

A desirable feature of this circuit is that the turn-on time of the relay is very sharp. However, the turn-off time is slightly exponential. The exponential condition does not cause any problems during normal operation of the circuit for any of the intended applications of the relay.



Modified circuit generates a fixed output pulse of 25 milliseconds for each input pulse.

Army's Electronics Command, Ft. Monmouth, N.J., if he were to design a low-power local oscillator today, he says he would choose the avalanche diode over the Gunn device. "The major reasons are better reliability, better yield and better [lower] cost," says Brand. For a higher power pulsed radar, however, Brand says he would look more closely at the Gunn and LSA mode devices.

The LSA device, since it is not a transit-time device, can be made thick enough to take high voltages and thus deliver high power. The conventional Gunn unit, as a transit-time device, must be kept thin for high microwave frequencies, which limits its power capabilities.

The limited space-charge accumulation device suppresses the Gunn mode and operates as a bulk negative resistance which, when properly biased and driven, provides power at a frequency determined by the external resonant circuit and not by the device itself. Rudolf Engelbrecht, head of Bell's microwave integrated device department, compares it, in a gross sense, to a giant tunnel diode, in that its volt-ampere characteristic is similar to the tunnel diode's, biased on the negative-resistance portion of the curve to allow oscillations in the circuit. The LSA device, however, doesn't have a junction whose width limits the available power from tunnel diodes. The only limitation of the LSA device is that the voltage must swing back over the current hump during each cycle to quench the space charge that would build up to force the device to operate in the Gunn mode.

If he were questioned six months ago, says Brand, he would probably have said that the first bulk gallium-arsenide devices in general use would be the original Gunn type. Now, however, he believes the LSA mode could conceivably leapfrog its predecessor and be used first because of its high peak power, reasonable efficiency, and the possibility of easy tuning.

The new devices will affect varactor multipliers in cases where frequencies near X-band are needed. At this frequency, where several stages of varactors are needed, Gunn devices can operate directly. Present efficiencies of the two systems, though, still are comparable.

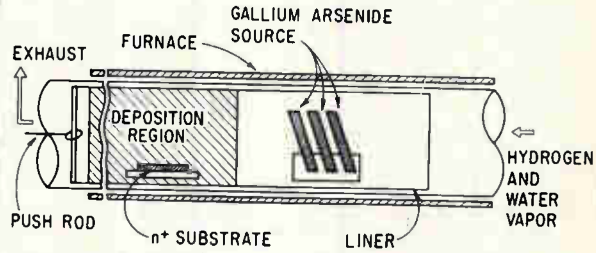
Much more can be done with Gunn-effect devices beyond supplying microwave power. Since an electric field controls the operation of the device, researchers are studying methods of shaping the electric field by means of device geometry. A variable voltage to modulate or sweep the frequency of the device is a likelihood. The high-resolution mask-making capability of semiconductor manufacturers suggests that a high level of dimensional control of the devices is possible.

But the immediate problem is to design devices to perform predictably. To reach this point, more research on the materials and contacts is needed.

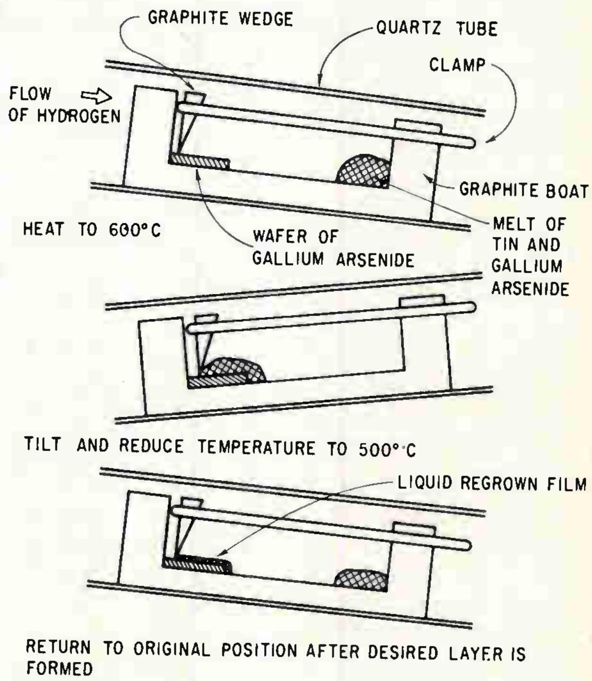
Better materials technology needed

While gallium arsenide has been used in many semiconductor devices, the effort expended on de-

Growing the layers . . .

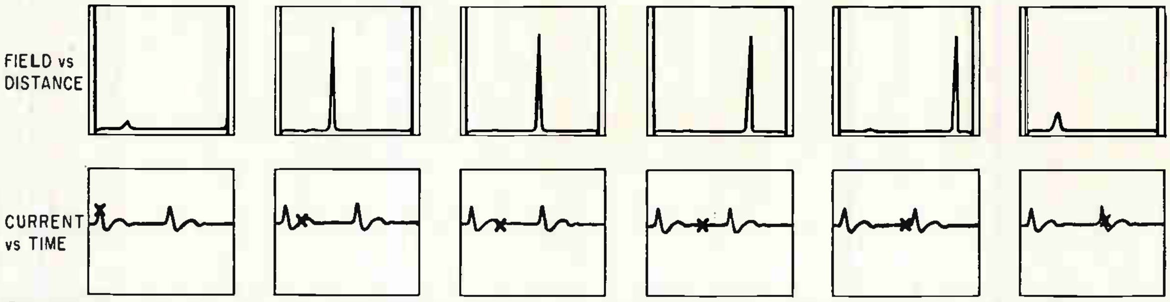


Hydrogen-water vapor process has been successfully used at Bell Telephone Laboratories to epitaxially grow an intermediate-resistivity active layer on a low-resistivity n^+ substrate. The gallium-arsenide source is maintained at 1,050°C and the substrate at 1,000°C. A mixture of hydrogen and water vapor enters one end of the tube and flows over the GaAs, forming gases of gallium sub-oxide and arsenic. When these gases flow into the lower temperature region containing the substrate, they reform into GaAs and water vapor. The water vapor exhausts from the tube while the GaAs deposits onto the substrate.



Liquid-regrowth process is used at Bell Labs to grow the low-resistivity n^{++} layer on the active layer which was grown in the hydrogen water-vapor process. A graphite wedge holds the n-type gallium arsenide in place at one end of the boat and a melted solution of tin and GaAs is placed at the other end. Hydrogen is admitted into the reaction tube to prevent formation of gallium oxide. The boat is first tilted while the temperature is increased to 600°C and then is tilted back to allow the melt to run onto and cover the wafer. The boat then is cooled to 500°C and as it cools, the gallium arsenide precipitates from the melt and deposits on the wafer to form the n^{++} layer.

Simulating the Gunn Effect



Several frames of computer-produced motion picture show how the dipole layer propagates through the sample after being nucleated at a point where the doping is 10% lower than the doping throughout the rest of the sample. The X's on the current curve show the current at the instant which is pictured in the field distribution plot. The time between frames is about 0.6 nanosecond. The repetition frequency is 680 megahertz.

Some of the most important research on Gunn effect is being done at the computer console, not the lab bench. Engineers are gaining a wealth of knowledge from computer simulations by Dean E. McCumber and others at Bell Telephone Laboratories. The new limited space-charge accumulation mode, for example, was identified by Bell's John Copeland while working on a computer simulation of the Gunn effect.

The basic, observed facts of the Gunn effect are: when the d-c voltage impressed across a small sample of gallium arsenide is slowly increased, the current rises at first according to the material's normal positive bulk resistance, but at a particular critical voltage, the sample suddenly begins to produce a high-frequency current oscillation. Capacitive probe measurements made by J.B. Gunn at IBM showed that a dipole layer was moving through the sample at a velocity of about 10^7 centimeters/second, and that the time needed for one passage through the device corresponded to the period of the oscillations. For example, a 0.01 cm-long device oscillated at 10^9 hertz, or 1 gigahertz.

The Gunn effect is seen only in semiconductors having two electron conduction bands separated by an energy gap. The normal conduction band is at the lower energy level. In the higher conduction band, electrons have a lower mobility, but in normal operation this state is unfilled. A high electric field can excite electrons to the higher-energy, lower mobility band. As the electric field is increased from zero, the current increases at first as the normal conduction band electrons are accelerated. But as the field is increased further, more electrons are excited to the lower-mobility band where they move more slowly. The net effect: overall current tends to decrease with increasing voltage and the material is said to have a negative resistance.

Repeats itself. This kind of situation is unstable. Any deviation in charge concentration will cause the building up of a charge accumulation layer and a depletion layer. For example, at a point where the electron density suddenly decreases due to, say, nonuniform doping, the field will increase and the electrons will move more slowly. (On the negative resistance portion of the characteristic, increased field produces decreased current.) Thus, at the edge of the depletion layer nearer the negative electrode, electrons traveling toward the positive electrode tend to accumulate and the accumulation layer grows; at the edge nearer the positive electrode, electrons tend to move away from the depletion layer faster than they move into the layer, so the depletion layer grows. The layers move across the sample at the average electron drift velocity until they reach the positive electrode, where they disappear. Then a new accumulation-depletion layer appears and the process repeats itself.

Working from the basic field and charge-continuity equations and the doping and energy band structure of the material, McCumber programed the computer to produce the internal field pattern and oscillating current waveforms on a cathode-ray tube. These clearly show the dipole layer moving through the device.

The crt display of the computed field distribution at each instant can be photographed and the photos sequenced to produce a motion picture of the field's movement through the device. Bell researchers used a Stromberg-Carlson microfilm recorder to photograph the output display from an IBM 7094 computer and produced movies of the device's operation. The film has been shown at technical meetings.

Transactions award. The computer studies show that the moving dipole layer originates, or nucleates, at a point where the doping level of the sample deviates from the average doping level. Although measurements on the first samples showed an approximate relationship between frequency and sample length, the computer studies show how the frequency depends on the length of the dipole path. If the dipole layer is nucleated at one end, then the period would be equal to the transit time from one end of the device to the other. However, if the dipole nucleates at a point inside the sample, then the path length will be less and the frequency higher.

A flip-page sequence of the film's individual frames was published in the January 1966 issue of the IEEE Transactions on Electron Devices. For their paper accompanying it, McCumber and A.G. Chyonweth—also of Bell—will receive the W.R.G. Baker Prize at the IEEE convention this month for the year's outstanding Transactions paper.

■ 140 mw continuous wave at 6 Ghz at TI, Dallas, where devices are reported to have been subjected to 3,500 hours of test operation.

■ 10 mw c-w at 10 Ghz with efficiency of 0.5% at Mullard, London. Carrying out the work in conjunction with the Royal Radar Establishment in Malvern, the Gunn-effect oscillators have been used as local oscillators in radar systems and as pumps for parametric amplifiers.

■ 100 mw c-w at 8 to 12 Ghz and 5 to 10 mw at 24 Ghz with 2 to 3% efficiency at Japan's Nippon Electric Co. The life of these epitaxial devices appears to be good, with the company reporting continuous operation in excess of 700 hours with 10 mw output. Nippon engineers say the resistivity of the undoped epitaxial material increases with increasing temperature, which decreases the input current and thus prevents thermal runaway.

■ 120 mw c-w in S band with 18% efficiency at the Westinghouse Electric Corp.'s Aerospace division in Baltimore, Md., where a Read avalanche diode oscillator also has been operated in X band, delivering 240 mw c-w with 3.8% efficiency.

■ 60 mw c-w at 13.5 Ghz at Raytheon. Pucell calls conventional packages unsatisfactory for Gunn devices—"We'd like to expand the holder in a way that does not forfeit high-frequency performance." Two methods are being tried: mounting the chip on a waveguide wall and making a package resonant to the desired frequency and coupling it to the cavity structure. Neither method will sacrifice high-frequency performance, says Pucell. But for c-w operation, the most serious problem is appropriate heat-sinking. "We need an ingenious way of getting heat out of the top and the bottom of the device," says Pucell.

■ 1 kw peak at 1 Ghz at NASA's Electronics Research Center, Cambridge, Mass. "We don't know if this is a single frequency pulse or not," says Harold Roth, head of advanced research. "When it runs that high, it's difficult to see separate frequencies." Roth suspects that this diode was operating in the LSA mode, but the results were obtained before the LSA mode was identified. "Now we're looking specifically for LSA operation," adds Roth. A Gunn transmitter using pulse rate modulation has been tested. The device was driven by a pulse circuit triggered by a modulated, voltage-controlled oscillator.

■ 15 w peak in the 4 to 7 Ghz range, with efficiency about 2.5% at Standard Telecommunications Laboratories, Harlow, Essex, England. Frequency stability with time and temperature was found to be largely determined by the cavity. The shape and the construction of the cavity, it is reported, also affects the noise.

■ 2 w peak at 10 Ghz with 0.5 microsecond pulses and an efficiency of 9% at Lincoln Laboratory. "It's a question of power dissipation," says Foyt. "You can't get rid of more than a few watts." But in the LSA mode, Foyt adds, it may be possible to get away from dimensional problems and thereby get more heat out.

■ 1.5 w peak at X band at Motorola Inc.'s aerospace center at Scottsdale, Ariz. "It is not a transit-mode type of operation," says Tony Kallas, Gunn-effect project leader, noting that the 45 to 50-volt input was well above the transit-time voltage. "By going to a higher voltage, you can get a higher power output, but efficiency is only about 1%," he says. "Reproducibility is now very, very poor." Motorola's preliminary objective is to reproduce a 10-watt output and then extend this to 400 watts by paralleling several chips. It feels it has solved the heat sinking problem on peak powers up to 100 watts by thermally bonding the chip to a heat sink on its lower side. The upper contact is a low-inductance bellows contact. "Before we developed this system, we were burning contacts out one after the other," Kallas says.

Motorola also is investigating the use of a Gunn-effect device in the construction of microcircuit modules in an active phased array configuration to drive a phased-array antenna. The goal is 1- to 5-watt output in X band. "We think we will have circuits for prototype demonstration by the end of the year, particularly in phased arrays," says Kallas. He expects Gunn-effect devices will be in general use in the field in 18 to 24 months.

Comparing Gunn-effect devices with avalanche type devices, Kallas sees greater power potential in Gunn devices because of the greater area available compared with the small active area of the junction devices. However, at present, the results with junction devices are much easier to reproduce because the technology is more advanced.

Says Kallas: "Once they [Gunn devices] are in production, costs will be considerably less than conventional devices, such as ceramic triodes."

But regardless of the promise shown by Gunn devices, NASA's Carol Veronda, head of microwave circuits research, says the Electronics Research Center will continue working on tubes and other solid-state sources. He points out that "if people had given up triodes when the traveling-wave tube was invented, we would have missed out on the higher frequency, better performing triodes that came along."

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For a history of the Gunn effect see:
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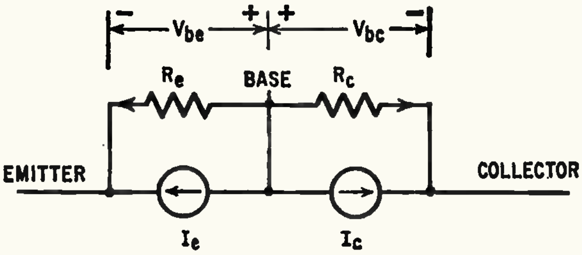
Active circuit models

TRANSISTOR MODEL



Transistor equations:

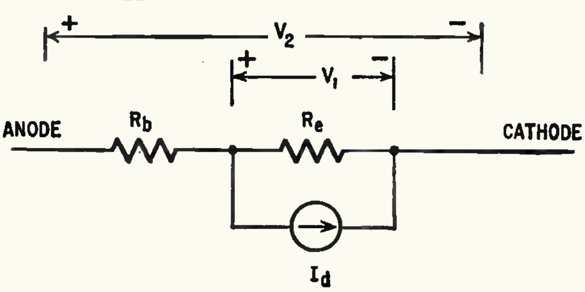
$$I_e = I_{es}\left(e^{\frac{qV_{be}}{M_e kT}} - 1\right) - \frac{\beta_R}{\beta_R + 1} I_{cs}\left(e^{\frac{qV_{be}}{M_c kT}} - 1\right)$$

$$I_c = I_{cs}\left(e^{\frac{qV_{be}}{M_c kT}} - 1\right) - \frac{\beta_F}{\beta_F + 1} I_{es}\left(e^{\frac{qV_{be}}{M_e kT}} - 1\right)$$

Definition of terms:

I_{cs}, I_{es} = Saturation currents
q = Electronic charge
k = Boltsmann constant
T = Absolute junction temperature
β_F = Forward beta gain
β_R = Reverse beta gain
M_e, M_c = Constants determined empirically

DIODE MODEL



Diode Equations:

$$I_d = I_s\left(e^{\frac{qV_1}{MkTN}} - 1\right)$$

$$V_2 \approx M\frac{kTN}{q}\log\left(\frac{I_d + I_s}{I_s}\right) + NI_dR_b$$

Definition of terms:

N = Number of diodes in series
R_b = Bulk resistance
R_e = Leakage resistance
I_s = Saturation current
M = A constant determined emperically
k = Boltzmann constant

Model for the transistor and the diode are used for d-c analysis. Equations represent current-source relations.

gram is based, each branch can have a voltage source, a dependent current source, an independent current source and a passive element (written as an impedance, or an admittance). Nonlinearities of the circuit branches are included in the dependent current source and solved by iterative procedure.

The equivalent circuit for the transistor model consists of two diodes, one each for the base-emitter junction and collector-base junction. It is a nonlinear version of the Ebers-Moll model and is similar to the model used in NET-1; however, it contains far fewer parameters. Capacitors have been removed since they are not pertinent to d-c analysis. To reduce computational complexity and the number of model elements that the operator must specify, the following parameters are omitted: the emitter-bulk resistance, base-spreading resistance and collector-bulk resistance. The dependency of the current gains β_F and β_R on junction voltages is also neglected.

All four regions of operation are covered by the model: cutoff, active normal, active inverted and saturation. The nonlinear equations for the dependent current sources appear on the diagram. These equations are combined with linear network equations and solved iteratively for the operating points of the transistors.

The equivalent circuit for the zener diode or a conventional diode model is represented by the same model. The zener diode operates in three distinct regions with each region described by an appropriate equation. The term N in the equations represents the number of series diodes.

When strings of series diodes are examined, it is usually the voltage drop across the entire chain that is of interest. Therefore, the equations were modified to account for the number of diodes in a series string. Thus, the desired effect was obtained without the addition of extraneous nodes that occur when each diode is examined individually.

Field effect transistors and other less conventional devices require different models than the program provides. Because of this, the program has been extended to allow the inclusion of linear equivalent circuit models with appropriate input data. However, these models must be constructed from the basic circuit branch. An equivalent circuit model for a transconductance, G_m, can also be inserted between branches. The transconductance sets up a dependent current source in one branch related to the voltage drop across the resistance in another. The equation is expressed by $I_d = G_m V$.

A nonlinear d-c analysis

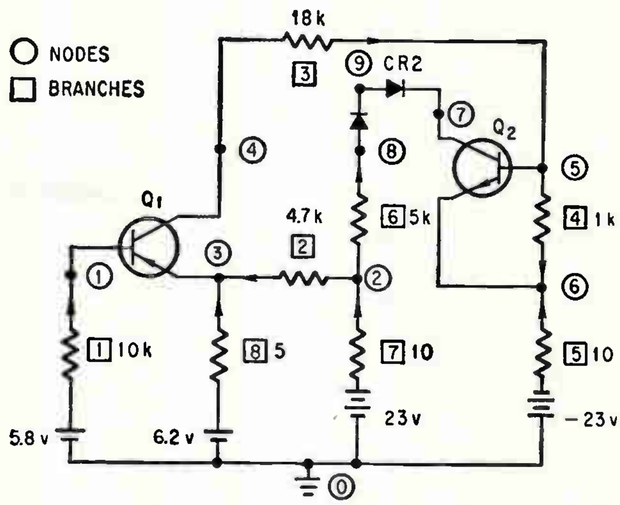
The capabilities of the program are best illustrated with a sample problem. In the problem circuit all nodes and branches are arbitrarily numbered. Additional nodes and branches are automatically inserted by the program where required for the equivalent models of the transistors and diodes.

The operator enters both control and general information—which describe the circuit—on the first

Nonlinear d-c analysis example

The sample circuit at the right contains nonlinear transistors and diodes. To begin the nonlinear d-c analysis of the circuit the operator arbitrarily numbers all the node points and branches—circled numbers for the nodes, boxed numbers for the branches. Then a description of all the branch-node connection data is entered in the three input cards that are shown below in abridged form.

Also entered on the cards are the values for the node voltages, transistor emitter saturation currents and diode currents, emitter and collector resistances, diode saturation currents, diode currents, bulk resistances, and diode leakage resistances.



RESISTOR	NODES FROM	TO	RESISTANCE-OHMS	± % R	VOLTAGE-VOLTS	± % E	CURRENT-AMPS
R 1	0	1	10. E+03		5. 8		
R 2	2	3	4700.	5.			
R 3	4	5	18. E+03	5.			
R 4	5	6	1000.	5.			
R 5	0	6	10.				
R 6	2	8	5000.	1.			
R 7	0	2	10.		−23.		
R 8	0	3	5.				
					23.		
					6. 2		

Branch-node resistor connection data for input card.

TRANSISTOR	NODES E	B	C	TYPE	BETA FORWARD NOM.	LOW	HIGH	BETA REVERSE	EMITTER 1. SAT. CURRENT	EMITTER 2. DIODE CURRENT	COLLECTOR 2. DIODE CURRENT	EMITTER LEAKAGE RESIS.	COLLECTOR LEAKAGE RESIS.
Q1	3	1	4	P	60.	30.	90.	.8	5. E−09	.001		1. E+06	2. E+06
Q2	6	5	7	N	60.	30.	90.	.8	1. E−08	.005		1. E+06	2. E+06

Transistor connection and parameter data for input card.

DIODES	NODES ANODE	CATHODE	SATURATION CURRENT	CURRENT	BULK RESISTANCE	LEAKAGE RESISTANCE	NO
CR1	8	9	1. E−12	.005	10.	1. E+06	1.
CR2	9	7	1. E−12	.005	10.	1. E−06	1.
CR1+2	8	7	1. E−12	.005	10.	1. E+06	2.

ALTERNATE METHOD OF CODING, FORMING A STRING OF DIODES AND ELIMINATING NODE 9

Diode connection and parameter data for input card.

BREAKDOWN OF VARIANCE (PERCENT)

PARAMETER	NODE 1	NODE 2	NODE 3	NODE 4	NODE 5	NODE 6	NODE 7	NODE 8	NODE 9	NODE 10
R 1	0.00E-99	0.00E-99	0.00E-99	0.00E-99	0.00E-99	0.00E-99	0.00E-99	0.00E-99	0.00E-99	
R 2	8.29E-01	8.01E+01	2.97E+01	1.27E-02	9.73E-03	9.17E-03	1.18E-02	1.26E-02	1.23E-02	
R 3	3.01E-01	5.34E-05	2.13E-01	1.42E+00	2.81E-01	2.75E-01	2.60E-01	2.44E-01	2.54E-01	
R 4	2.82E-09	9.20E-05	1.15E-09	1.41E-08	4.23E-02	4.37E-05	5.64E-01	5.29E-01	5.50E-01	
R 5	0.00E-99	0.00E-99	0.00E-99	0.00E-99	0.00E-99	0.00E-99	0.00E-99	0.00E-99	0.00E-99	
R 6	5.87E-08	1.97E+01	2.64E-05	2.07E-06	7.22E+00	9.54E+00	9.01E-01	7.07E+00	3.32E+00	
R 7	0.00E-99	0.00E-99	0.00E-99	0.00E-99	0.00E-99	0.00E-99	0.00E-99	0.00E-99	0.00E-99	
R 8	0.00E-99	0.00E-99	0.00E-99	0.00E-99	0.00E-99	0.00E-99	0.00E-99	0.00E-99	0.00E-99	
E 1	0.00E-99	0.00E-99	0.00E-99	0.00E-99	0.00E-99	0.00E-99	0.00E-99	0.00E-99	0.00E-99	
E 5	0.00E-99	0.00E-99	0.00E-99	0.00E-99	0.00E-99	0.00E-99	0.00E-99	0.00E-99	0.00E-99	
E 7	0.00E-99	0.00E-99	0.00E-99	0.00E-99	0.00E-99	0.00E-99	0.00E-99	0.00E-99	0.00E-99	
E 8	0.00E-99	0.00E-99	0.00E-99	0.00E-99	0.00E-99	0.00E-99	0.00E-99	0.00E-99	0.00E-99	
BF 1	9.88E+01	1.75E-02	7.00E+01	9.85E+01	9.22E+01	9.01E+01	8.54E+01	8.01E+01	8.33E+01	
BF 2	1.09E-08	2.08E-03	1.34E-09	5.96E-08	1.79E-01	1.00E-03	1.28E+01	1.20E+01	1.24E+01	

MANDEX WORST-CASE ANALYSIS, NODE 5 HIGH

NO. OF ITERATIONS = 2

NODE VOLTAGES ARE

1= 5.894E+00, 2= 2.287E+01, 3= 6.212E+00, 4=-2.194E+00, 5=-2.254E+01,
6=-2.289E+01, 7=-2.282E+01, 8=-2.146E+01, 9=-2.214E+01,

STRESS ANALYSIS

BRANCH	CURRENT	VOLT-BRANCH	VOLT-COIL	POWER-DISSIPATED	POWER-BRANCH
1	-9.444E-06	-5.894E+00	-9.444E-02	8.919E-07	5.566E-05
2	3.731E-03	1.666E+01	1.666E+01	6.216E-02	6.216E-02
3	1.189E-03	2.034E+01	2.034E+01	2.421E-02	2.421E-02
4	3.389E-04	3.558E-01	3.558E-01	1.206E-04	1.206E-04
5	-1.014E-02	2.289E+01	-1.014E-01	1.029E-03	-2.323E-01
6	8.957E-03	4.434E+01	4.434E+01	3.972E-01	3.972E-01
7	1.268E-02	-2.287E+01	1.268E-01	1.610E-03	-2.902E-01
8	-2.531E-03	-6.212E+00	-1.265E-02	3.205E-05	1.572E-02

SUMMATION OF BRANCH POWERS =-2.311E-02 WATTS

TRANSISTOR ANALYSIS

NO.	STATE	VBE	VBC	VCE	IE	IB	POWER
1	-ACT-NOR	-3.182E-01	8.088E+00	-8.407E+00	-1.199E-03	-9.444E-06	1.000E-02
2	- SAT	3.558E-01	2.832E-01	7.261E-02	9.808E-03	8.510E-04	9.533E-04

DIODE ANALYSIS

NO.	STATE	VOLTAGE	CURRENT	POWER
1	- ON	6.786E-01	8.957E-03	6.079E-03
2	- ON	6.783E-01	8.957E-03	6.076E-03

TOTAL POWER DISSIPATED IN CIRCUIT= 5.095E-01 WATTS

MANDEX WORST-CASE ANALYSIS, NODE 5 LOW

NO. OF ITERATIONS = 3

NODE VOLTAGES ARE

1= 5.913E+00, 2= 2.289E+01, 3= 6.213E+00, 4=-1.129E+01, 5=-2.257E+01,
6=-2.292E+01, 7=-1.416E+01, 8=-1.285E+01, 9=-1.351E+01,

STRESS ANALYSIS

BRANCH	CURRENT	VOLT-BRANCH	VOLT-COIL	POWER-DISSIPATED	POWER-BRANCH
1	-1.130E-05	-5.913E+00	-1.130E-01	1.278E-06	6.686E-05
2	3.380E-03	1.668E+01	1.668E+01	5.638E-02	5.638E-02
3	5.970E-04	1.128E+01	1.128E+01	6.738E-03	6.738E-03
4	3.651E-04	3.468E-01	3.468E-01	1.266E-04	1.266E-04
5	-7.677E-03	2.292E+01	-7.677E-02	5.894E-04	-1.759E-01
6	7.080E-03	3.575E+01	3.575E+01	2.531E-01	2.531E-01
7	1.046E-02	-2.289E+01	1.046E-01	1.094E-03	-2.394E-01
8	-2.771E-03	-6.213E+00	-1.385E-02	3.841E-05	1.722E-02

SUMMATION OF BRANCH POWERS =-8.179E-02 WATTS

TRANSISTOR ANALYSIS

NO.	STATE	VBE	VBC	VCE	IE	IB	POWER
1	-ACT-NOR	-3.007E-01	1.720E+01	-1.750E+01	-6.084E-04	-1.130E-05	1.045E-02
2	-ACT-NOR	3.468E-01	-8.410E+00	8.757E+00	7.312E-03	2.319E-04	6.208E-02

DIODE ANALYSIS

NO.	STATE	VOLTAGE	CURRENT	POWER
1	- ON	6.534E-01	7.080E-03	4.626E-03
2	- ON	6.535E-01	7.080E-03	4.627E-03

TOTAL POWER DISSIPATED IN CIRCUIT= 3.999E-01 WATTS

MANDEX ANALYSIS COMPLETED

standard deviation for node voltage v. The term $\partial v/\partial P_i$ is the partial derivative of the node voltage with respect to the i-th parameter and σP_i is the standard deviation of the i-th parameter. The formula is valid only for small excursions about the nominal values of the node voltages, but requires less input information on parameter distributions and far less computing time than a more sophisticated Monte-Carlo analysis. The outputs of this analysis are the standard deviation, variance and the 1-sigma and 3-sigma limits for each node voltage. The 1-sigma limit is obtained by adding the standard deviation to the nominal value of the node voltage, with the corresponding operation for the 3-sigma limits.

Examination of the outputs indicates whether circuit voltage excursions due to parameter variations will remain within specified limits. The "breakdown of variance" printout lists the percent contribution of each parameter to the variance of the node voltage and shows which parameter tolerances are most critical. These are obtained by dividing each parameter in the propagation of variance formula by the total variance, σ_v^2. By scanning the printout for a particular node, the designer can find the parameters that cause most of the variance.

Conversely, it is possible to determine the parameter tolerance that yields a desired value of variance for a particular node voltage. With this information the circuit is easily optimized with respect to design centers and parameter tolerances. This reduces the amount of overdesign that often occurs when only sketchy information is available for parameter tolerances on circuit performance.

The last optional routine in the sample problem is the "Mandex worst-case analysis." This analysis is helpful where large tolerance extremes are encountered. The approximate solution obtains worst-case limits by summing the contribution of each parameter tolerance to the worst-case limit. The formulas are

$$\Delta_v = \sum_{i=1}^{N} \frac{\partial v}{\partial P_i} \Delta P$$

$$V_{wc} = V_{nom} \pm \Delta V$$

where V_{wc} is the worst-case limit, and ΔP is the parameter tolerance expressed as the tolerance extreme minus the nominal value of the parameter. The solution breaks down for nonlinear circuits with large parameter variations because the partial derivative is not constant throughout the range of the variation.

The Mandex analysis obtains a new nominal solution with all parameters set to their tolerance extremes. It requires more computer time to obtain the worst-case limits but gives more accurate results.

A Mandex analysis was run for node 5 in the sample problem and the results are tabulated. The analysis is made first for node 5 at its high (maximum) value and then for the low (minimum) value. The values for all the node voltages are given along with the stress, transistor and diode analyses. This additional information may show overstressed components even for the node voltage that is within worst-case tolerance limits.

A comparison of the approximate worst-case minimum and maximum values with the Mandex high and low values for node 5 is:

Node 5

	Mandex	Approximate	
High	−22.54	−22.54	Maximum
Low	−22.57	−22.55	Minimum

The small tolerances on the circuit's parameters caused the node voltage is almost identical for both analyses. This would not be the case, however, if the tolerances had been large, i.e. 10-20%.

It should also be noted that the Mandex analysis for the low value on node 5 shows that transistor 2 has changed state, whereas no indication of this was given in the approximate analysis.

Communication—still a stumbling block

One of the biggest bottlenecks to the efficient use of circuit analysis is man-machine communication. Normally several computer runs are required per circuit to correct input errors and to investigate the effects of design modifications. With each computer run the user must contend with delays associated with the mechanics of getting a job run. Also, it is difficult for him to gain insight into a circuit's operation by looking at printouts.

Norden is planning to add on-line graphics to its circuit analysis programs. This will enable the user to correct input errors and make modifications directly with a light pen on a cathode-ray-tube display console. Thus, as fast as the modifications can be made they will appear as program outputs displayed directly on the crt. With the display console time-shared with the central processor, the computer can be doing other jobs while the user is observing outputs on the crt and deciding what to do next. Time sharing will make on-line operation economically feasible.

An experimental version of ECAP with on-line graphics has already been developed at IBM. Thus, the trend to graphics combined with circuit analysis programs is already started.

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Integrated circuits in action: part 5 In search of the ideal logic scheme

Dilemmas galore confront the uninitiated designer trying to pick the logic form that is best for his application

By Donald Christiansen
Senior editor

The history of the integrated circuit is a short one but already many logic schemes have been proposed and a score of them have been fabricated. Trying to make sense of the mishmash has caused sleepless nights for the prospective user of IC's.

Circuit experts, on the other hand, maintain things are a good deal simpler than they appear. For example, if consideration is restricted to bipolar gate topologies, they note, there are just three basic forms of IC logic schemes. They are: collector-coupled, input-coupled inverter, and emitter-coupled logic. The types are also known as current sourcing, current sinking, and current mode, respectively.

Sourcing and sinking

In those types of logic classified as collector-coupled or current-sourcing, current flows from the output of a circuit and is forced into the input of a similar circuit to activate the circuit which it drives.

Input-coupled or current-sinking logic types on the other hand, require that current flow out of the input of a circuit and back into the output of the preceding stage, which serves as a current sink instead of a source.

Finally, current-mode logic circuits can be either sink or source types. The salient point is that such circuits switch logic levels by assuming one of two active current modes. The circuits have common-emitter inputs and emitter-follower outputs.

Easy way in

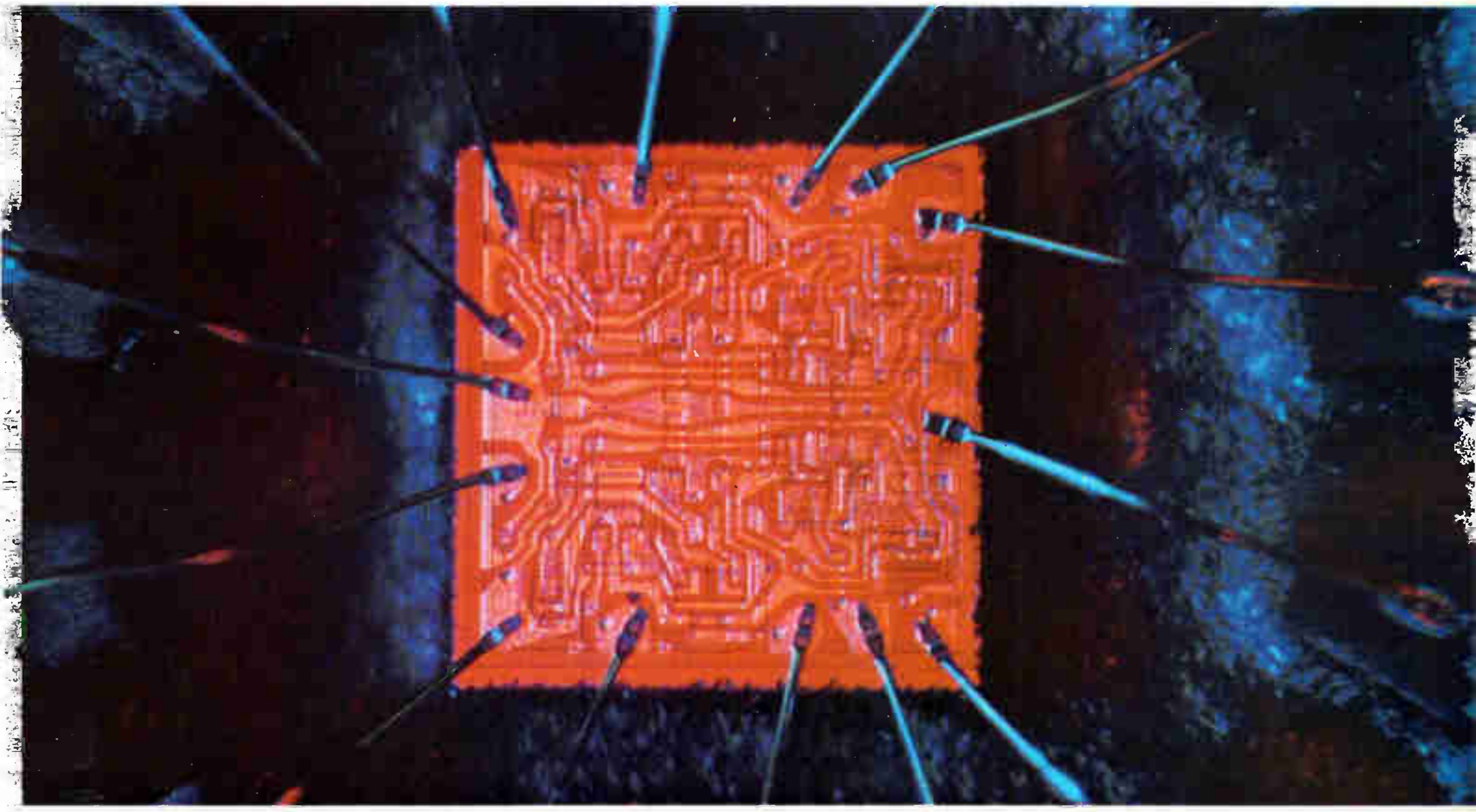
When IC designers first began building logic devices, they took the path of least resistance, converting directly from well-known and widely used discrete component logic schemes. One of the earliest formats was direct-coupled transistor logic (DCTL), shown in the schematic on page 150, a basic form of collector-coupled logic. An advantage of this logic is that power dissipation is low, but current hogging by one of several transistors which it is attempting to drive limits its usefulness. To overcome this shortcoming, the logic was modified by adding either resistor or resistor-capacitor coupling networks. The resulting circuits were resistor-transistor logic (RTL) and resistor-capacitor-transistor logic (RCTL), shown in the schematics on page 150. RTL was popularized by Fairchild Semiconductor, a division of Fairchild Camera & Instrument Corp. in its Micrologic lines. Texas Instruments Incorporated made its debut into the IC field with its Series 51 RCTL line. RCTL differs from RTL chiefly in the use of small speedup capacitors across the input resistors. The resistors in commercial RTL circuits are significantly smaller than those in RCTL circuits, and the signal swing for RTL is about a volt compared to 6 volts for RCTL. As a result, the problem of noise rejection is more serious in RTL, though it can be improved at the expense of fan-out.

Less noise

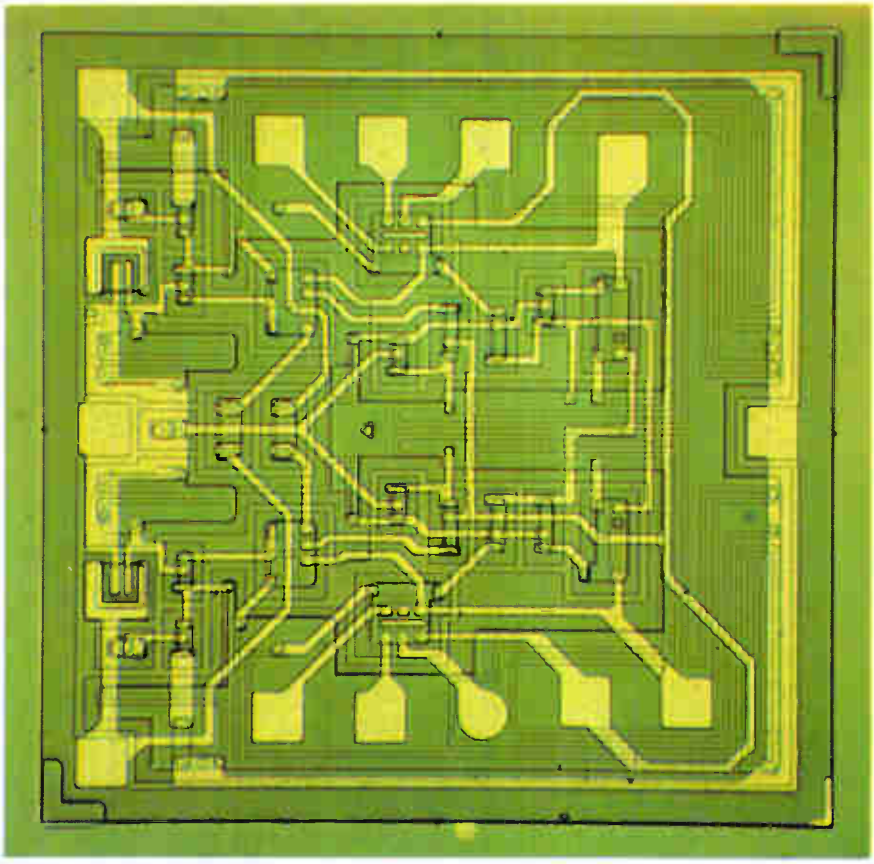
Attempts to improve noise margin resulted in the development by the Signetics Corp., a subsidiary of the Corning Glass Works, of the first input coupled logic scheme, diode-transistor logic (DTL), whose basic schematic is shown on page 150. In this circuit, R_3 and C form a dynamic battery whose purpose is to set the input threshold level of the gate.

Usually R_3 and C are replaced by one or more diodes. What is sought is a fast turnoff of Q_1. Therefore, the coupling diodes should be charge-storage diodes (unlike the input diodes). Since the two types of diodes are hard to achieve in a mono-

Flip-flops: designer's mainstay

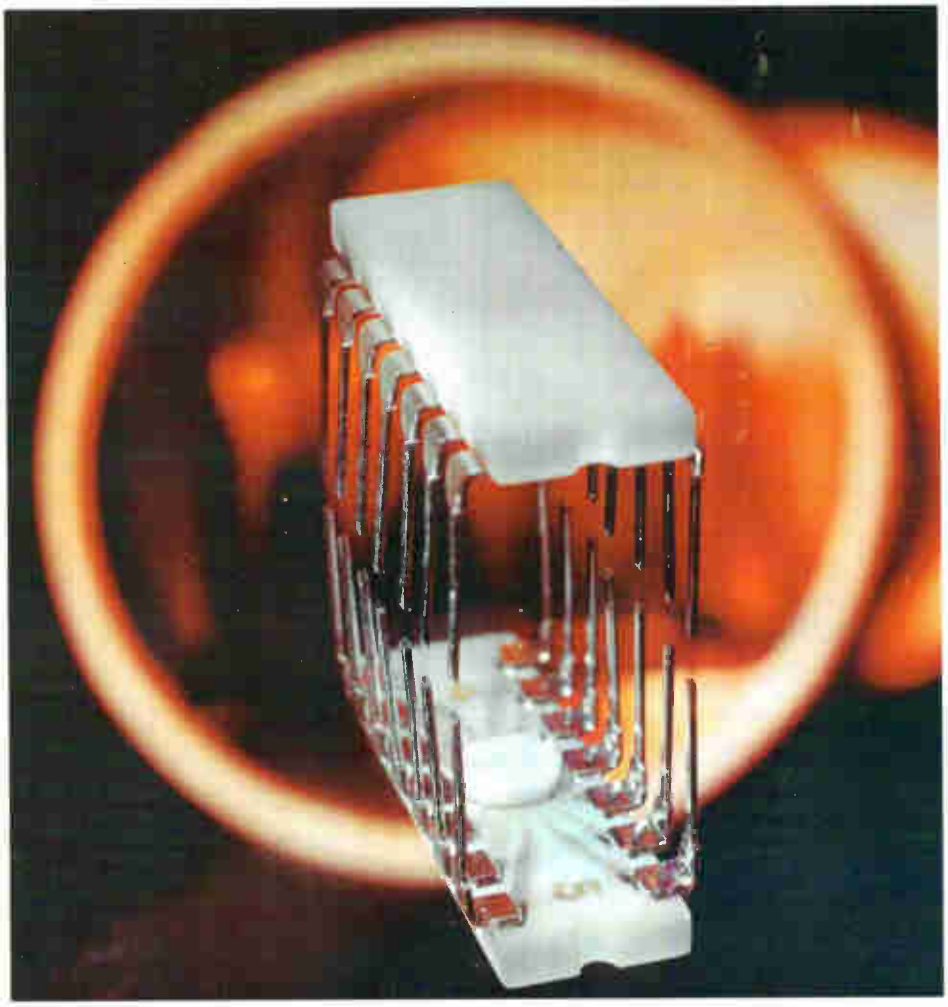


Dual J-K flip-flop contains 28 transistors, 38 resistors. The RTL device is a complete general-purpose storage element designed by Fairchild Semiconductor for industrial shift registers and binary counters.

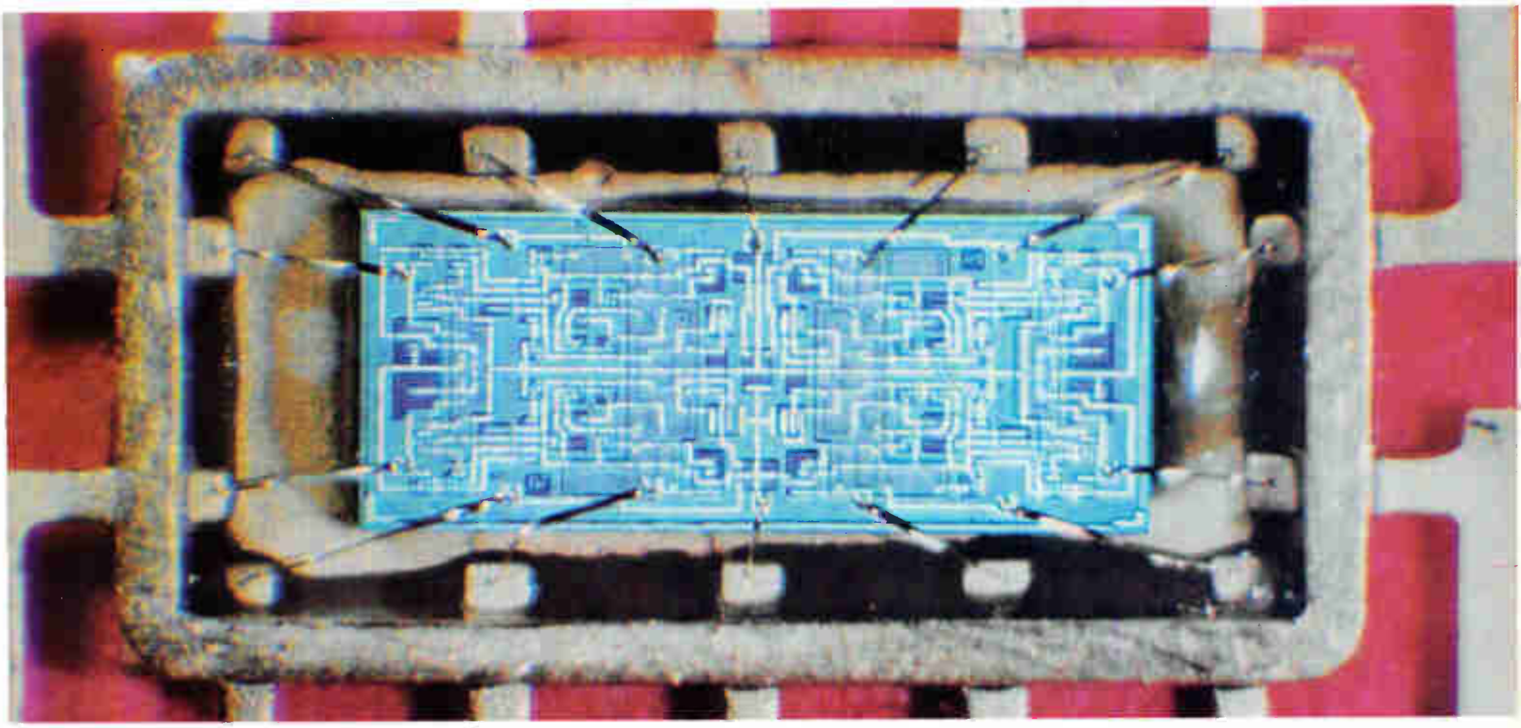


Master-slave flip-flop in new low-power TTL line, series 54L, will be introduced by Texas Instruments at the IEEE show and convention.

Cracking the consumer and industrial markets



New ceramic dual in-line package containing DTL IC's will be exhibited by Fairchild at the IEEE show and convention. Circuit is contained on circular ceramic "button," bonded face down to join with fired-on lead pattern on underside of rectangular ceramic body. The package may help IC vendors reach avowed goal of supplying military-grade IC's at industrial and consumer price levels.



One of modified-DTL devices used in Cincinnati Milling Machine numerical control system is this dual J-K flip-flop, part of TI's series 73. Silicon slice contains total of 80 transistors, resistors, and capacitors.

label it, belatedly, complementary-transistor logic (CTL). The fan-out of the driving circuit is boosted by the pnp transistors. Q_3 is driven by Q_2 operating as a collector follower, and Q_1 provides extra gain, driving the succeeding stages through R_3 and permitting resistor tolerances up to 30%.

Low- or ZERO-level DTL output voltage is determined by the saturation voltage of the output transistor, and high-or ONE-level voltage is equal to supply voltage Vcc. Thus the voltage swing is basically large, leading to good noise immunity.

Of those logic types mentioned so far, DTL is unquestionably the most widely used.

TTL a comer

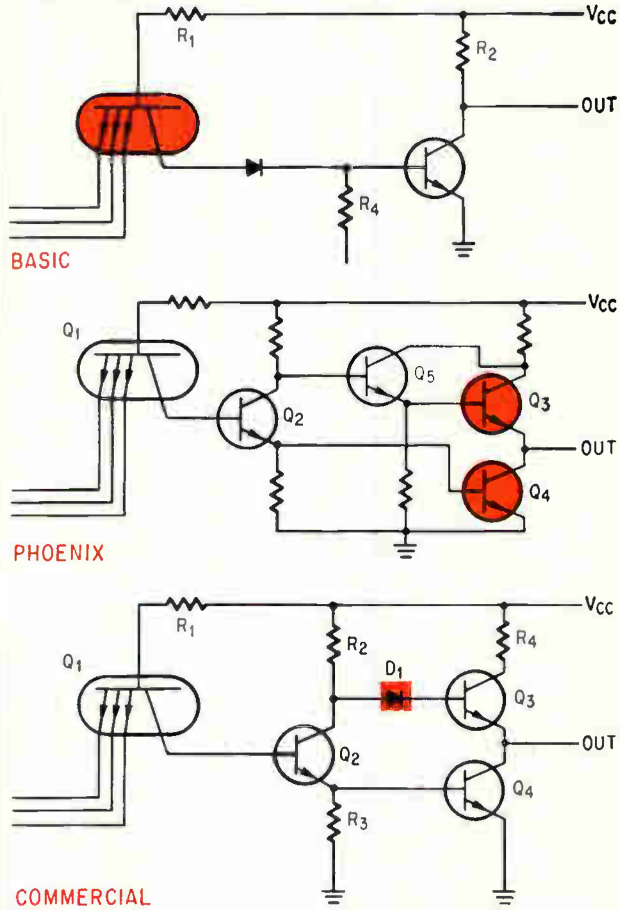
The logic type destined to become the workhorse of the industry, however, appears to be transistor-transistor logic (TTL), a direct descendant of DTL.

A shortcoming of DTL is that it is not fast enough for some applications. The input diode network and the first coupling diode of a DTL gate can be replaced by a multiple-emitter npn, top right. This decreases capacitance loading and as a result boosts speed. The resulting circuit is TTL (when first developed it was called transistor-coupled logic).

One of the early TTL circuits, dubbed the Phoenix gate because of its use by Litton Industries Inc. in the Phoenix missile, is shown at middle, right. In TTL, a low impedance path is developed through which Q_1 is discharged; after Q_1 is turned off, the collector of the multiple-emitter transistor effectively opens.

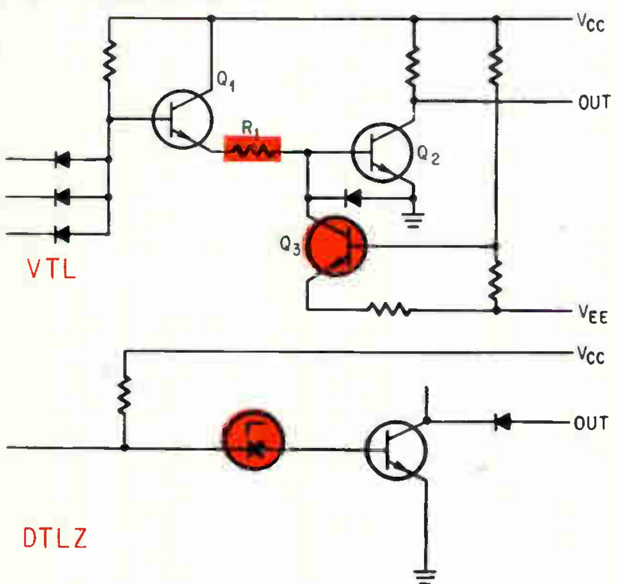
It is possible that high leakage of the multiple-emitter transistor may load a circuit excessively. To offset this, and to provide a charging current during both ON and OFF transient conditions under capacitive loading, the totem pole output stage is used. Totem pole refers to stacking Q_3 and Q_4; the output is thus driven through an active device during both rise- and fall-time, (through Q_3 and Q_4, respectively). Commercial versions of TTL are called high-level TTL because they provide a voltage swing of about 3 volts. Among them are the version produced by TI, Series 54, and the almost identical version shown above, made by the Sylvania Electronic Components Group, a division of the General Telephone & Electronics Corp., and the Transitron Electronic Corp. Note that the Darlington amplifier of the Phoenix gate has been omitted in favor of the single transistor Q_1. By avoiding the extra transistor and by altering the values of resistors, the manufacturers have reduced power dissipation

Input coupled logic: TTL



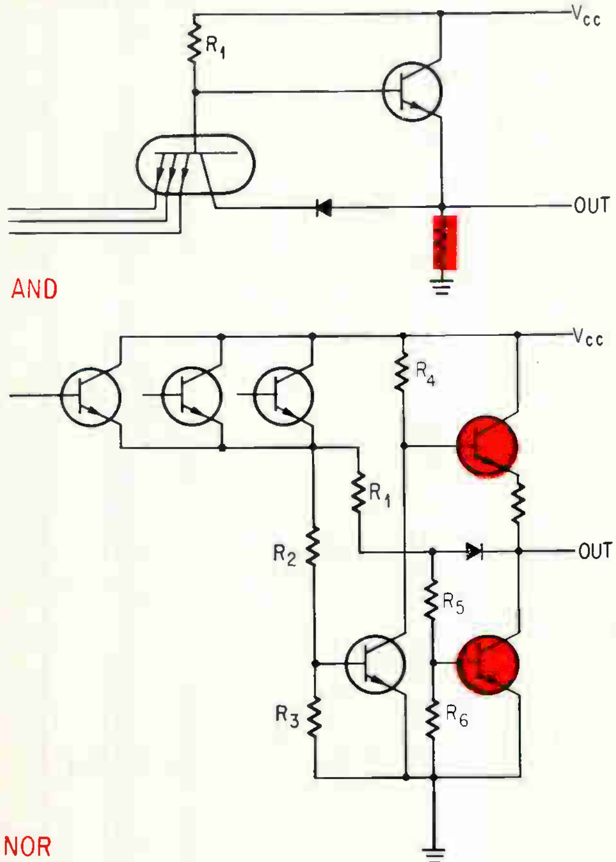
Popular form of current-sinking logic is transistor-coupled or transistor-transistor (TTL). Basic gate at the top shows how input diode network is replaced by multiple-emitter transistor at center, the Phoenix gate, with its totem pole output. Widely used commercial version at the bottom omits one transistor of the Phoenix gate to cut power dissipation.

DTL variations cut noise



Variable-threshold logic, at the top, in which supply voltages are set at high or low values to provide high or low noise rejection. R_1 replaces level-setting diodes of DTL, and Q_3 acts as constant-current source. Zener diode in the DTLZ circuit, below, replaces conventional diodes to boost noise threshold to about 6 v, but power and propagation delay zooms.

Hybrid method



AND gate, at the top, in "Utilogic" has noninverted emitter-follower output. NOR gate, at the bottom, has totem pole output, all npn transistors.

rent to R_1 and the output goes low.

Several transistors can be paralleled with transistor Q_1, forming an emitter-coupled npn gate at the input. The output will be the logic OR of the inputs or, if a resistor is placed in the common-collector circuit of the input and an emitter-follower stage added, as in the commercial version, illustrated on the opposite page, an inverted output (NOR) is provided.

CML is finding application in very high speed general-purpose computers. However its critics cite the need for multiple reference and power supply voltages and its relatively high power dissipation, particularly in lower speed applications.

Another deterrent to widespread use of CML is its incompatibility with all saturating types of logic.

One variation of CML is called current-mode complementary transistor logic (CMCTL). Its developers, Compagnie Europeene d'Automatisme et d'Electronique of France, claim very high speed, low package count and power consumption. The basic gate, opposite page, uses coupled emitters and a current-mode amplifier. The output is transmitted through emitter followers and the voltage level is restored by a current-mode amplifier. The circuit provides a logic swing of 1.1 volts and gives complementary logic outputs. Only one supply voltage is needed, and its tolerance need be no better than 10%.

Fairchild's complementary-transistor logic line (CTL or CTμL) can be classed as a current-mode type. Fairchild notes it was designed for use in simple circuit board or open transmission line systems. The inputs in the circuit, opposite page, require low voltage, a current sink to drive the output to its low level value, and a current source to drive it to its high level value. The pnp transistors, the company notes, have a low f_T of only about 30 Mhz, which helps avoid instability.

A problem encountered in some current-mode circuits, including CTL, is shifts in level due to a voltage gain of slightly less than unity. The result is an output voltage not quite equal to the input voltage, and after propagation of a signal through several stages, the logic level must be restored.

Hybrids

Not all designers believe that using a single logic scheme will necessarily provide the optimum system. The important thing, they point out, is to match logic levels, get the needed speed and keep power dissipation low.

Fortunately, there is good compatibility among saturating logic schemes. Fairchild Semiconductor has exploited this compatibility to pick and choose in order to come up with a line it calls compatible current-sinking logic (CCSL). The new line combines three families: TTL, DTL and low-power DTL. All are classed as current-sinking circuits, meaning circuits that accept current into their outputs from the circuits they drive. Each CCSL gate can drive or be driven by every other CCSL gate.

Signetics several years ago introduced a line of digital IC's called Utilogic.

Utilogic is a line built around a basic AND and a basic NOR circuit, displayed at top left. The AND has multiple-emitter inputs while the NOR has emitter-follower inputs. Output for the AND is an emitter-follower and, for the NOR, a totem pole arrangement. In the NOR circuit, the threshold levels are determined by the ratios of R_2/R_3 and R_5/R_6. The NOR gate will drive capacitive loads efficiently. Notice the similarity of the NOR gate to the TI Series 53 "modified DTL" line. Some engineers label it a variation of Series 53—one that does not require complementary transistors. Since the emitter-coupled input gate is npn, it performs the OR function for positive logic. Hence this is a DTL modification that performs NOR logic instead of the usual NAND logic.

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When monolithic diode-transistor logic (DTL) was introduced it copied discrete NAND circuitry, and began the present emphasis on NAND devices.

Easier than it looks

Any system can be built up from OR and NOT (NOR) circuits or from AND and NOT (NAND) circuits. A case in point is the Apollo program, which used NOR gates throughout in its first and second generation spaceborne guidance computers. Either scheme (NOR or NAND) uses inversion (NOT) in each gate. The inverter (a common-emitter amplifier circuit) provides power gain, which permits it to drive a number of other similar circuits. Thus it provides fan-out capability, or what is sometimes called logical gain. Furthermore, it serves as a logic-level restorer since its output is accurately determined by either its cutoff or saturation mode of operation, even though its input may range over wide values.

An ABC approach

Should the designer want to avoid a long, involved Boolean transformation, he may duplicate any natural AND-OR logic system using NAND circuits and inverters. NAND inputs are tied together or unused inputs are bussed to the positive supply or left open when an inverter is desired. An AND gate, for example, is made from a NAND followed by an inverter, above right. An OR is a NAND with an inverter ahead of each input, while an AND-OR combination is made from NAND's into another NAND. An OR-AND combination is more complex, requiring inverters working into NAND's, then into a NAND followed by another inverter. Fortunately, this combination rarely occurs in logic systems.

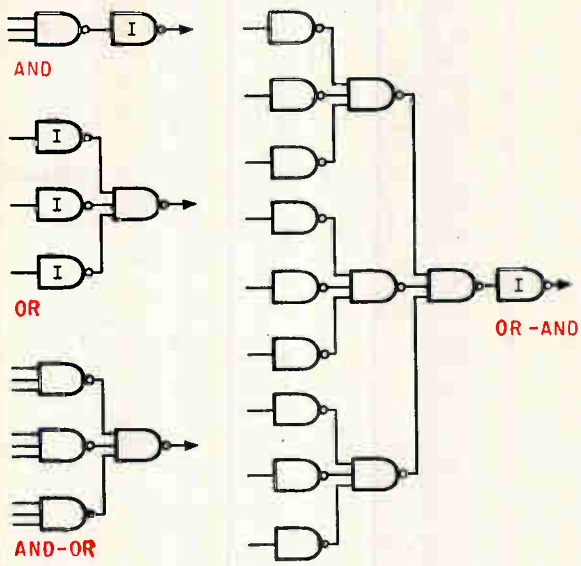
The AND-NOR function is available directly in several devices. A number of IC vendors provide such a device, page 160, with two 2-input AND gates into a NOR and call it an exclusive-OR gate.

A true exclusive OR provides a ONE output when one or the other but not both of its inputs is ONE. When the inputs are not of the same value a ONE output appears; similar inputs provide a ZERO. The AND-NOR device in question, on the other hand, provides the inverse; dissimilar inputs cause the ZERO output. Thus a better label would be "exclusive NOR." Furthermore, the device works only as an exclusive-OR if both inputs provide both regular and complementary signals, as in the diagram on page 160. If complementary signals are not available, two additional input inverters are required.

Fun with flip-flops

A flip-flop is essentially a pair of cross-coupled inverters in which a high output of one holds the output of the other low, and vice versa. A flip-flop remains in a stable state until externally triggered. Alone it is useless; its value is determined solely by its input gating. The simple flip-flop, page 160, is made from two NOR gates. The Q output is low and the $\overline{Q}$ output is high in the normal or ZERO state. The leading edge of a momentary positive pulse applied to either the S or P input turns

A universal approach



Using only NAND gates, such as in TTL circuitry, AND gate, OR gate, AND-OR, and OR-AND can be produced. For the AND, a NAND is followed by an inverter; in the OR, inverters precede a NAND; and AND-OR is made up entirely of NAND's; and the OR-AND is three stages of NAND's followed by an inverter.

the OFF side to ON, reversing the flip-flop. In this new state (the ONE state), Q is high and $\overline{Q}$ is low. A simple change in d-c level cannot be used as a trigger because it locks up the flip-flop against further changes; a pulse is a must. Reset to the ZERO state results from a pulse on the R or C lines.

While discrete-component flip-flops are a-c gated, IC flip-flops are normally d-c gated. A delay flip-flop is produced by adding a gating scheme like the one shown at the bottom of page 160. The basic flip-flop is shown as a simple rectangle. Complementary control levels are applied to the D inputs and the clock is normally low. A pulse on the clock line passes through the gate to which the higher control level is applied and changes the state of the flip-flop accordingly. If the flip-flop was already in that state, nothing happens. The d-c conditions applied to the control inputs appear at the outputs one clock pulse later, hence the name delay flip-flop.

If the clock line in the delay flip-flop is high or missing, the circuit reverts to the simple SET-RESET type. If the clock is present but the D inputs are both high or missing, the flip-flop is useless because it has an indeterminate state for each clock pulse. This is the outstanding disadvantage of a SET-RESET flip-flop when both inputs are applied simultaneously. The flip-flop does not toggle.

Shortcomings

The simple SET-RESET flip-flop can be used in storage registers and in some control functions, but it is otherwise not very useful. Indeed, some SR flip-flops on the market are worse than useless, because they have an indeterminate stage for both which the a-c flip-flop can be SET and then RESET is limited by twice the transition time—the time required for a change of state—and by the width of the trigger pulses. Moreover, if both pulses are applied simultaneously, the flip-flop can't decide which state to assume. With the gates, however, the pulse width is not important because it is only the transition times of the trailing edges that count. If both signals are applied at the same time—either through coincident trailing edges or equal-width pulses—the flip-flop assumes the opposite state; it complements or toggles.

Universal circuit

If the flip-flop is modified by tying the J-K inputs to form a clock input, and additional control inputs are added, opposite page, an a-c "universal" flip-flop is formed. While similar in some respects to the D flip-flop, it has two differences. If the clock is high or missing, the D inputs become true J-K inputs that SET and RESET the flip-flop. If the D inputs are high or missing, the flip-flop toggles from a clock input. When additional inputs are added to the gates, this configuration is truly universal in application.

Unfortunately, not one single available d-c J-K integrated circuit flip-flop will perform the functions of the a-c universal circuit. They are, however, designed to perform the D logic function. And they will toggle if the D inputs are high or missing. They do not, however, perform the true unclocked J-K function. The essence of this is that "J" and "K" inputs of available d-c integrated circuit flip-flops are really only D and $\overline{D}$ inputs as far as functions go. The devices do have the additional capability of toggling but this is only one special use of the J-K function.

NAND not NOR

Most IC flip-flops are made from two cross-connected NAND gates rather than the NOR gates of the basic flip-flop, opposite page. The positive AND direct inputs are OR inputs for negative logic so most IC flip-flops SET and RESET on negative (toward ground) pulses from a normally high level. A few leading-edge flip-flops SET and RESET on positive pulses, however. Several devices can be used for other than their stated purposes. For example, one device labeled "two-phase SR clocked flip-flop" provides the D function, triggering on the leading edge of positive clock pulses. A second set of inputs provides SET and RESET functions for negative pulses. The device does not toggle.

Regardless of whether the direct SET (PRESET) and RESET (CLEAR) inputs require positive or negative pulses, the vast majority of IC firms offer so-

Using IC's: Trials and tribulations

While integrated-circuit manufacturers promote lines that are designed to eliminate all woes of the digital equipment designer, users express skepticism. Robert Sanford, author of the article, "Understanding IC logic," beginning on page 158, experiences frustration each time he begins work on a new logic system and finds that available IC's are woefully inadequate. Sanford, a senior digital engineer working on ECM systems for the Babcock Electronics Corp's Aerospace division, finds that unclocked asynchronous systems for the military don't always fit gracefully into the "computer scheme of things," where IC's are concerned.

No one series provides all the functions needed, he says, so most systems combine IC's from two or more lines. That's when the fun begins, Sanford reports, citing differences in logic levels, power supply requirements, fan-out, and input loading.

A pet peeve of Sanford's is the flip-flop. Most control flip-flops, he notes, are SET and RESET as opposed to toggle types—and this requires one-shots for pulse generators. A typical one-shot used by Sanford will set and reset a flip-flop made by another manufacturer, but it requires an additional inverter for use with flip-flops of its own line.

Frequently special logic schemes must be fabricated to circumvent the shortcomings of existing IC's. Designs could be simplified, Sanford notes, if the flip-flops were true J-K's that would respond to changes in level, instead of requiring trigger pulses.

William Rhoades, who wrote the article "Logic IC's don't live alone," starting on page 162, emphasizes that the IC must be considered as part of the over-all system. Equipment performance often rests more upon the interconnections than in the IC's themselves, reports Rhoades, who is a senior staff engineer in advanced techniques for the engineering division of the Hughes Aircraft Co. Rhoades is now evaluating high-speed IC logic circuits for general-purpose computer programs. Problems faced by digital system designers, Rhoades says, are turn-around time, cost of spares, and the time and complexity of field testing. If a true sequential test of a computer system were to be undertaken, one would not live long enough to see the end of the test, Rhoades points out. Furthermore, the test equipment in the field could be more complex than the system being tested.

How noise affects a system is another big problem. Both Sanford and Rhoades criticize the conventional ways that vendors characterize IC's for noise. Both deride the fictitious "switching point." Semiconductor junctions do not switch on and off like a light switch, Sanford points out. In a TTL gate, for example, any input voltage greater than 0.5 to 1.0 volt will cause partial conduction and a reduction of the output voltage from its ONE level. Usually the output transistor in a gate will be at the ZERO level when the input is above about 1.4 to 1.7 volts. Any input voltage between these limits will produce an indeterminate output voltage.

The real troublemaker is a-c noise—primarily switching spikes. But, Sanford says, the IC vendor is careful to avoid specifying a-c noise immunity. About all one can do, he says, is use large power busses—particularly for ground, clean up the power lines and use LC filters in the positive lead on each board—and hope.

noise immunity under 20% require shielded structures such as coaxial or strip lines. Noise immunity for typical gates, operating without a hysteresis effect, is about 20% to 30%.

Spurious signals

In a transmission network designed to connect digital IC's together in a logic system, coupling between nearby signal paths can raise havoc. For example, a signal passed through one transmission line can produce spurious signals at the terminations of adjacent lines. The spurious signals, called crosstalk, can be classified in terms of the ways in which coupling occurs: common impedance, electrostatic, and electromagnetic.

Factors that combine to make analysis of crosstalk difficult are:

- Interaction is usually not just between two but among many circuits of a transmission complex.
- The distributed, rather than lumped, nature of the inductances and capacitances of the circuits involved.

Nevertheless, there are precautions that can be taken to reduce crosstalk. For example, where two or more loads share a common line impedance such as in power distribution, a solution is to run separate lines to each load, or reduce the impedance common to both.[2]

When a line connecting two IC's is cut by magnetic lines of force generated by a nearby current-carrying conductor, an unwanted voltage will be induced.

Below 10 kilohertz, shielding, to be effective, must be done with ferromagnetic materials. Decreasing the length of the coupled lines is usually the most effective way to reduce crosstalk. Finally, changing the circuit parameters—such as increasing the signal-source impedance, decreasing the signal-load impedance, and decreasing the magnitude and frequency of the currents generating the field—may reduce coupling.

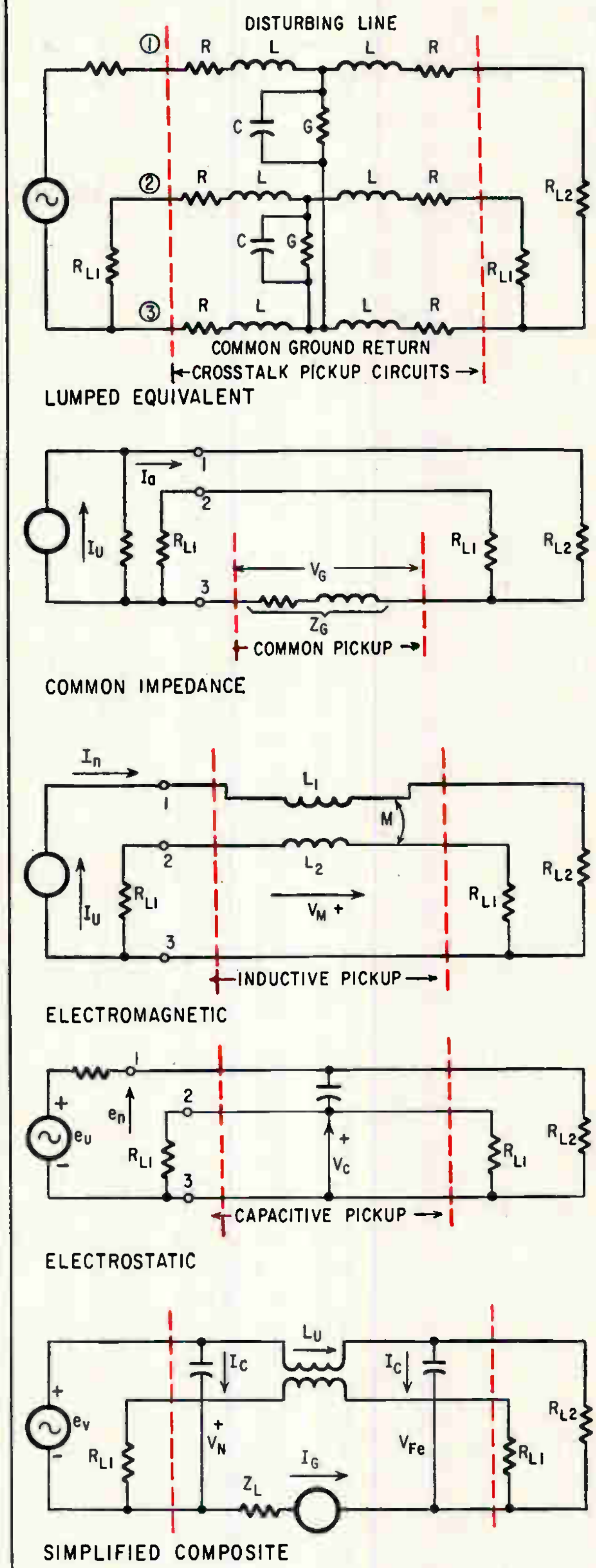
Electrostatic coupling

When two lines differ in potential, capacitive coupling can exist. The coupling current will result in a voltage drop in the signal load. An electrically conductive shield reduces the stray coupling, bypassing it to ground.

Unfortunately, the capacitances of the shield to ground are across the load and may be significant. If the shield is ungrounded and its potential is varied with the signal voltage, part of the capacitance is eliminated but the shielding effect is reduced.

Other ways to reduce capacitive coupling are standard: increase the distance between lines, decrease the dielectric constant between lines, and decrease the diameter and length of the conductors. The best choice is usually to reduce length, since the relationship of capacitance to spacing and diameter is logarithmic, and the dielectric constant is low to begin with. Helpful circuit changes include reducing voltage differences between close wires,

Crosstalk circuits

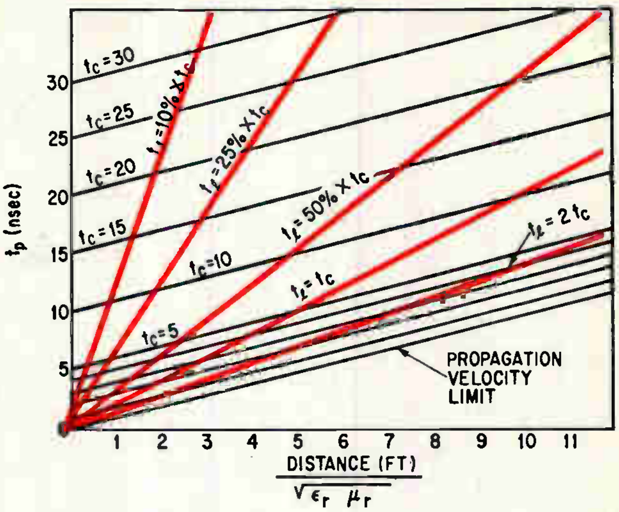


Equivalent circuit for a multiconductor system, top, accounts for common impedance, capacitive and inductive crosstalk. Next three diagrams show separate equivalent circuits for the three crosstalk sources, and the bottom circuit represents the simplified composite equivalent.

lowering frequency and signal-source impedance and signal-load impedance.

Multiconductor systems can be studied through the equivalent circuit on page 163 representing two lines sharing a common ground return.[3] In that circuit, R, L, C, and G are distributed parameters per unit length.

The common impedance, capacitive, and magnetic crosstalk sources for multiconductor systems can be represented separately, as in the three diagrams on page 163. The composite equivalent circuit at the bottom shows how the crosstalk pickup voltages differ at the near and far ends of the circuit. The dominant crosstalk mode can be found by either measuring the polarity of the voltage on the coupled line or through calculation. If $M_P/C_P >> R_{L1} R_{L2}$, the inductive mode predominates, whereas if $M_P/C_P << R_{L1} R_{L2}$, the capacitive mode is dominant, and the appropriate equivalent circuit can be used. In the above expressions, M_P is mutual inductance and C_P is capacitive coupling.



Trade off between system logic delay, t_p, and interconnection lengths between IC's. Delay resulting from IC is t_c, while delay caused by the interconnecting media is t_l. The line lengths are normalized for relative permittivity and permeability of unity.

More noise

Ground noise margin is the voltage that may be applied at the ground connection without causing the circuit to malfunction. It is usually measured by increasing the static ground voltage on a single gate until the logic fails to operate properly. By sweeping the ground both positive and negative while the input voltage, V_{in}, is set at the operating logic levels, the change in the output voltage can be observed as a function of ground noise.

A more accurate method of testing ground noise also makes use of a pair of gates. V_{in} is set at the worst-case logic levels, and ground voltage is increased on both gates—in the worst-case direction —until the output changes state.

With ground noise margin known, one must determine how much ground noise will be developed. Ground noise is the sum of the voltage developed due to series inductance in the ground paths and the d-c drops. The latter voltages are often negligible, although they cannot be overlooked in high current circuits such as CML or in large-scale integration. Thermal effects also plague very high speed systems.[4]

A-c voltages developed in the ground path can be determined from the rate of change of current in the ground path and its inductance. The former, a function of the IC, is called the inductance factor. It is high in HL-TTL gates because of the totem-pole output and modifications of HL-TTL are sought to reduce it.

One can compare the permissible inductance dictated by noise margin of the circuit itself with that which would result from the use of specific transmission line formats. The table on the next page can be used to compute the latter.

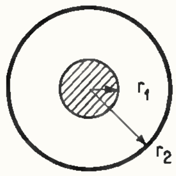
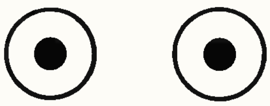
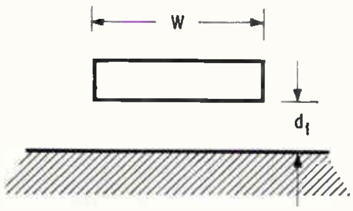
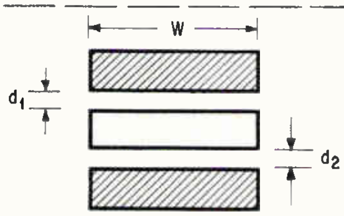
Propagation delay

Two important sources of delay in a logic system are circuit delay, t_c, and delay caused by the media used to interconnect the circuits, t_l. Circuit delay, meaning propagation delay due to the IC alone, is usually expressed on IC data sheets as t_p, but we reserve t_p for the propagation delay (per logic decision) resulting from the circuit and its interconnections in a system; we call this "system logic delay." The trade off between the system logic delay and the interconnection lengths can be determined with the aid of the universal chart directly above. The chart is applicable to a matched signal transmission system. Its abscissa is the allowable line length normalized for relative permittivity and permeability of unity, so that allowable line lengths are reduced for media having constants greater than unity. The graph is general in that dividing or multiplying the abscissa by a scale factor divides or multiplies the ordinate and lines of constant t_c by the same factor.

It is important to recognize that t_c is not only constrained by t_p and t_l but it is also a function of the circuit design and loading. It is useful to introduce the concept of propagation power, P_p, and examine the thermal problems related to it. Propagation power is the absolute minimum rate of energy dissipation required to propagate logical information at the slowest permissible rate throughout a system. An ideal logic element would draw no power when it is not switching, and only propagation power when it is switching. Standby power is considered wasted, although it may be required to make the logic element work properly.

Consider a case in which the load R_L, and source impedance R_S are very large compared to the line impedance, Z_O. Propagation power can be found experimentally by measuring t_c as a function of load capacitance, C_L. Due to fixed propagation power available from the logic circuit, t_c increases as a function of some power of C_L (i.e., $C_L^{1/n}$ with $n > 0$, where larger values of n indicate greater propagation power capacity). In our example

$$P_p = (\Delta e)^2 C_L / 2t_p$$

CROSS SECTION	INDUCTANCE L IN NANOHENRIES/ FOOT (ALL DIMENSIONS IN INCHES)	COMMENT
	$140 \log_{10} \frac{r_2}{r_1}$	FOR 10 AWG, AT 0.005 INCH SPACING L=2.8 nh/FT
TWISTED PAIR 	SAME FORM AS THE COAXIAL LINE, BUT THE VALUES FOR THE ARGUMENT OF THE LOG FACTOR IS A FUNCTION OF TWISTS/FOOT	FOR 24 AWG, 19 STRAND TEFLON INSULATED, EE, 60 TWISTS/FT, L=140 nh/FT
	$385 \frac{d_1}{W}$	FOR 0.75 INCH BY 0.002 INCH SPACING L=1.02 nh/FT
	$\frac{385}{W} \frac{d_1 d_2}{d_1+d_2}$	FOR 0.75 INCH BY 0.002 INCH SPACING L=0.51 nh/FT

is permitted for the line. The table at the right gives typical capacitance values per unit length of various types of unmatched lines, which are used to calculate allowable line lengths.

High-speed rules

For high-speed systems in which the effective delay must equal the line delay, fan-out methods can be a problem. For one thing, good matching is a must. Two popular techniques are the radial method, on the next page, and the tapped method, below it. In the radial approach, all inputs to the logic circuits must be matched to the transmission line. Also, the driver must drive an impedance of Zo/n, where n is the fan-out. Such an impedance can be undesirably low if n is large. Then too, a separate line is used for each load. This method is recommended only for n equal to one.

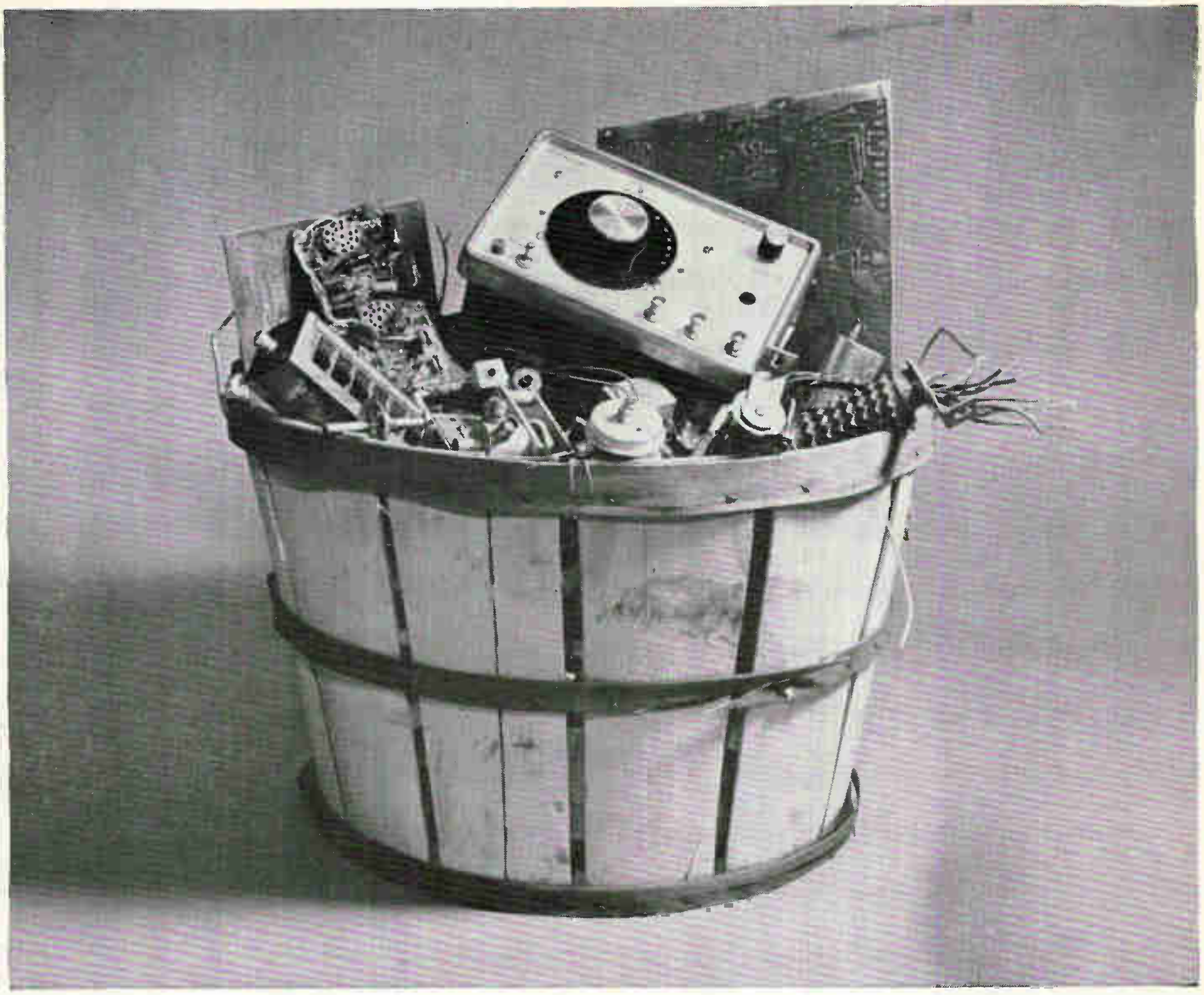
The tapped method requires very high impedance loads to prevent undue line loading.

A third method, the tree method, is recommended when $1<n<5$ since it provides matching at every point in the line. It also drives loads located in different directions (like the radial method). Yet it requires a smaller number of lines than the radial method and, for reasonable fan-outs, the driver output impedance need not be unusually low. If there are just two tree members, the driving gate may be placed anywhere along the line.

The radial method is superior in the case of ex-

Capacitance for various transmission lines

Type of line	Typical capacitance per inch (pf)
Microcoaxial	2.5
Microstrip	1.0
Strip line	1.79
Multilaminate	1.20
Flat flexible wiring	0.6
Twisted pair	1.10
Point-to-point	0.4
Conventional etch	0.5



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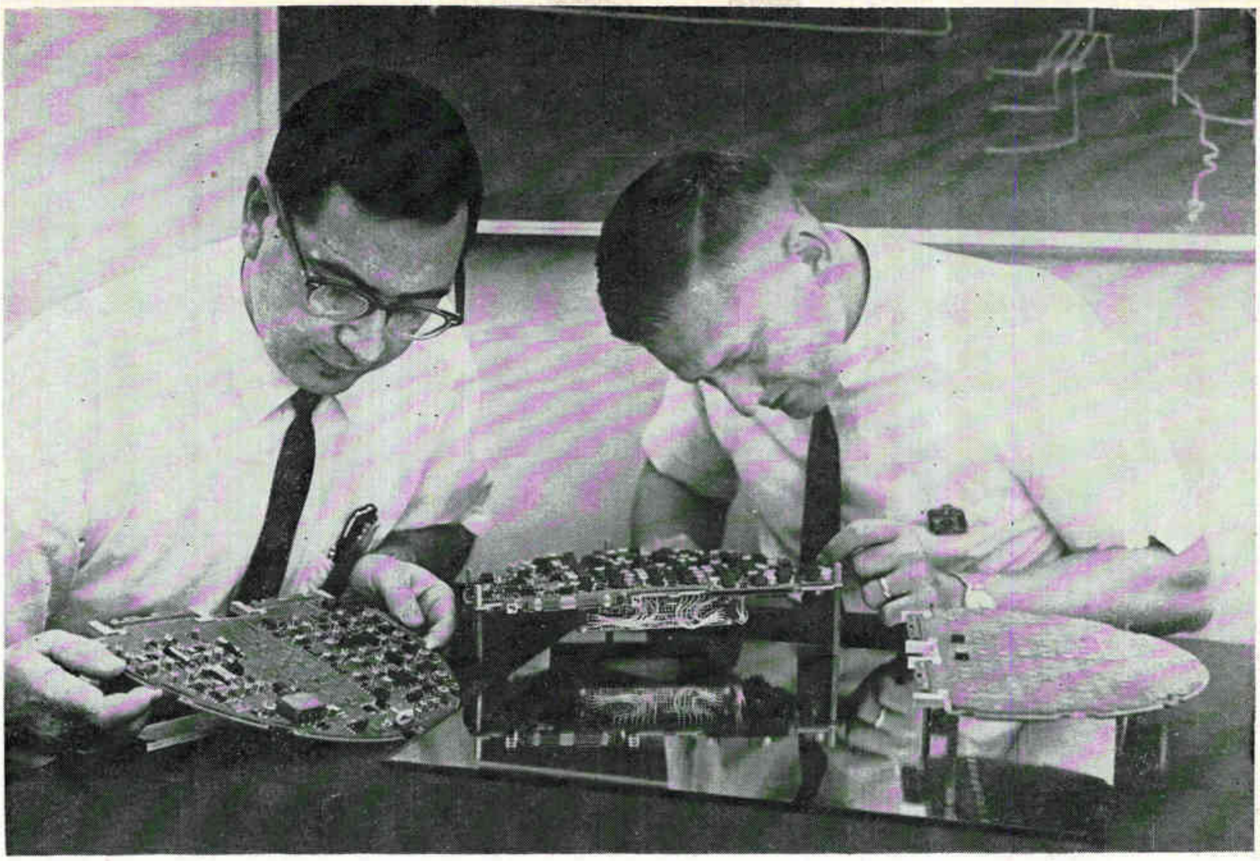


Three subassemblies constitute IBM's new mass production computer for varied aerospace applications.

Computers

The airborne 4 Pi computer: IBM aims at aerospace guidance

A low-cost computer now being mass-produced promises to replace traditional computers in guided missiles. Intriguing organization and the use of IC's contribute to its attractiveness

By William N. Carroll and Frederick F. Jenny
International Business Machines Corp., Owego, N.Y.

General-purpose digital computers have heretofore been too expensive and too large for use in expendable aerospace applications such as in the guidance system of a missile. But now they can compete with the special-purpose machines that have traditionally been used in such vehicles. The widespread availability of varied monolithic integrated circuits, new packaging techniques and high-speed core memories makes the competition possible. Mass production of logic circuits has cut the cost of such a general-purpose computer and the inclusion of IC's has reduced the size of the machine sharply.

Although special-purpose analog, hybrid analog and digital, and incremental computers have all been used in aerospace vehicles, the military would prefer a general-purpose machine instead because wired, the read-only portion stores programs and subroutines that have been completely debugged. Instructions in the read-only memory aren't changed by temporary malfunctions or unusual conditions that arise during missile storage, testing or flight. In space vehicles particularly, the read-only memory is useful because it occupies little space and is highly reliable. In the larger models of the 4 Pi series [Electronics, Oct. 31, 1966, p. 42], and in general-purpose computers like IBM's System 360, the read-only memory controls the execution of programs but does not itself contain program instructions; the programer is not concerned with the read-only memory.

The set contains only eight instructions, each consisting of an operation code and a single address. All instructions have the same execution time except the multiply and shift instructions. Two of the eight instructions can be coded to perform different operations: the process input-output can initiate 31 different operations, and the transfer can cause either conditional or unconditional transfers (execution out of normal sequence) or a change in the memory sector being addressed.

Memory design

The core array is a single plane automatically fabricated and tested, containing 1,024 eight-bit words, expandable to 2,048 words. Additional planes can be stacked to build larger memories, up to 16,384 words. The larger memories, however, will not fit on a single page. Drive and sense electronics consist of monolithic and discrete components. The memory system cycle is 2.5 microseconds, but each active cycle is followed by a 1.5-μsec idle period to reduce power consumption; the total cycle is therefore 4 μsec.

The read-only memory is identical to a normal memory except that cores are removed from those locations which contain zeros. This arrangement has several advantages. The memory construction is essentially similar to a conventional system and can be fabricated on existing automatic equipment. Data can be written into as well as read from the memory during development, thereby allowing flexibility in the programing design. The memory with appropriate cores missing is truly unalterable, and cannot be affected by electrical transients or erroneous addressing. The same drive and sense circuitry can be used as with the normal memory; the memory addressing is also the same.

A memory of this type presents certain difficulties. For example, cores with hysteresis loops that are not square could generate unwanted outputs caused by noise from the slanting top of the square. To reduce this hazard the timing of the memory drivers is staggered and extra cores on the drive lines compensate for the noise.

Sensing and controlling

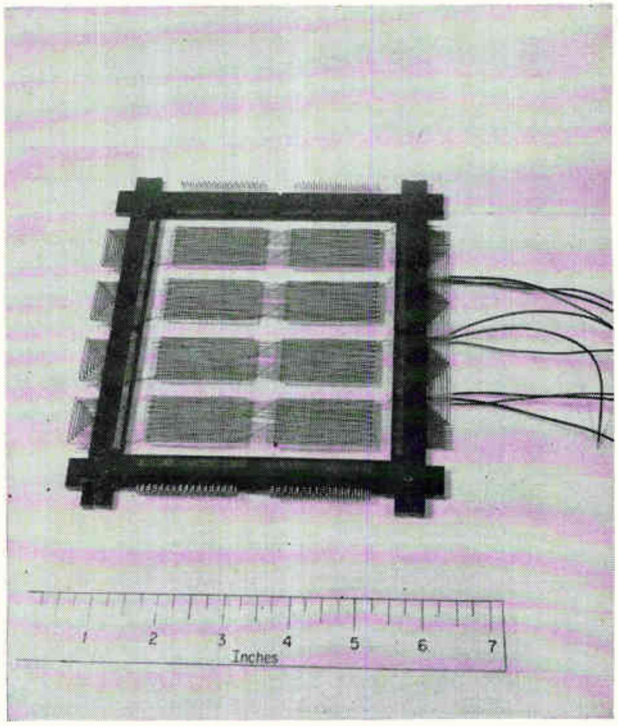
The input-output section of the guidance computer performs important functions:

- It decodes, buffers and amplifies control outputs and decodes and gates control inputs.
- It monitors the guidance processor, signals the occurrence of any program or power malfunctions and keeps track of real time.
- It accumulates input signals from the accelerometers for later processing, and works with external equipment during initialization and retargeting procedures.
- It assists in the alignment and torquing of the inertial platform and other control functions.
- It controls the sequence of power on-off to various subassemblies.

The specialized nature of these tasks require a mixture of digital and analog circuits using both discrete components and IC's in flatpacks. However, all circuits are mounted on a single multilayer board, as shown in the bottom table, p. 175.

All digital transmission line circuitry, all control circuitry, and most digital-analog conversion circuits are IC's packaged in 14-lead flatpacks. In most cases, analog IC's proved too costly to use.

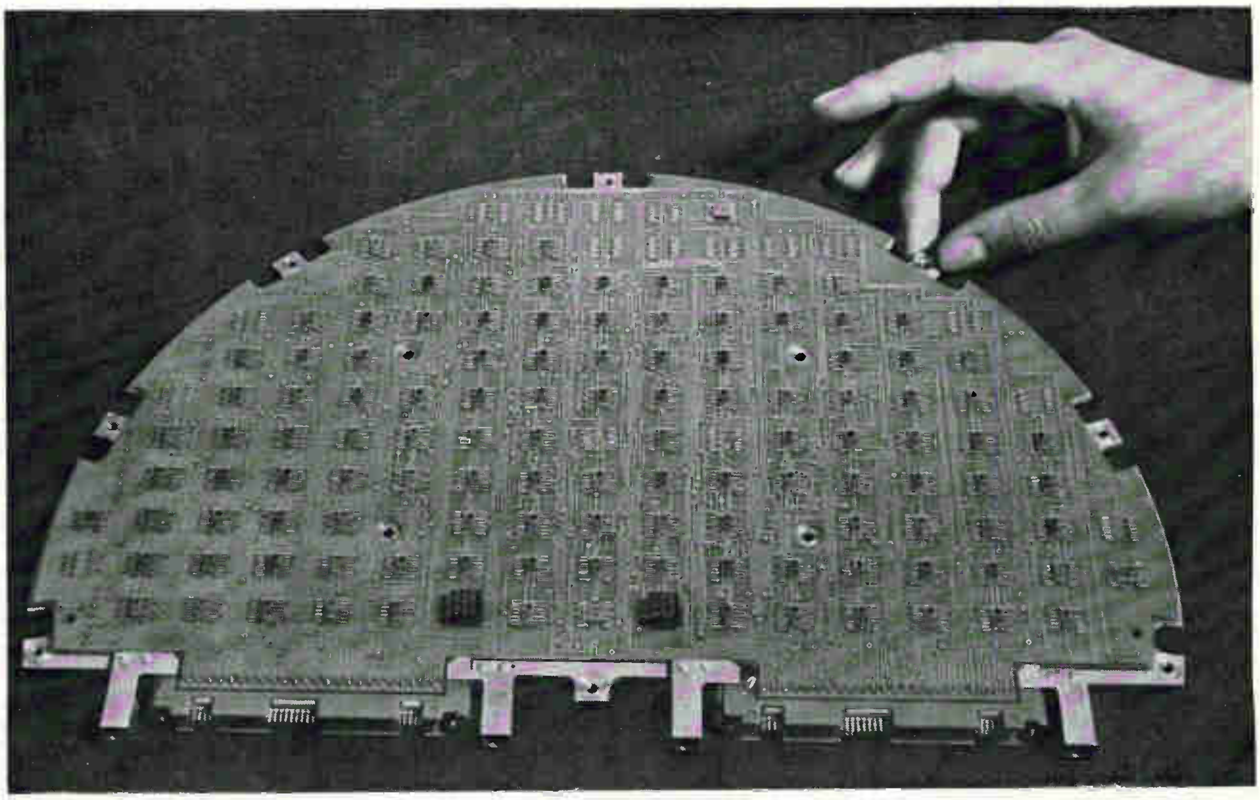
A major consideration with the multilayer boards



Memory array used in the tactical-missile computer is a single core plane that can hold 1,024 eight-bit words.

How fast the 4π works

Instruction set	Time (μsec)
Clear and add	12
Add	12
Subtract	12
Multiply	140
Store	12
Shift (left or right up to 16 places)	20
Process input-output (31 codes)	12
Transfer (6 codes)	12



Flatpack mounting and wiring details are visible in this view of the arithmetic and control subassembly.

placed next to the memory with either one in the middle. The entire unit is sealed with a O-ring gasket to keep out excessive humidity and dirt.

Heart of the computer

The central processor subassembly is a general-purpose unit that performs the basic arithmetic and control functions. The two multilayer boards making up this subassembly contain 243 standard 14-lead flatpacks. The basic structure of the board avoids signal crosstalk and provides some power supply decoupling; additional discrete decoupling capacitors are mounted around the page assembly. Connections between boards are provided by 100 feed-through pins along the edge of the boards. Two 98-pin connectors are mounted on the flat edge of the subassembly for connections to the memory, input-output pages, and external guidance equipment.

The computer is built with seven types of transistor-transistor logic (TTL) circuits. One consideration in the choice of an IC family was its applicability to other programs, since purchase in large volume saves money.

The logic requirements of the computer suggested a few additions to the standard TTL line, the most significant of which was two flip-flops on one flatpack. Sixty-three of these dual flip-flops are used in the design as registers, shifters and counters.

T^2L circuit characteristics

Circuit delay (maximum)	25 nanoseconds
Power consumption (average)	10 milliwatts per gate
Power supply	5 volts ±10%
Fan-in	8
Fan-out	10
Signal levels, nominal	0 and +5 V
Noise margins (minimum)	400 millivolts
Temperature range	0 to 70° C

What lies ahead

The logic circuits now used are nonfunctionally

Counting the components

	Processor	Memory	Input-Output	Total
Integrated circuit flatpacks	243	56	34	333
Discrete semiconductor flatpacks	....	80	...	80
Transistors	....	76	59	135
Diodes	....	109	39	148
Resistors	....	288	98	386
Capacitors	12	79	33	124
Miscellaneous	....	68	1	69

ANALOG MONOLOGUE

On Means for Modelling, Measuring, Manipulating, & Much Else

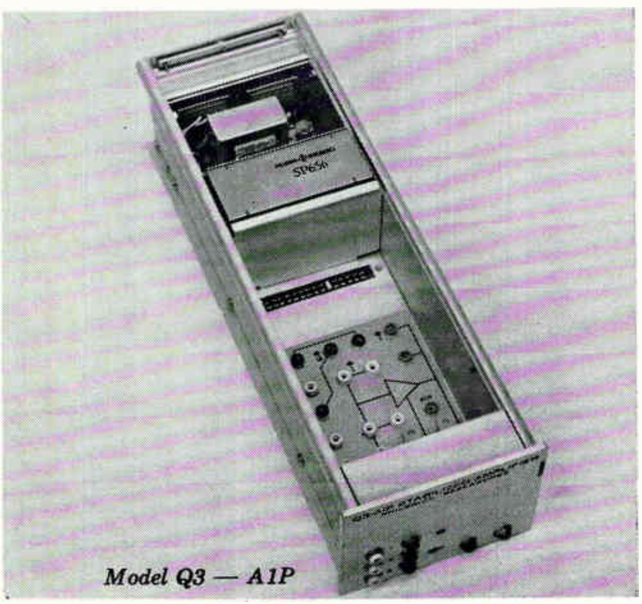
Volume 1, No. 4

A SHORTER PATH TO PRACTICAL ELECTRONIC MEASUREMENTS

One requirement is common to all scientific research . . . threads through all development engineering . . . marks every empirical exercise — *the need to measure*. Our interest in this arises from the fact that electronic circuits (often with transducers) are generally the most practical means for measuring and recording parameters. Moreover, an increasing number of practical and economical electronic measuring circuits employ Operational Amplifiers — our specialty in analog computing devices since before 1946, and as a circuit component since their introduction as such in 1952.

During the past twenty years, we have been privileged to work closely with specialists in many disciplines, helping them to design and build literally thousands of different kinds of circuits — instruments, signal "conditioners", and data "processors" and others ad infinitum. We have learned that our "opposite numbers" in Chemistry, Metallurgy, Aerodynamics, Hydraulics, Mathematics, Stress Analysis, Physics, Thermodynamics, etc., are generally enthusiastic about what Analog Operational circuits *can do*, but almost totally disinterested in *how* they can be made to do it . . . and that is pretty much as it should be. To each his own.

We have observed that a major deterrent to more widespread use of the powerful Analog Way (of sensitive, accurate measurement and data processing) has been the time, effort, and considerable skill required to convert the circuit diagram into a complete, functioning instrument. Now we have found a way to speed and simplify that process. We call it the *Universal Operational Module* (U.O.M.): One such module, the Q3-A1P, is shown here.



Model Q3 — A1P

The Q3-A1P consists of a unique mechanical structure, in which are mounted a high-performance, chopper-stabilized Operational Amplifier, a compatible power supply, and an "Operating Deck", on which is located a cluster of conveniently-disposed, clearly-labeled jacks, for interconnecting input and feedback components with the amplifier and its supply. The structure also provides connectors and space for auxiliary networks, for input and output cables, and a front panel with duplicate input/output terminations. With a Q3-A1P and a few simple pluggable components (i.e., resistors, capacitors, etc.) any one of literally thousands of useful circuits — complete and ready to use — may be realized . . . *minutes after it is conceived*, without punching a hole, or soldering a wire.

Best of all, the physical organization of the Q3-A1P has been carefully planned to anticipate and prevent or circumvent most of the tiresome and unproductive "debugging" and "tweaking" that plagues almost any original design. Shielding, guarding, wire-routing; "strays", "sneaks", "parasitics" — you may forget them all, in almost every instance.

The Q3-modular packaging system which includes a variety of universal operational modules, some of which are listed in Table 1, permits concentration on the *important* things — What and Why, instead of How.

TABLE 1

Q3-A1P	Compact, self-powered, chopper-stabilized amplifier complete with patch panel and accessory socket.
Q3-A2P	As above, but using a low noise, low current-offset, differential amplifier.
Q3-J1P	A switch-programmable, self-powered integrator-differentiator.
Q3-M1P	A switch-programmable, self-powered unit capable of performing non-linear functions such as multiplying, dividing, squaring and rooting.
Q3-M2P	As above, less switches, programmable via a patch panel.

These universal operational modules (U.O.M.'s) consist of a standard Q3 series package, equipped with a carefully optimized interface facility to permit the combination of amplifiers, networks, components, and power supplies into highly-flexible, universal analog devices.

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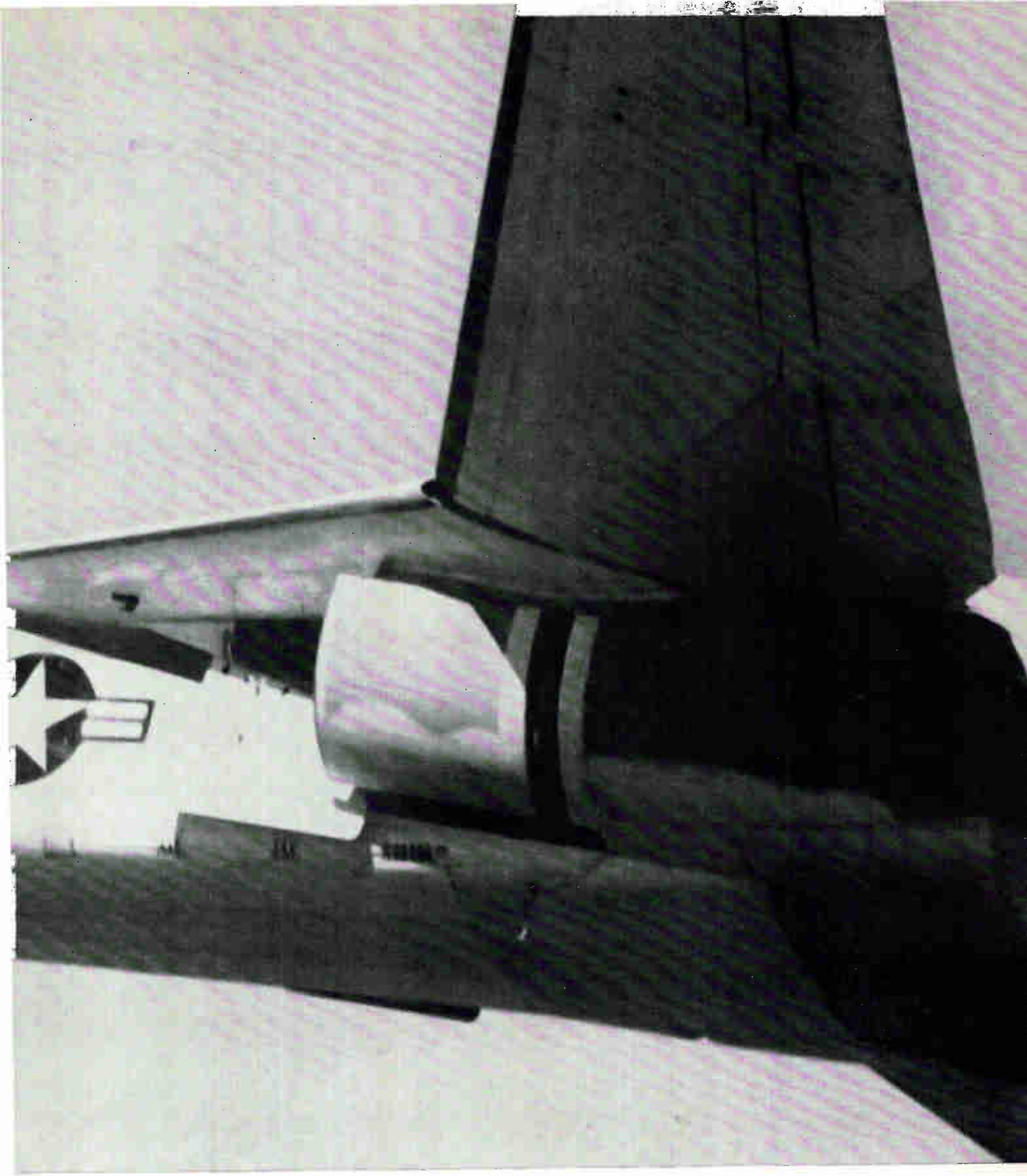

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Circle 179 on reader service card

Apollo television camera with telephoto lens attached is held by Westinghouse engineer. Handle also serves as an electrical connector that can be engaged and disengaged without the contacts welding in the moon's vacuum environment. Cable in handle carries d-c voltages to camera and video output to transmitter in the spacecraft. All the electronics are mounted on the top plate. Bottom pan is an enclosure. Thick casing is for protection from meteors.

also connect the camera's video output with the module's S-band transmitter. After selecting a lens appropriate to the light conditions and the scene to be viewed, an astronaut will switch to the desired scan mode. He will use the edges of the camera as an aiming sight.

The heart of the Apollo camera is a sensitive image tube that combines a variable-gain light intensifier with a secondary electron conduction (SEC) target.[1, 2] This target produces gain and stores the image that is subsequently scanned by the tube's electron beam gun. Although the tube is slightly less sensitive than an image orthicon, the electronics for reading out the stored image are as simple as those of a vidicon tube. With fast response, the SEC tube's video output signal at low light level reproduces objects in motion without smearing—unlike the video output of vidicon and image orthicon tubes. At the same time, the SEC target can store and integrate signal information over a relatively long time period, a factor that contributes to the tube's slow-scan capability and sensitivity.

Optical system

The Apollo camera, built by the Westinghouse Electric Corp.'s Defense and Space Center, is provided with four interchangeable lenses of fixed focal length. A wide-angle lens will be used primarily for pictures inside the command module, while a telephoto lens will be used to view the earth and moon during the trip back and forth. Two general-purpose lenses will be used on the moon's surface, one during the lunar day and the other during periods of darkness.

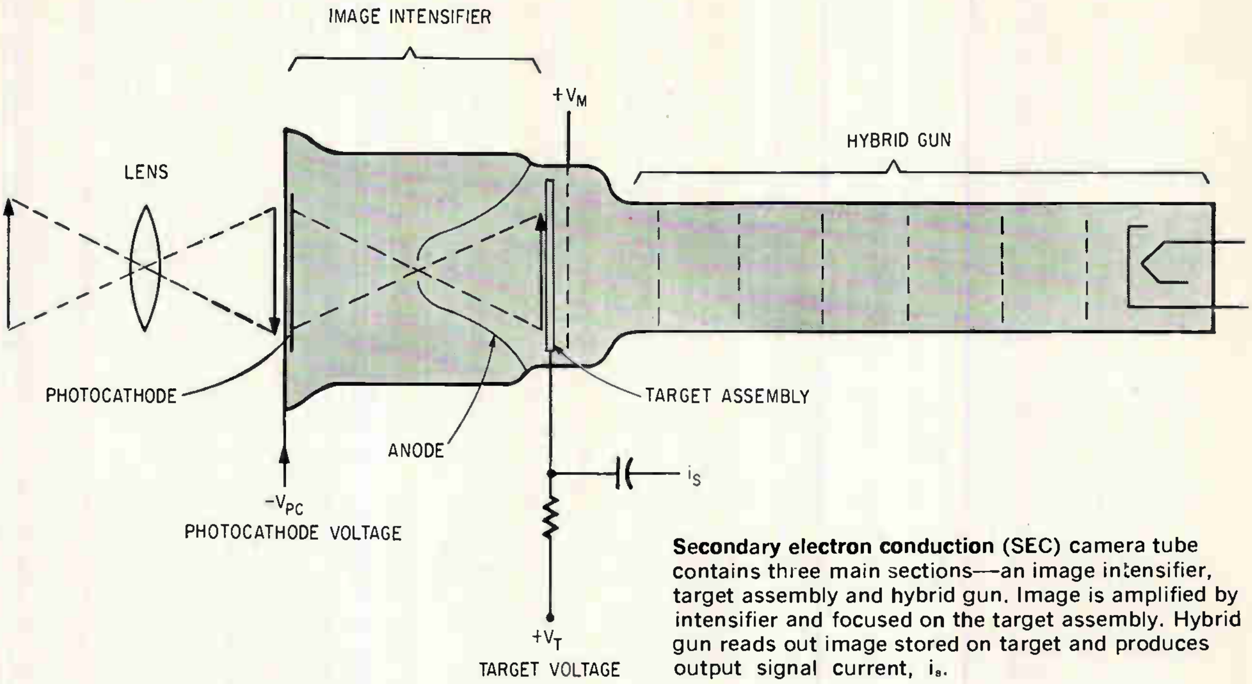
The lenses focus light onto the electrostatic diode image intensifier's photocathode, which emits electrons in proportion to the incident light level. A faster lens—one with a larger aperture—collects more light and thus increases the number of emitted electrons. S-20 photocathode material is used in this tube because its quantum efficiency is relatively high and uniform over visible wave lengths.

The potential difference between the photocathode and the SEC target accelerates the emitted electrons and the intensifier's electronic optics focus the image onto the SEC target.

Depending on the incident light level, an automatic control circuit varies the accelerating potential so that electrons hitting the target have energies ranging from 2,000 to 8,000 electron volts, with the higher energy level corresponding to low light levels. In this way, the tube is able to accommodate a wide range of illumination while maintaining a relatively constant signal output.

The SEC target releases secondary electrons in proportion to the number and energy of the impinging electrons. These secondary electrons are collected by a thin aluminum plate that is at a higher potential than the target material. As a result, each point on the face of the target becomes positively charged in proportion to the incident light level.

The operation of reading the stored image out of the SEC target is similar to that in a vidicon tube. When the electron gun scans across the target, it



Secondary electron conduction (SEC) camera tube contains three main sections—an image intensifier, target assembly and hybrid gun. Image is amplified by intensifier and focused on the target assembly. Hybrid gun reads out image stored on target and produces output signal current, i_s.

circuit. Hybrid circuits were used in the mixer, sweeps and power supply.

Whether made by Westinghouse or purchased from outside vendors, the circuits have had to meet specifications far in excess of the environmental stresses they are liable to encounter.

Design constraints

For transmission of pictures back to earth, the camera's video output frequency-modulates the S-band transmitter. The signals will be transmitted in analog form because NASA studies have shown that such a system requires only one fourth the bandwidth of a digital transmission scheme. Since power is limited, the bandwidth has to be restricted to 500 kilohertz.

To prevent excessive deviation of transmitter frequency, the video signal must be less than 2.1 volts when working into 100 ohms. The sync burst format used puts both the sync amplitude and the video signal above a reference black level. In this way, both the sync and picture information can have a full 2-volt swing and thus deviate the transmitter the full 500 khz. In comparison, the amplitude-modulated format of commercial tv would prevent full deviation because video information is on one side of a fixed black level and the sync information is on the other.

As in commercial tv, the vertical sync pulses in the Apollo system are serrated at the horizontal line frequency to maintain horizontal sync in the receiver during the vertical sync pulses.

Scan modes

The 10-frames-per-second, 320-line scan format —the primary mode in the Apollo camera—affords good vertical resolution and adequate display of motion. In telecasting fast actions—a man quickly raising his arm, for instance—there is breakup or smear at frame rates below 15 frames per second, and this breakup is quite pronounced at 10 frames per second. However, because the astronauts will move slowly in the spacecraft and on the lunar surface, the rendition of motion at the slower rate is acceptable.

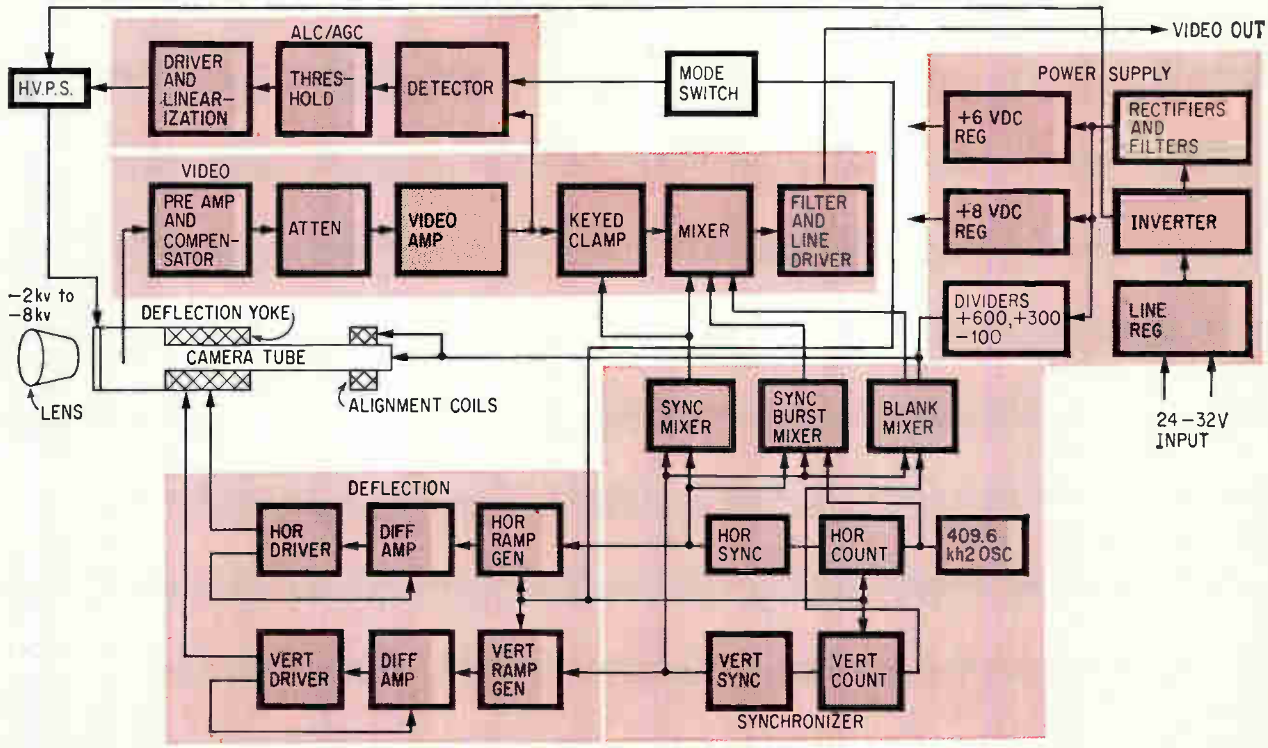
The resolution is actually lower than the number of lines. A 500-khz transmitter bandwidth would theoretically limit the maximum resolution to 210 lines, but because the filter in the video amplifier section has a frequency response that rolls off gradually, the resolution is equivalent to that of a 250-line system.

The high resolution offered by the slower scan mode—⅝ frame per second with 1,280 vertical lines—is limited by the camera's aperture response.

Signal controls

The combined control of the photocathode and video gain by the ALC-AGC circuit compensates for a 65-db change in light level in about 2 seconds. Over this wide dynamic range, the signal-to-noise ratio will change only about 20 db. Not shown in the schematic diagram on page 185 are transistors that electronically switch the input level, detector time constants and threshold levels when changing operation modes.

The first step in controlling the signals is to produce a d-c signal proportional to the video signal. This conversion starts in detector Z_1. D_1 and C_1 will clamp to a fraction of a positive voltage (black level) that is generated by the blanking pulse at the end of each sweep. In this camera, R_1 is usually set so that the clamping level is about 1.5 volts. This fixes the minimum peak-to-peak video signal that must appear before D_2 begins to conduct. The video output (white signal) is a negative-polarity

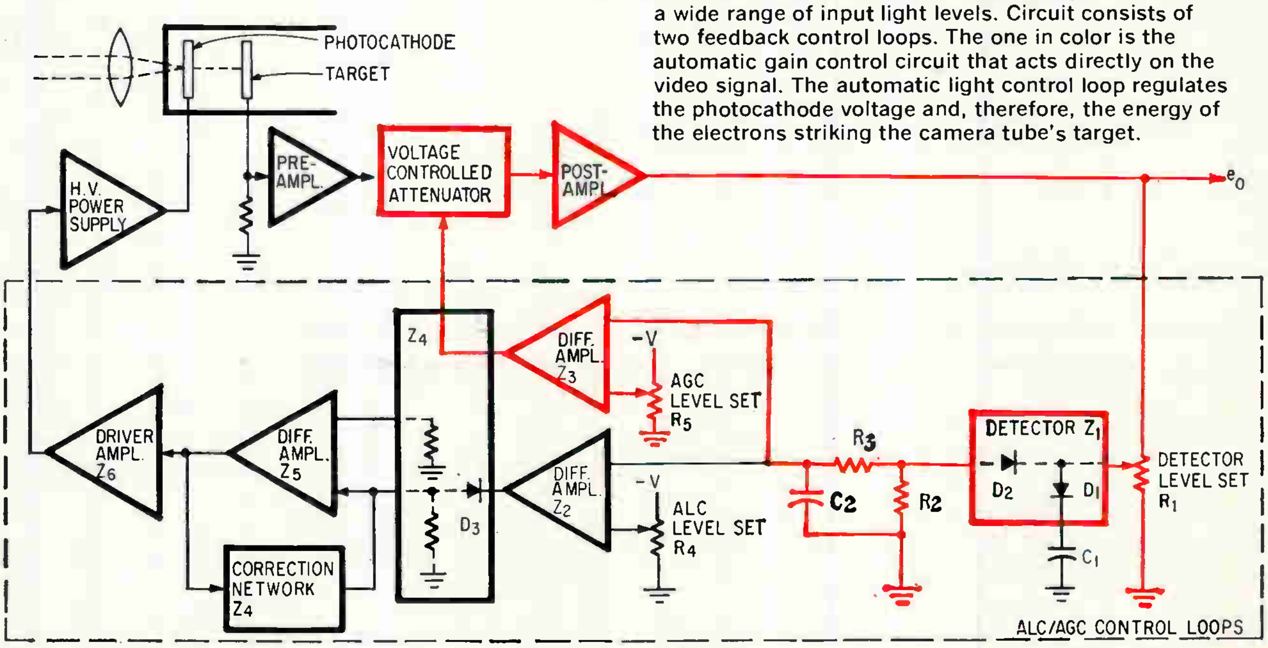


Camera's five major sections are shown in color in the block diagram above. Shaded portions indicate the percentage of integrated circuitry. Deflection circuits generate the waveforms to scan the tube. Camera's signal is controlled by the automatic light control and automatic gain control (ALC/AGC) circuit. Video signal is fed to S-band transmitter after amplification and mixing with synchronizing and blanking signals.

The 2-hz limitation is fixed by the amount of "droop" allowed in the slow scan mode. Droop is a change in amplitude caused by the loss of low-frequency components in the brightness signal; when viewing a uniform white scene, droop will cause the picture to have varying shades of gray. The 2-hz limitation is a compromise between acceptable droop and the increased size of the coupling capacitors that the amplifiers would otherwise require to improve the low-frequency response.

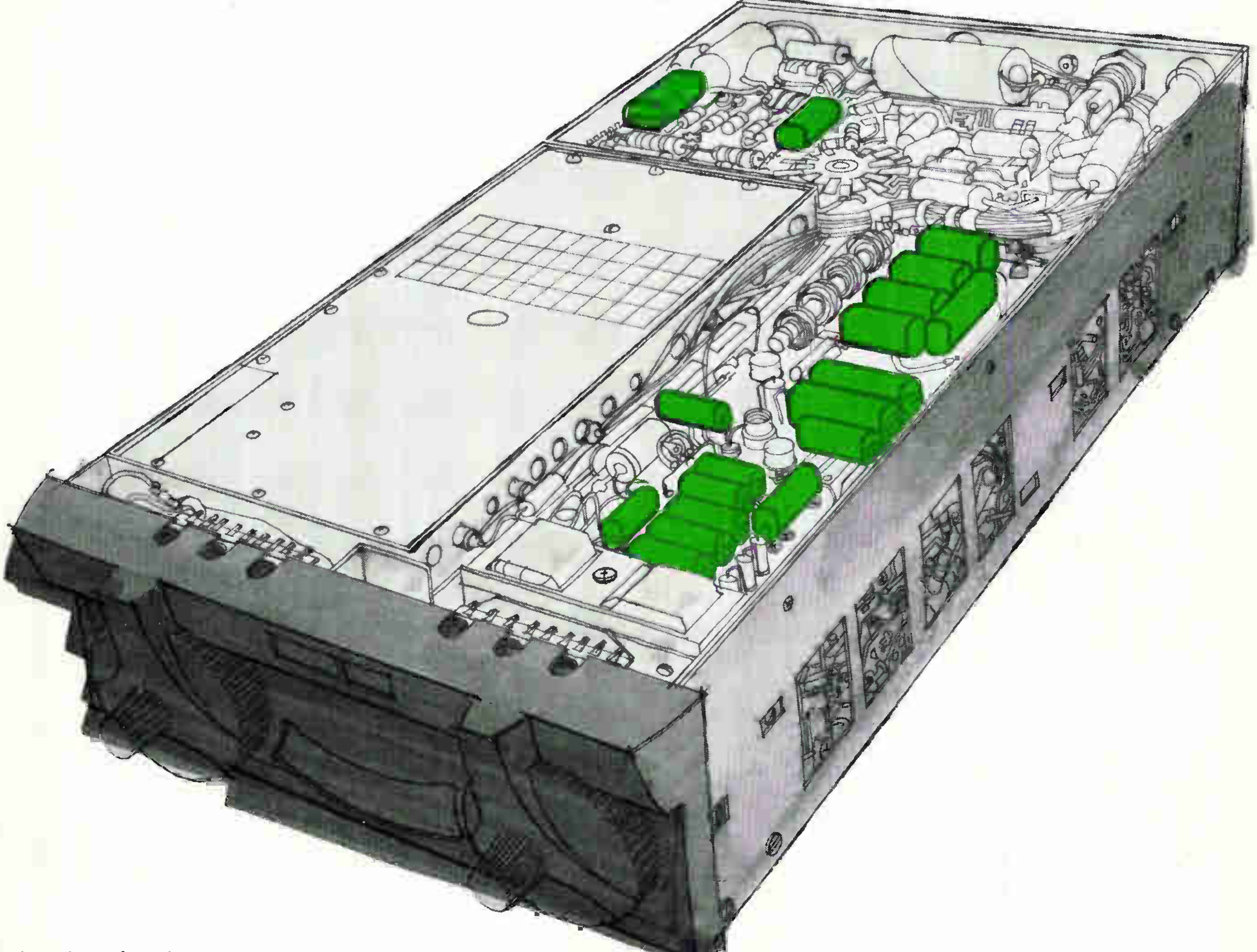
Three basically similar monolithic integrated circuits are used for the preamplifiers and post-amplifiers. The preamplifier is designed to compensate for the reduced frequency response that would be caused by the capacitance in the camera's target. The SEC camera tube has no detectable dark current, so low-noise performance is improved by reducing the noise in the preamplifier. A discrete

ALC/AGC control circuit holds video output constant over a wide range of input light levels. Circuit consists of two feedback control loops. The one in color is the automatic gain control circuit that acts directly on the video signal. The automatic light control loop regulates the photocathode voltage and, therefore, the energy of the electrons striking the camera tube's target.



King Radio needed: capacitors that stay reliable even with extreme cold, humidity and vibration.

So King Radio chose: capacitors of MYLAR.



Strict aircraft safety standards require the most reliable navigation equipment available. That's why King Radio Corporation uses capacitors of MYLAR* for their Distance Measuring Equipment. MYLAR can take temperature extremes from −60° to +150°C; MYLAR remains constantly stable under humid conditions.

But reliability isn't the only reason King Radio chose MYLAR. The extremely high dielectric strength of MYLAR permits its use in thinner film, thus helping King Radio to build the lightest and most compact distance measuring unit on the market. MYLAR is available in films as thin as 15 gauge.

And another reason why you will want to investigate using capacitors of MYLAR: they usually cost no more than others. Write for complete technical data to DuPont Company, Room 4960A, Wilmington, Delaware 19898. (In Canada, for information write Du Pont of Canada Ltd., Post Office Box 660, Montreal, Quebec.)

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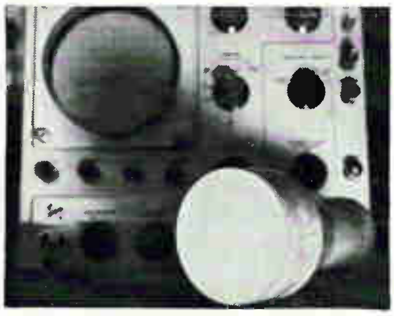
It's so hot it's freezing. This statement comes close to reality at Hughes Aircraft's Santa Barbara Research Center. They use G-E Type 204 fused quartz prepared for application in infrared detectors. In the process, a quartz tube is partially filled with semiconductor materials and evacuated. It is then torch-sealed at 1800°C

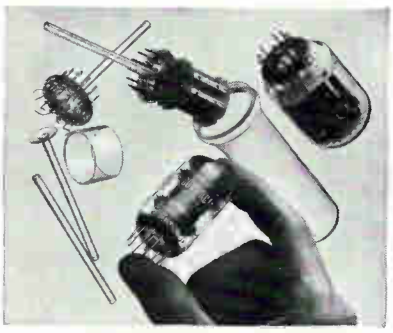
while one half inch away the same quartz tube is cooled by liquid nitrogen to −196°C. In half an inch, G-E fused quartz accepts a temperature gradient of 1994°C. Remember this fantastic capability of G-E quartz as you, in your own field, seek solutions to the uncommon challenge.

Circle 575 on reader service card

Ceramic-to-metal seals posed no problems for RCA when G-E Lucalox® ceramic was selected as the faceplate material in its multiplier phototube. This Lucalox application, a unique development in scintillation counters, not only simplifies nuclear detection systems but also makes scintillation counting more accurate. Why? The answer is in the high purity of Lucalox; its freedom from radioactive elements. Elimination of conventional graded seals results in sturdier construction which in turn reduces tube failures. Perhaps this evidence of Lucalox's ability to meet demanding ceramic-to-metal seal requirements will point the way to solving one of your problems in your industry. Translucent Lucalox®, 99% alpha alumina, has unique transmission characteristics for numerous applications.



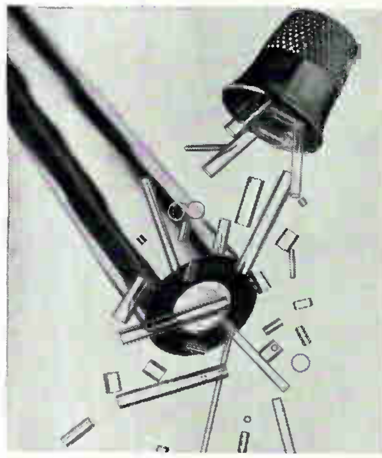
Circle 576 on reader service card



Over 100,000,000 have been made, so there must be something special about the G-E Compactron tube. There is. One Compactron, as produced by the G. E. Tube Dept., can do the work of up to three conventional vacuum tubes. But right here, we at the Lamp Glass Dept. think the Compactron can be used to illustrate our own capability in selecting specific glass types for specific applications. We provided three types for the Compactron: Type 008 lime glass, best for close tolerance forming of bulbs; Type 012 lead glass, best for preventing glass electrolysis in stems; Type 001 glass, best for close tolerance cutting of tubulations, in this case ±0.5 mm. If you want electronic glass to do something for you, call us. We have the types and we know when to use which one.

Circle 577 on reader service card

Drawing .010 inch tube from one-inch lead glass stock is the artistry performed by Hanibal Glass in Santa Ana. Hanibal produces about 100,000,000 assorted tubes monthly, used as seals for electronic circuitry components. Seals of G-E Type 012 lead glass are virtually



inert, durable, stand up to heat and humidity and have excellent dielectric properties. Why does Hanibal use General Electric glass? Because tubing won't draw to .010 acceptably unless the one-inch raw stock has uniformity in wall thickness and weight. Quality control, as delivered by the Lamp Glass Dept., turns out to be the key to this advanced application of a versatile material you might give more thought to. Electronic glass.

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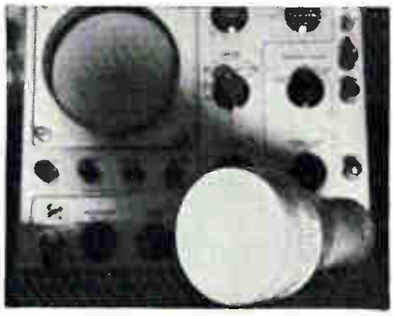
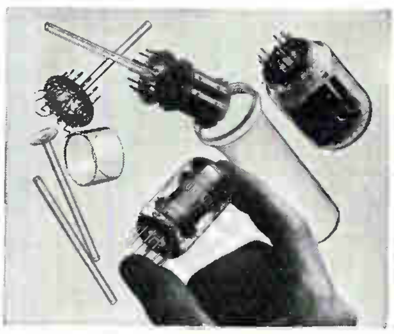


Circle 576 on reader service card



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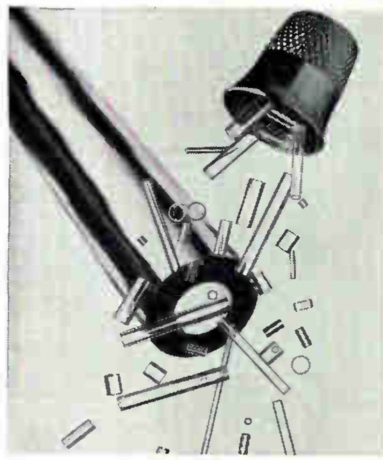

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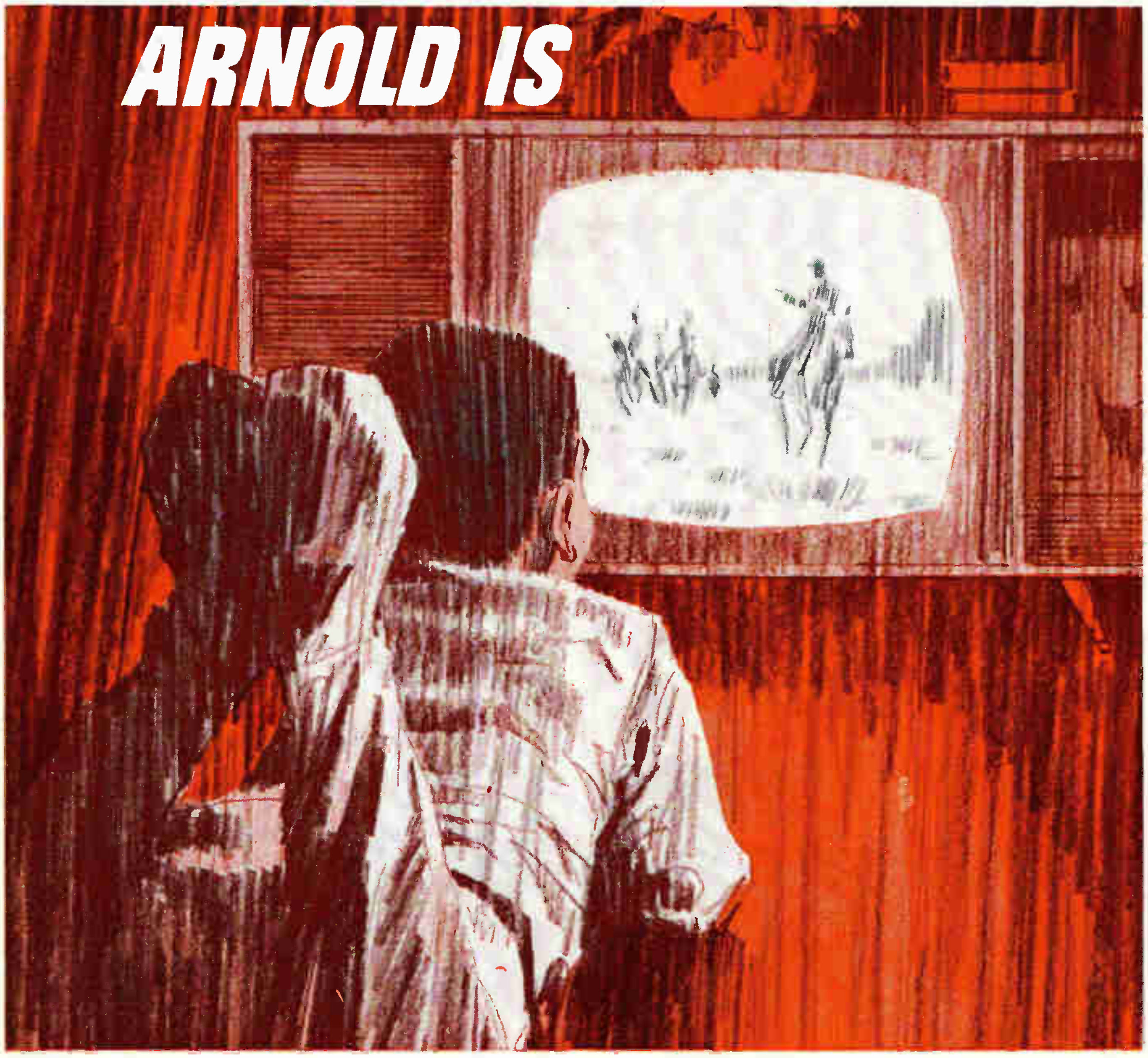

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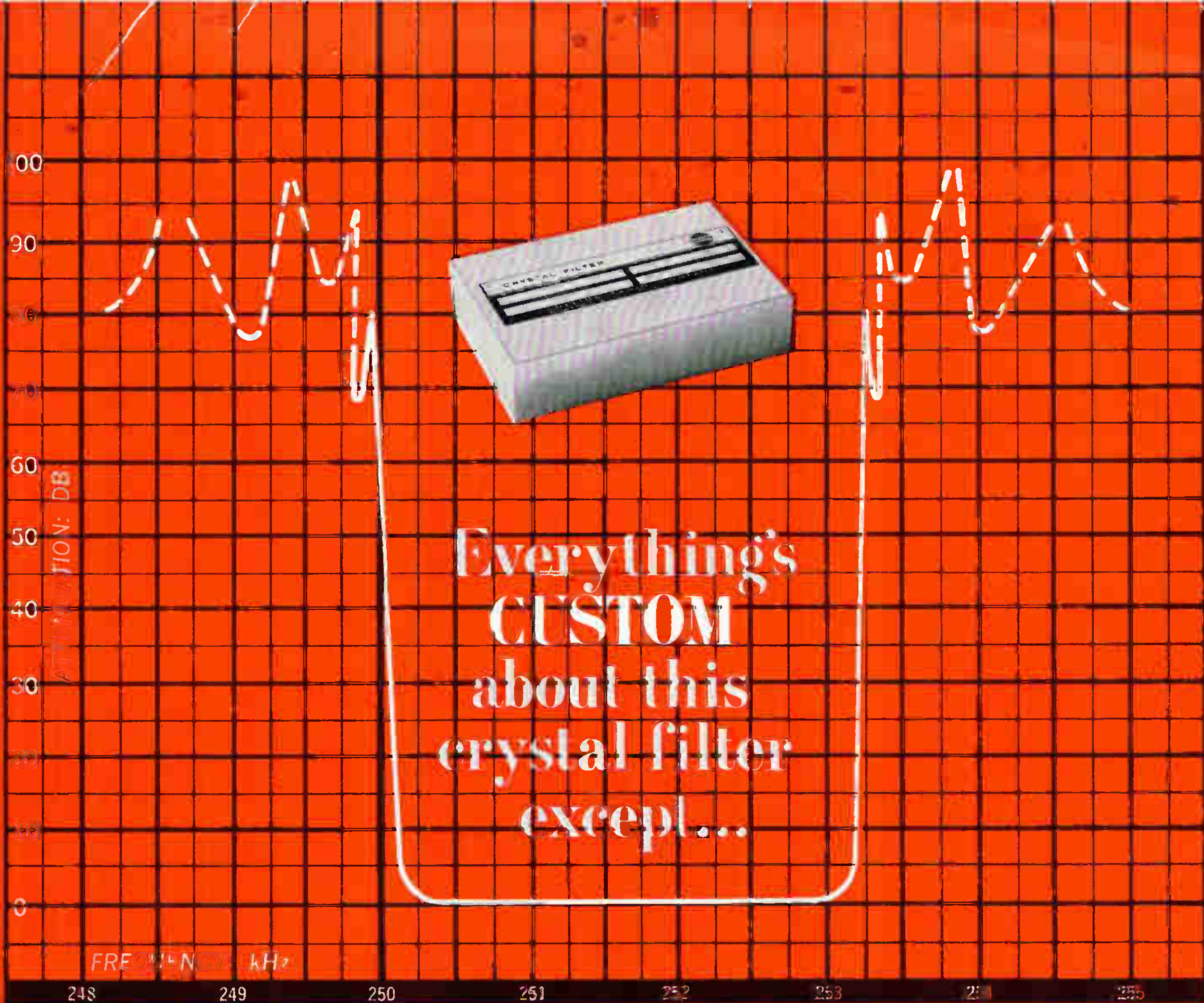

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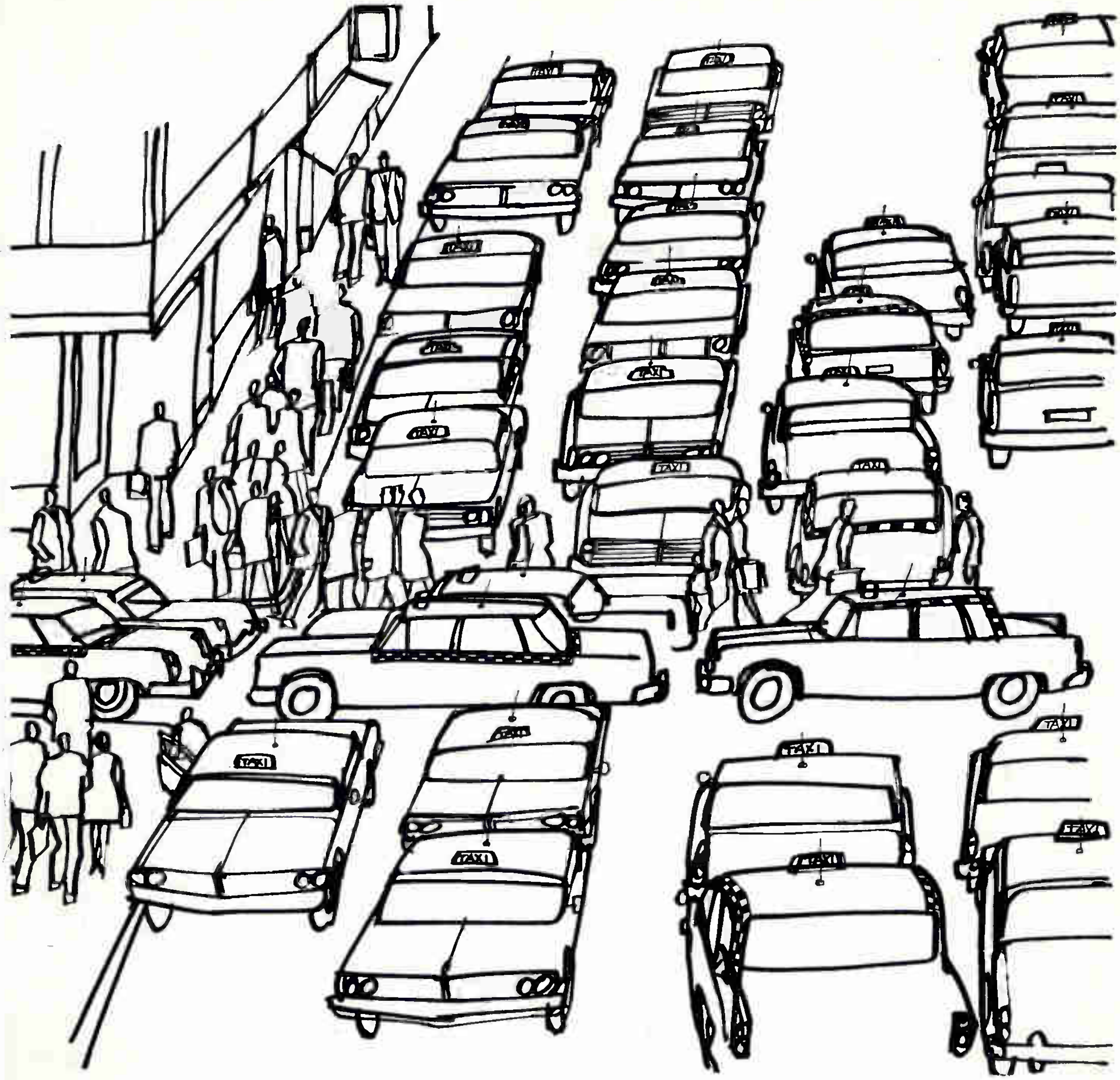

153,472 radio-dispatched taxicabs and only one tetrode rated for PTTS*

The cab driver is rarely on the air with his dispatcher for as long as 60 seconds and he drives at least 5 minutes between calls. The same goes for most radio-dispatched vehicles.

PTTS* (Push-To-Talk-Service), with its duty cycle of ONE MINUTE ON and FOUR MINUTES OFF has been shown to be the most realistic, economical and practical rating system for vehicular communications systems.

For this reason, Amperex developed the 8637, the only twin tetrode ever designed and rated for PTTS. Featuring high thermal inertia anodes and incorporating a wealth of twin-tetrode manufacturing experience, the 8637 offers the designer a new approach in creating a better vehicular radio. Fewer, and less costly components may be used. Some typical operating conditions which bear this out are shown on the chart at right . . . lower plate voltage, lower drive and higher efficiency at the VHF frequencies.

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50 MHz	PLATE	OUTPUT	DRIVE
CCS	375v.	25w.	0.67w.
ICAS	450v.	34w.	0.82w.
PTTS	**600v.**	**84w.**	**0.86w.**
175 MHz			
CCS	300v.	18w.	1.4w.
ICAS	350v.	26w.	1.6w.
PTTS	**560v.**	**63w.**	**2.2w.**

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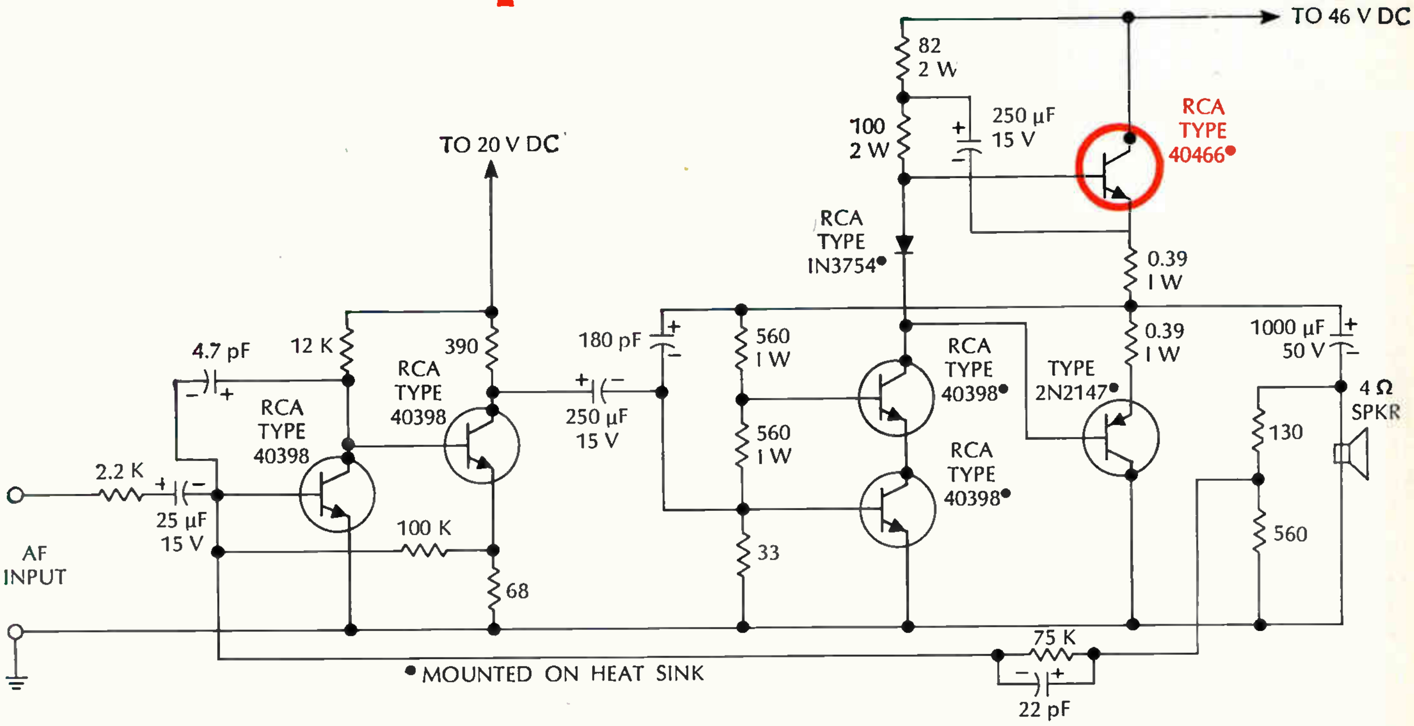
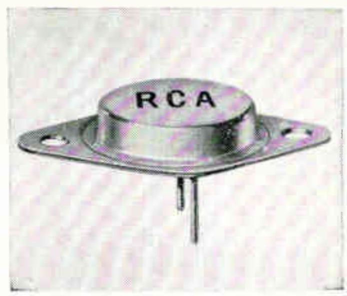


you can now design economical complementary-symmetry audio power amplifiers with extended high frequency response...simple driver requirements...and low distortion!



Hermetically sealed in a TO-3 low profile metal case

RCA's new 40466 silicon n-p-n power output transistor lets you combine real high fidelity performance with superior electrical ruggedness and the economy of *transformerless design*.

You can get 50 watts music power per channel in the circuit shown when the 40466 is complemented with the high-performing RCA 2N2147 germanium drift-field power transistor. Together they make a low cost output pair.

Response is flat from 10 Hz to 80 KHz . . total harmonic distortion at 20 watts with a 1 KHz signal is 0.13% . . . 0.05% at 1 watt.

Because of its epitaxial base construction, the 40466 also provides virtual freedom from second breakdown. And its high minimum beta of 50 at 2 amperes simplifies driver stage requirements.

RCA's new 40464 and 40465 silicon transistors are also available for lower power hi-fi stereo circuits. Your RCA Field Representative can tell you the whole story of how these new audio power devices can improve the performance of stereo phonographs, receivers, and tape recorders. He can also give you price and delivery. For a technical data sheet on the RCA 40464, 40465, 40466, write RCA Commercial Engineering, Sec.EN3-1, Harrison, N.J. 07029.

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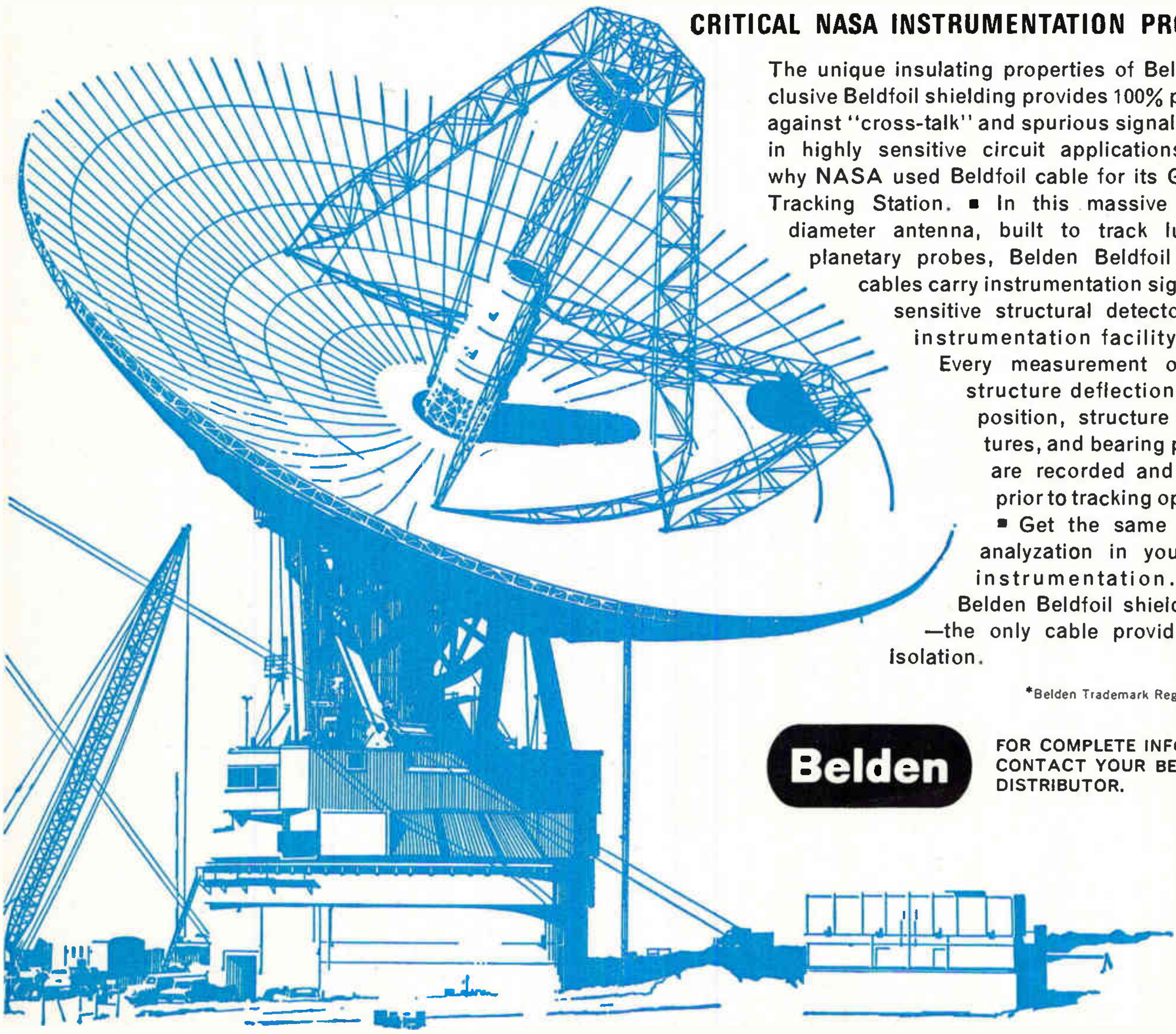
BELDFOIL* SHIELDED CABLE SOLVED CRITICAL NASA INSTRUMENTATION PROBLEM!



The unique insulating properties of Belden's exclusive Beldfoil shielding provides 100% protection against "cross-talk" and spurious signal impulses in highly sensitive circuit applications. That's why NASA used Beldfoil cable for its Goldstone Tracking Station. ■ In this massive 210 foot diameter antenna, built to track lunar and planetary probes, Belden Beldfoil shielded cables carry instrumentation signals from sensitive structural detectors to an instrumentation facility nearby. Every measurement of critical structure deflection, angular position, structure temperatures, and bearing pressures are recorded and analyzed prior to tracking operations. ■ Get the same precision analyzation in your critical instrumentation. Specify Belden Beldfoil shielded cable—the only cable providing 100% isolation.

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Probing the News

Manpower

Electronics engineers are fair game

With graduates becoming choosier and experienced specialists warier, the scramble for talent is becoming more intense and wide ranging

"If 300 of the right electronics engineers walked in this door right now, I could find a job for them." The open door is at Lockheed Missiles & Space Co. in Sunnyvale, Calif., and the speaker is Lloyd Leoma, supervisor of employment. Over-all, the division of Lockheed Aircraft Corp. is beating the bushes for 1,000 electronics engineers.

Up the coast in San Francisco, an employment agency manager, John M. Harris, says: "We're down 40% in the number of qualified applicants from a year ago, and up 25% or more in job requests from electronics firms. There just aren't as many men available."

In Boston, the Raytheon Co. is urgently seeking 935 engineers for four New England divisions.

In New York City, Careers Inc., a recruiting organization, has booked 200 hotel rooms for interviews during the four-day International convention of the Institute of Electrical and Electronics Engineers, which opens March 20. Last year the firm represented 40 companies at the convention and attracted over 1,300 job-seeking engineers. This year it is back representing even more firms.

Paradox. This contest for electronics engineers, however, is being staged against a strange backdrop. While recruiters point despairingly to the problem of finding enough warm bodies, the threat of layoffs hangs over the semiconductor and consumer-oriented sectors of the industry. At some companies, one division will be hiring while another is laying off engineers.

Companies that have had to furlough engineers recently include the National Video Corp., Motorola Inc., and the appliance division of

Where the jobs are

	types of engineers	openings
East		
General Precision, Aerospace Group	circuit, systems	150
Lockheed Electronics	radar, antenna, circuit	175-200
Grumman Aircraft Engineering	systems	200
General Electric Missile and Space division	design	200
Sperry Gyroscope	design, systems, inertial	200
Westinghouse Electric Defense and Space Center	radar	300
Southeast		
Lockheed-Georgia	design, systems	100
Pan American World Airways	radar, communications	100
Radiation	systems, computer	150
Douglas Aircraft, Missile and Space division	computer	75-100
Southwest		
Collins Radio, Dallas	systems	200
Texas Instruments	circuit design, semiconductor	600
General Dynamics, Ft. Worth	systems, electromagnetics	200
Ling-Temco-Vought	digital, electro-optics	200
Midwest		
Control Data (nationwide)	circuit design, logic	200-250
Automatic Electric	solid state, packaging	175
Conductron	computer, radar	200
AC Electronics	circuit design, systems	50
New England		
Raytheon	circuit design	935
Microwave Associates	microwave, solid state	50
Mitre	communications, data processing	70-80
Honeywell, Electronic Data Processing division	computer development	100
West Coast		
Ampex	circuit design, audio	100
Lockheed Missiles and Space	communications, circuit	1,700
Fairchild Semiconductor	circuit, product	150
Varian Associates	instrumentation, circuit design	150
Litton Industries, Guidance and Controls Systems division	computer design, control systems	50-100
Hughes Aircraft	circuit design, radar	525
Autonetics	systems, circuit	800
TRW Systems	guidance and control, communications	1,450

indicate the shortage of professional electronics engineers; recruiters to staff design facilities and research laboratories.

and aggressiveness. They get out to the campus early to secure the names of the students so they can send letters of invitation. Many send telegrams to remind students of scheduled interviews. Some even phone the students' homes or give prospects a dollar just to fill out a questionnaire.

Despite these efforts, many interviews are cancelled. The reason, says Dale Barbee, director of student placement at Case, is that the number of companies in search of employees is increasing while the number of students is holding fairly steady.

Jerry Hall, employment manager at Sylvania Electric Products Inc., a General Telephone subsidiary in Mountain View, Calif., agrees. He says his company is attracting fewer graduates than usual because the number of companies recruiting on campuses has more than doubled since last year. And Frank McCarter, employment manager at Litton Industries Inc.'s Guidance and Controls group, says: "We would like to fill about 25% of our engineering needs from college, but we only talk to the top one-third and they're hard to get." Litton usually ends up filling 15% of its new job openings with recent college graduates, according to McCarter.

III. Playing hard-to-get

With an increasing number of graduates, many of them concerned about the draft, going on to work on advanced degrees, the available talent is getting choosier about the sort of job offers it will consider. Many students, taking the big pay packet for granted, are more interested in the level at which they would enter a company and their prospects for promotion, possible graduate work, and membership in prestigious professional societies.

With all of the attention being paid to the student, however, it isn't surprising to find that he's also asking for more money. "It's not unusual for the college student to be offered $9,450 a year," says Barbee of Case. Hall of Sylvania finds that new graduates with masters' degrees are asking $10,000 and up right off the bat. What's more, they're getting it. Larry Dooley, manager of personnel for the Bendix Corp.'s Launch Support division at Merritt Island, Fla., says a brand-new electrical engineer can expect $7,500 and up, depending on his background, his class standing, and the reputation of his college.

Like his younger colleague, the experienced engineer making a move is asking for, and getting, more money, but there is some disagreement as to how much the increase comes to.

For instance, most recruiters in the Southeast report a leveling off in the rate of salary rises at about 5%. But on the West Coast, the home of so many aerospace concerns, recruiters see no such leveling off. John Doolittle, personnel manager at Ampex, says engineers moving to new jobs can expect a 10% to 15% pay increase. James Pietrowsky, at the Autonetics division of North American Aviation, Inc., Anaheim, Calif., concurs. "Engineers won't move for less than a 10% salary hike, and they'll often ask for 15% without batting an eye," he says.

However, a fellow Californian

Brand new Case graduate learns the ropes at Goodyear Aerospace.

Friden looks for pot of gold at end of electronics rainbow

Five-year program to put electronics in its business machines is set to pay off as company introduces a billing and accounting unit with integrated circuits

By William Arnold
San Francisco Bureau

When the Friden Co. realized that electronics would eventually obsolete its entire product line of electromechanical business machines, it turned to advanced technology in general and integrated circuits in particular. Friden's effort to break into advanced electronics took almost five years to pay off. But late last month the company introduced its first homegrown product with IC's—a desk-sized billing and accounting machine, called the model 5610 Computyper, that employs transistor-transistor-logic circuits for all logic functions. These devices were supplied by Texas Instruments Incorporated and 85% were made to Friden's specifications.

"We are a big company now and we're beginning to think and act like one," says Martin H. Dubilier, 40, who wears two hats as executive vice president and executive vice president for operations. "Five years ago, we had two product lines in a stable business. Today, we have five product lines in a rapidly changing business," he asserts. Dubilier estimates that this year Friden will buy more commercial integrated circuits than any company outside of the computer business. Its demand will rise to over three million circuits this year and more than six million in 1968.

Winds of change. Since the Computyper represents Friden's IC debut, the huge increase in IC purchases suggests that the company is ready to make extensive changes in its products. "We can't rely on anything in the sales line being there five years from now," Dubilier says.

Electronic products, with life expectancies of five years or less, clearly require development times faster than those of Friden's conventional products, which once lasted from 10 to 15 years. "You can't waste six months on a product with a life cycle of four years," Dubilier reports.

Friden, which was acquired by the Singer Co. in 1963, took its first tentative step into electronics that year by bringing out the model 6010 computer—essentially a sophisticated billing machine. A year later the company introduced its solid-state model 130 calculator, a desk-top unit for those with big desks. It followed up with the model 132—a 130 dressed up with a square-root key.

In 1966, Alan W. Drew took over as president and started action programs, increasing the number of employees in market research, and converting some field sales personnel to product management. He also redefined the product manager's role by making him a busi-

Custom-built IC's are mounted on board for Computyper—Friden's first advanced electronics business machine.

ness manager for his line. To speed the planning process he tightened liaison between product planning, the product line manager, and the engineers.

During this period, Friden expanded its small stakes in graphic arts, mailing-room devices, and such original equipment as the photoelectric keyboard into full product lines to match its original lines of adding machines, calculators, and data processing wares. Concurrently, it began pumping more money into research and development. Friden had created the base for this diversification program during the 1950's when it acquired plants in Rochester, N.Y., Lewiston, Pa., Nijmegen, the Netherlands, and Mechelen, Belgium. In 1963 it acquired the Physical Sciences Corp. of Arcadia, Calif.

I. Double Time

In 1964, the company invested 2% of its sales dollar in research and development. Now it allocates 3%—a level that Dubilier expects to maintain. On an estimated $170 million in sales last year, that amounts to over $5 million. With sales growing at an annual rate of 20%, the company will spend another $1 million on R&D in 1967.

Two groups share research funds. One, the Friden Research division, is an autonomous entity set up to do Singer-wide research, though 99% of its work is now done for Friden. Its chief, Leland P. Robinson, stresses that his bailiwick is mainly a computer lab for applied research.

"Part of our mission for the next few years is to help in every way to accelerate the industrial design of integrated circuit technology," he says. By improving wiring, minimizing interconnections, and reducing the number of components, Robinson's group hopes to lower production costs on Friden's equipment. The group has two main approaches: incorporating IC's in Friden products, and introducing computer-aided design to the engineering process.

Friden's other R&D operation is headquartered in a $1.25-million, 40,000-square-foot building that houses 180 employees. Three years ago, it had only 80. This facility is set up to compress research time, according to George E. Comstock, vice president for research and development. Essentially, he explains, Friden wants to use engineering as "a working tool for the marketing man to evaluate new products from a marketing point of view." Thus Friden can be in a better position to consider the economic tradeoffs in its custom-designed circuits.

Pathway. So far, and for some time to come, Comstock indicates, Friden sees those tradeoffs favoring double-diffused integrated circuits. "In today's technology," he says, "double-diffused technology is economical. It's basic, the art is well understood, and the yields are agreed upon." Comstock calls metal-oxide semiconductor technology "glamorous but impractical," and does not expect it to be really useful for five years.

II. Hardware and soft

First fruit of Friden's fling with advanced technology is the 5610, which makes use of about 220 custom-built circuits containing six inverters, acting as three flip-flops per chip. The chip has been dubbed the Hex (Greek for six) and costs about $2 per unit. Friden chose the transistor-transistor-logic chip some 18 months ago on the advice of Texas Instruments which said that it would be cheaper for custom design.

Friden claims it achieves flexibility by using the same chip throughout the machine. With external diodes the chip functions as a diode-transistor-logic input, since TTL devices can't operate with diodes. As a TTL output, the circuits afford speed and high fan-out. The 5610 contains 3,000 diodes in high-voltage delay lines and in the interface with Friden's model 2205 Flexowriter, one of the 5610's input-output paths.

The machine stores 60 programs on punched tape and comes with a simple software package called Swift—for software implemented Friden translation. With Swift, an operator can type out simple commands in English or any other language, and not worry about adhering strictly to computerese.

One program gives the 5610 troubleshooting capability, which Friden says is unique in a small-scale data processor. If the machine malfunctions, a diagnostic program can be fed in and the fault will be isolated and typed out.

III. Taking it easy

The glamor of IC's has not blinded Friden to its bread-and-butter business. The company now produces four times as many conventional calculators as electronic machines, and expects the changeover to all-electronic units to be gradual. It will be some time, Dubilier believes, before electronic calculators can match rotary machines in price. One conventional machine costs $1,195, while its speedier electronic counterpart has a price tag of $1,950.

But the company is now in the third year of an ambitious sales drive which it hopes will more than double volume and profits by 1970. At the same time Friden wants to keep its production force at the 13,000 level that now prevails around the world. "We're right on target, so far," Dubilier says. The business-machine industry, with a growth rate more than five times that of the economy as a whole, provides a nice foundation for Friden's ambitions.

A possible check on those ambitions is the need for trained personnel. Comstock admits to some difficulties in recruiting because "we're cloistered and not well-known in electronics." He feels, however, these drawbacks are offset by Friden's aggressiveness, growth, potential, and high salary scales. Still, San Leandro is across San Francisco Bay and removed from the electronics enclave in Santa Clara County. Robinson's research division, now located near Oakland International Airport, is currently negotiating for land in the Stanford University Industrial Park in Palo Alto in an attempt to bridge that distance. Friden is also trying to set up with the University of California at Berkeley the same kind of working agreements that many Peninsula companies enjoy with Stanford.

Change is not easy. Friden, which considers itself number one in calculators and adding machines, was once in danger of being leapfrogged by the electronics industry. But with electronics capability, says Dubilier, ". . . you keep up the momentum, and competitors can't catch up."

Time-sharing inquiry shakes industry

The FCC probe into computers' impact on communications will bring to a boil the controversies now simmering among common carriers, computer makers, users, service bureaus, and specialty companies

When the FCC decided to probe the impact of computers on communications last November, the language of its notice startled a lot of attorneys used to working with regulatory agencies. Instead of requesting comments on carefully defined issues, the Federal Communications Commission asked business firms to suggest areas for the inquiry. Said one attorney, "From reading this notice, I'd say the commission doesn't even know where to begin."

Now the commission has filed a supplementary notice of inquiry and everybody can see where the probe is going. It will delve into every aspect of time-sharing from the pricing of computers to the policing of compupter connections. Its scope could reshape the computer industry. At the International Business Machines Corp., an excited executive who studied the announcement exclaimed, "There's a large chunk of our future in here."

Nearly 35 companies responded to the FCC's November call for suggestions and the replies fell into two broad camps: one wants the commission to regulate time-sharing of computers completely, the other wants as little regulation as possible. In general, the common carriers familiar with the FCC and its procedures want regulation; industrial companies want regulations restricted to tariffs for communication lines.

The current investigation started when the FCC found difficulty untangling cases involving time-shared computers, machines in which many users have simultaneous access to a single computer from a distant site. Ostensibly the commission's interests were threefold:

- Are communications utilities providing adequate services to computer users?
- Are there any aspects of data processing that the commission should regulate?
- Is the privacy of subscribers to time-shared computers being adequately safeguarded?

Now industrial companies, to whom any regulation is anathema, believe the probe is going much deeper. What is at stake, they feel, is who will profit from the exploding market for data transmission. In fact, almost every company that has a computer may have something to gain or lose from the outcome of the inquiry. Soon there will be hardly a single computer that is not connected by telephone lines to a data bank, other computers, branch offices, or departments within a company.

I. Behind the probe

At the FCC over the past 18 months, the men assigned to watch communication common carrier companies, facilities, and services have become preoccupied with computer matters. The first major impasse, which most people claim prompted the FCC's inquiry, cropped up in 1965 when the Bunker-Ramo Corp. complained unofficially that the American Telephone and Telegraph Co. would not make telephone lines available for a specialized computer service to connect brokerage houses around the country with stock exchanges. The telephone company claimed that 5% of the traffic the new service would carry was the kind that ought to go over ordinary telephone or telegraph lines.

In the new service, which was to be called Telequote IV, a broker in any branch office anywhere in the United States could send a buy or sell order for a stock or commodity to any security or commodity exchange through a central computer which would assign the order to the firm's floor man at the proper security exchange, and send an acknowledgment of the completed transaction back to the proper office as well as do all the necessary computation and paperwork. Using the system, the branch office could also send and receive such ordinary messages as requests for hotel reservations, inquiries about the weather, or personal communications. Bunker-Ramo saw the system as an extension of the stock market pricing service it now offers brokerage firms. But the telephone company considered the move a definite encroachment upon its common carrier business.

Basics. Since both the service company and the telephone company recognized that a fundamental principle was involved, they agreed to go to the FCC unofficially. Since the experts at the commission did not have enough background information to make a precedent-setting ruling they persuaded the two companies to compromise. Bunker-Ramo would eliminate the features the telephone company found objectionable and the utility would supply lines for the remaining service. The company's modified service, now called Telecenter omniprocessing system will begin in about two months.

Then, Western Union International, a carrier regulated by the commission, disclosed plans for leasing data processing time on the same computers it was installing to switch Telex lines [Electronics, Nov. 28, 1966, p. 128], thereby adding an activity the commission could not regulate.

To cap the commission's worries, a professor at the Massachusetts Institute of Technology warned that computers were generating so much data for transmission over telephone lines the lines were in danger of being clogged, and the tele-

. . . common carriers want to diversify into data processing services . . .

phone system faced ruin.

In the replies to the commission's first notice of inquiry, storm signals were apparent from the number of companies that responded and their conflicting interests. Among them were: common carriers, including the two biggest, AT&T and Western Union; computer companies like IBM, Honeywell Inc., and the General Electric Co.; service bureaus operations like CEIR and McDonnell Computer Service; leasing companies such as Randolph Computer Co.; trade associations, the National Association of Manufacturers, the National Association of Broadcasters, the Business Equipment Manufacturers Association, and the American Petroleum Institute; manufacturing companies with an interest in electronics, for example, the Xerox Corp. and the Collins Radio Co.; and companies that want to sell specialized computer services like Bunker-Ramo.

Specific battle lines have been clearly drawn:

- The common carriers will fight to keep any computer-oriented company from performing a service which could be done by conventional telephone or telegraph lines. At the same time, the carriers want to diversify into data processing.
- Service bureaus and computer users want lower charges for the use of telephone and telegraph lines carrying data. They claim that the lines in use today are not as efficient as they should be because they were designed to carry voice communication primarily, not data.
- Computer manufacturers want a relaxation of restrictions that ban their hardware from being connected directly to telephone and telegraph lines. They fear that carriers could set arbitrary rules that would make some forms of data transmission uneconomic. AT&T has enjoyed a marketing advantage with its Dataphone equipment because it is the only data input gear a Bell System company will allow on a dial telephone line. Late last year, Bunker-Ramo Corp. went to the FCC and forced a reduction in rental of Dataphone sets, charging that AT&T's prices were far too high. The commission agreed and cut rentals from $40 per month to $30.
- Specialty companies want the common communication carriers to provide all the lines they need even if some ordinary message traffic is carried by the specialized service. For example, Bunker-Ramo expected to use the same telephone lines that already supplied buy and sell prices for its proposed Telequote IV brokerage service and its stock market quotation service. So far AT&T has forced the company to use separate lines—a procedure which runs up a customer's cost considerably.

II. The computer utility

In addition, Western Union, which is diversifying into a data processing service bureau operation, would like the commission to regulate prices of computers, a proposal that makes computer manufacturers furious.

Western Union's plans to build a so-called computer utility that will provide all kinds of data processing services has given the FCC still another kind of problem. The telegraph company has already installed big computers to switch Telex lines automatically, a function clearly under the FCC's jurisdiction. Later this year, the company will start leasing time for data processing to outside customers on these same machines, an activity the commission currently does not regulate. The big dilemma is how Western Union should divide the cost of the computers between regulated and nonregulated services when they are operating at the same time.

Which route? A question that worries nearly everybody is what the giant AT&T will do about data processing. So far, the telephone company has shown no inclination to follow Western Union down the computer utility route. But computer manufacturers and service bureaus are nervous because Bell System companies are installing electronic switching systems that are really special-purpose computers. Although AT&T engineers say considerable hardware and software modifications would be required to enable these machines to perform ordinary data processing, they admit it is technically feasible.

Some people have felt that a consent decree in which AT&T entered with the Justice Department in 1956 would bar the company's diversification into the data processing business or service bureau operation. But some experts say no and the company agrees with that view. In the consent decree, the phone company agreed to engage only in activities regulated by the FCC. Testifying before a Congressional committee last year, AT&T executives offered the opinion that if the company filed and the FCC accepted a tariff for a computer service, the strictures of the consent decree would not apply.

Thus if, as a result of the current probe, the FCC should ask for and receive legislation to control data processing activities that cross state lines, AT&T might well launch a large-scale invasion of the data processing service bureau business.

Government's role. The great concern over, and interest in, computer utilities is shown by the calling of two major meetings later this month. The American Management Association has scheduled a three-day session from March 8 to 10 entitled "The computer utility—management's stake in shared-time and shared-information systems." Later in the month, March 20 to 22, the College of Engineering at the University of California at Los Angeles will host a meeting called: "Computers and communications; toward a computer utility." At both meetings a discussion of the role of Government in the computer utility occupies an important place on the program.

Nobody expects the FCC to reach a fast conclusion from its probe into computers and communications. Most experts are predicting the inquiry will take three or four years. But the betting is that the commission will decide to ask Congress for additional legislation so it can regulate time-sharing. Explained one attorney who has specialized in presenting cases before Government agencies, "I never heard of a regulatory agency that didn't try to expand its operations. The main question is where the FCC will stop with time-sharing."

Easing of tube shortage in Japan opens color tv markets for set makers

With prices coming down and outlets available both at home and in the U.S., the industry gears for volume production

By the Lunar calendar, this is the year of the sheep in Japan. But for the country's color television manufacturers, 1967 could be more aptly named.

For the color tv industry in Japan has moved into a phase where none can afford docility. The color tube shortage that long held the pack at bay ended last summer. Unleashed, the dozen or so Japanese receiver makers scurried to get into big-volume production. Now that the production lines are pouring out sets, the scramble to sell them has started.

Geared up to turn out upwards of a million color tv sets this year, the Japanese will toil like beavers to keep their prodigious output from piling up in warehouses. Color tv makers figure to be tigerish in their marketing techniques. Indeed, any set maker who outwardly appears attuned to the celestial conjunction of the ancient calendar most likely is a wolf masquerading in sheep's clothing.

Poised to climb. Luckily, the two major outlets for Japanese color tv makers should expand sharply this year. An early-year flurry of new models priced at below $500 shows signs of triggering a color boom in the domestic market. And in the United States, where the outlook is for total sales of some 6 million sets, Japanese producers expect to sell at least 500,000 units, double their 1966 business.

Export prospects, in fact, may become even brighter before year's end. So far, Japanese producers have made the 19-inch set their bread-and-butter model. Most, though, will add 15-inch sets to their lines before the year is out. Traditionally, Japanese consumer electronics producers have fared best in the U.S. market with small, low-cost receivers.

For the long term, Japanese producers seem to be in a good position to snare a substantial share of the U.S. small-screen color tv market. Both the Sony Corp. and the General Corp. (formerly the Yaoun Electric Co.) have in the works post-deflection focus tubes—without shadow masks—that are admirably suited for the forthcoming generation of small solid-state sets.

I. Full swing

More than anything else, what makes 1967 anything but the year of the sheep for Japanese color tv makers is a burgeoning shadow-mask tube output in the country. In mid-1966, the Asahi Glass Co. boosted its bulb capacity substantially. The company, which exports heavily but at the same time supplies more than half of the bulbs used in Japanese color sets, will probably turn out two million this year, as against 800,000 last year.

Smaller tube makers have followed suit. Tokyo Shibaura Electric Co. (Toshiba), for example, recently doubled its monthly capacity to 60,000 bulbs. Hitachi Ltd. is going from 13,000 to 30,000 units and the Matsushita Electrical Industrial Co. from 15,000 to 25,000. The New Nippon Electric Co. will soon begin its own tube production at a rate of 20,000 units a month.

Shadow-mask makers are keeping pace. By mid-1967, the three major Japanese producers will have doubled their output. By then, the industry leader, the Dai Nippon Micro Co., a subsidiary of the Dai Nippon Printing Co., will hit 100,000 monthly. The other two will put out 70,000 between them.

With tubes no longer a problem, Japanese color set production most likely will run about 1.3 million

Toshiba, one of a dozen Japanese tv makers cashing in on the color boom, at home and overseas, will be producing at a rate of 30,000 sets in March.

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Uncalculated risks keep calculator on the shelf

Trying to take too big a step from the lab to production of an IC-equipped calculator, General Micro-electronics stumbled over a number of technical obstacles

By Lewis H. Young
Editor-in-chief

Sixteen months ago, at the annual show of the Business Equipment Manufacturers Association, the Victor Comptometer Corp. introduced a radically new electronic calculator that set some startling precedents. For one thing, 29 metal oxide semiconductor chips were to replace nearly 21,000 conventional discrete components. For another, the entire calculator, the Victor 3900, was to be fabricated and assembled by a semiconductor company, General Micro-electronics Inc. of Santa Clara, Calif. After the show, however, the Victor 3900 disappeared.

Last month, executives at Victor and the Philco-Ford Corp., which purchased General Micro-electronics last summer, shamefacedly explained the disappearance. The semiconductor company hasn't been able to manufacture the Victor 3900.

Philip Ferguson, president of Philco-Ford Micro-electronics, conceded that serious production problems have delayed the calculator's debut.

Items:

- Nearly half of the 29 integrated circuits had to be redesigned.
- Cost reduction efforts were too stringent and resulted in the use of components that couldn't perform satisfactorily.
- Engineers who designed the IC's underestimated the difficulty of shifting from hand manufacture in a research laboratory to commercial production.

But Ferguson had some good news, too. Redesign of the calculator has now been completed and mass production will start this summer. The new circuits are currently being evaluated and a few calculators are being assembled for testing.

Prototype on schedule. The initial design and construction of a prototype moved right on schedule after the project was begun in September 1964. By October 1965, every circuit worked and the assembled machine performed well. An over-confident Victor signed a fixed price contract with General Micro-electronics for a large number of machines at this point, but big troubles cropped up when the design went into production.

Because General Micro-electronics was running a pilot-line operation in 1965, the switch to mass production became a nightmare. Employment was more than tripled, and floor space was increased from 30,000 square feet to 100,000. The company, which was to deliver the calculators at a price low enough to make them competitive with conventional machines, found itself anteing up money at a rate it couldn't sustain. On some circuits, the yield was, in Ferguson's words, "substantially less than 1%." On one or two, yields were zero; they simply couldn't be mass produced.

Problems. "Most large steps forward take longer than you think," says Philco-Ford's J. Philip Ferguson.

Pound foolish. To keep costs down, the company cut corners and suffered the consequences. For example, it bought a cheaper transformer for the power supply only to find that the component couldn't perform satisfactorily. By the spring of 1966, Ferguson realized the worst; a major redesign was necessary if the calculator was ever to be mass produced.

The chief difficulty, according to Ferguson, was that the engineers who designed the circuits were overoptimistic about what they could do. "MOS was in research and development when the project started," he said, "so both systems designers and circuit people were going to school on the calculator, learning the technology."

I. A matter of microns

Probably the most important thing the engineers learned was that while design rules produced theoretically satisfactory integrated circuits when the devices were carefully made in the laboratory, the same rules weren't practical for commercial production. The big problem turned out to be a matter of microns.

One big advantage of MOS technology is that a transistor takes up an area only 5% the size of that required by a similar device made ponent density. Fewer components per chip would have meant more chips and raised costs sharply. As Ferguson explains it, "We think the true potential of MOS technology is in very complex circuits. The attractiveness of MOS drops rapidly as complexity falls." Even with revised design rules and loosened geometrical restrictions, Philco-Ford engineers have put 400 to 600 components on each of the machine's 23 different circuits (seven of the machine's total of 29 circuits are 96-bit shift registers). "We took exactly the right design route," Ferguson asserts.

Rumor: The electronic calculator was a poor product in which to try integrated circuits.

Experts at competitors debunk this charge. At Texas Instruments Incorporated, for example, Jack Kilby, often regarded as the father of IC's, agrees that the calculator is an excellent subject for MOS technology. His company is one of several conducting research aimed at producing MOS circuitry for a calculator.

Rumor: The work on MOS integated circuits has gone so badly that Philco-Ford has built calculators with discrete transistors in MOS IC cans to replace IC's that didn't work.

"Ridiculous," scoffs Philco-Ford's Ferguson. Another executive declared that the high cost of such discrete devices would preclude their use in this design.

Rumor: Victor is so upset about missed deliveries it is ready to sue Philco-Ford.

At Victor, Albert C. Beuler Jr., executive vice president, admits he would like to have had the machines in time for the planned January 1966 marketing debut, but says he understands the delay caused by the pioneering nature of the development. Victor has kept close watch on the difficulties at Santa Clara, so the schedule slippage was no surprise. Beuler says the relationship between the two companies is as good as ever.

Rumor: Philco-Ford will never build the Victor 3900.

Ferguson says prototype production has started again and deliveries should begin by summer. Beuler, at Victor, expects to start receiving machines by mid-1967. Normally, the business-machines company

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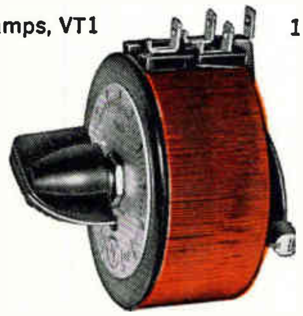
1.0 amps, VT1



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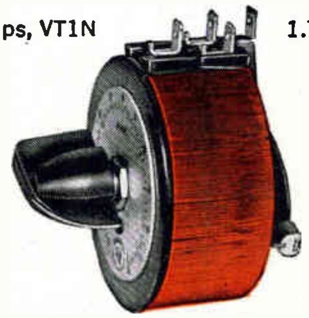

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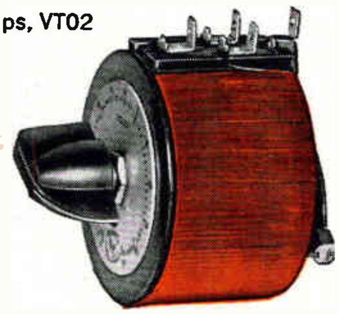
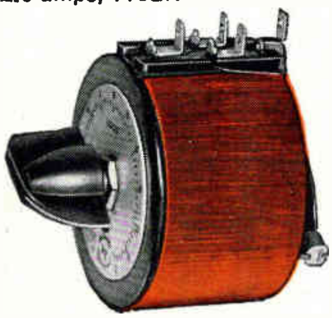
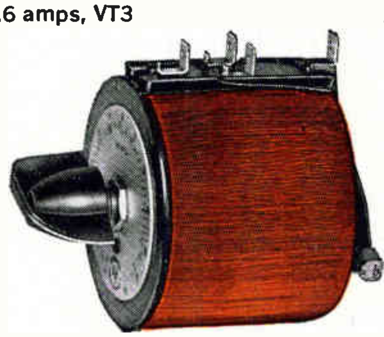


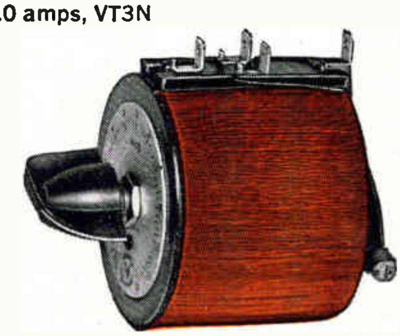
2.0 amps, VT02N



2.6 amps, VT3



3.0 amps, VT3N



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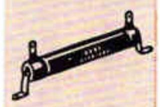

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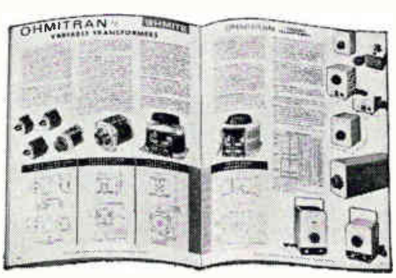

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Introducing... RCA Solid-State GaAs Optical Devices

- Injection Lasers with 1- to 50-W outputs at *room temperature* and threshold currents *below 15A*
- Miniature IR Diode Emitter with focused light output

	TA2628 laser	TA2930 laser	TA7008 IR diode
eak Power Output (min) @ 27°C	1 W @ 30 A	50 W @ 30 A	0.6 mW @ 0.1 A
hreshold Current	15 A	15 A	100 mA
utput Wavelength	9050 Å ±50	9050 Å ±50	9100 Å ±300
ine Width	5—10 Å	60—100 Å	600 Å ±50
perating Temp.	–196 to 50°C	–196 to 50°C	–73 to 50 °C
ulse Width/ Repetition Rate	0.2 μs/1000 pps	0.2 μs/1000 pps	CW

RCA's wealth of semiconductor experience introduces a new dimension of practicality to solid-state lasers and light diodes. Available now in sampling quantities, each of these optical devices represents an important new tool for the field of electro-optics.

Check these performance benefits of RCA's TA2628 and TA2930* laser diodes:

Practical Power Outputs—conservative peak power rating from 1 to 50 W at room temperature.

Practical Pulse Current—lasing action begins with threshold currents below 15 A.

Practical Circuit Usage—Inexpensive semiconductor pulse circuits can be used without cryogenic hardware.

Practical Size—hermetically sealed in modified TO-5 and TO-46 packages.

RCA's new laser diodes are ready now for your evaluation in applications such as secure communications, intrusion alarms, traffic control, instrumentation, ranging and field illumination.

And RCA's new TA7008 IR emitter is equally exciting. Featuring a miniature but highly efficient parabolic reflection system, this tiny device provides a new source of focused light for applications such as card-reading.

Call your RCA representative today for more information on RCA's new family of developmental optical devices. For data sheets and application note on laser power supplies, write RCA Commercial Engineering, Section IN3-1, Harrison, N.J.

*The availability of the TA2930 laser array is presently limited to qualified defense contractors.

RCA Electronic Components and Devices

The Most Trusted Name in Electronics

Circle 237 on reader service card

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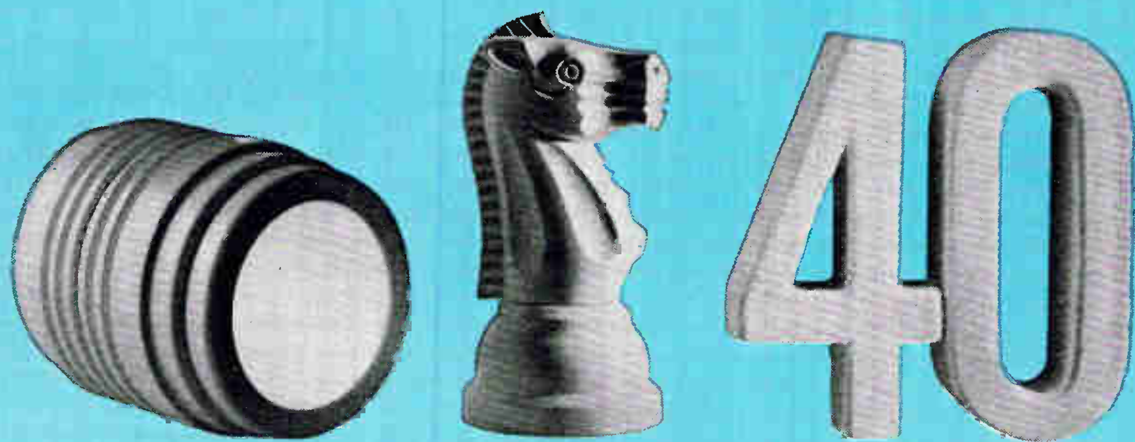
Bayonet Globar® heating elements offer complete design freedom. Introduce them—through roof, walls, or floor.

Three advanced grades of Combat boron nitride. For fixtures, jigs, and boats.

New oxide refractories extend the range of high purity, physical and thermal strengths. Check Mate system makes selection easy.

Fiberfrax® ceramic-fiber insulation holds K factors down in the one-figure range all the way up to 2300°F. Precisely. In 40 forms.



Precise physical properties and precise electrical characteristics start with our control over the electric-furnaced raw materials.

Then we work to hold that precision. The goal is to give you components and ceramic materials whose characteristics are those of their fire-born grain. Precisely. Meticulous technologies help us meet that goal.

Once we're satisfied with the precision of a given product, we get even more meticulous. We nail down every production step to assure you of automated precision that's uniform in part after part after part.

You're invited to talk with us at the Coliseum about our components for temperature or voltage compensation and about production uses of our ceramic products.

Precisely yours...

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roadest line of all-silicon quipment and laboratory use.

For Rack or Bench Use—From 1/2 amp to 35 amps, 0-10, 0-20, 0-40, 0-60, 0-120 VDC—with full five year guarantee on materials and labor

Features and Data

- **Convection Cooled**
- **Remotely Programable**
- **Remote Sensing**
- **Regulation**—.015% or 1 MV (Line or Load)
- **Temp. Coef.** .015%/°C
- **Transformer**—designed to MIL-T-27 Grade 6
- **Completely Protected**—Short Circuit Proof—Continuously Adjustable Automatic Current Limiting
- **Constant I./Constant V** by automatic crossover
- **Series/Parallel Operation**
- **No Voltage Spikes or Overshoot** on "turn on", "turn off" or power failure
- **Meet Mil. Environment Specs.**
Vibration; MIL-T-4807A
Shock: MIL-E-4970A
• Proc. 1 & 2
Humidity: MIL-STD-810
• Meth. 507
Temp. Shock: MIL-E-5272C
• (ASG) Proc. 1
Altitude: MIL-E-4970A
• (ASG) Proc. 1
Marking: MIL-STD-130
Quality: MIL-Q-9858
- **Ripple**—
LK models—500 μV RMS
LH models—250 μV RMS,
1 MV P-P
- **Wide Input Voltage and Frequency Range**—
L K models—105-132 VAC, 47-63 cps
LH models—105-135 VAC, 45-480 cps.
- **LH models meet RFI Spec.**—Mil-I-16910
- **Rack Adapters**
LRA-1—5¼" Height x 16½" Depth (For use with chassis slides) Price $60.00
LRA-2—5¼" Height Price $25.00

3 full-rack LK models—Size 5¼" x 19" x 16½"

Model[2]	Voltage Range	CURRENT RANGE AT AMBIENT OF:[1]				Price[2]
		40°C	50°C	60°C	71°C	
LK 350	0-20VDC	0-35A	0-31A	0-26A	0-20A	$675
LK 351	0-36VDC	0-25A	0-23A	0-20A	0-15A	640
LK 352	0-60VDC	0-15A	0-14A	0-12.5A	0-10A	650

6 half-rack LK models—Size 5-3/16" x 8⅜" x 16½"

Model[2]	Voltage Range	CURRENT RANGE AT AMBIENT OF:[1]				Price[2]
		40°C	50°C	60°C	71°C	
LK 340	0-20VDC	0- 8.0A	0- 7.0A	0- 6.1A	0-4.9A	$330
LK 341	0-20VDC	0-13.5A	0-11.0A	0-10.0A	0-7.7A	385
LK 342	0-36VDC	0- 5.2A	0- 5.0A	0- 4.5A	0-3.7A	335
LK 343	0-36VDC	0- 9.0A	0- 8.5A	0- 7.6A	0-6.1A	395
LK 344	0-60VDC	0- 4.0A	0- 3.5A	0- 3.0A	0-2.5A	340
LK 345	0-60VDC	0- 6.0A	0- 5.2A	0- 4.5A	0-4.0A	395

[1] Current rating applies over entire voltage range.
[2] Prices are for non-metered models. For metered models add suffix (FM) to model number and add $30.00 to price.
[3] Overvoltage Protection: Add suffix (OV) to model number and add $70.00 to the price for half-rack models; $90.00 for full-rack models.
[4] Chassis Slides: Add suffix (CS) to model number and add $60.00 to the price.

5 quarter-rack LH models—Size 5-3/16" x 4-3/16" x 15½"

Model[2]	Voltage Range	CURRENT RANGE AT AMBIENT OF:[1]				Price[2]
		30°C	50°C	60°C	71°C	
LH 118	0-10VDC	0-4.0A	0-3.5A	0-2.9A	0-2.3A	$175
LH 121	0-20VDC	0-2.4A	0-2.2A	0-1.8A	0-1.5A	159
LH 124	0-40VDC	0-1.3A	0-1.1A	0-0.9A	0-0.7A	154
LH 127	0-60VDC	0-0.9A	0-0.7A	0-0.6A	0-0.5A	184
LH 130	0-120VDC	0-0.50A	0-0.40A	0-0.35A	0-0.25A	225

5 half-rack LH models—Size 5-3/16" x 8⅜" x 15⅝"

Model[2]	Voltage Range	CURRENT RANGE AT AMBIENT OF:[1]				Price[2]
		30°C	50°C	60°C	71°C	
LH 119	0-10VDC	0-9.0A	0-8.0A	0-6.9A	0-5.8A	$289
LH 122	0-20VDC	0-5.7A	0-4.7A	0-4.0A	0-3.3A	260
LH 125	0-40VDC	0-3.0A	0-2.7A	0-2.3A	0-1.9A	269
LH 128	0-60VDC	0-2.4A	0-2.1A	0-1.8A	0-1.5A	315
LH 131	0-120VDC	0-1.2A	0-0.9A	0-0.8A	0-0.6A	320

[1] Current rating applies over entire voltage range.
[2] Prices are for non-metered models. For metered models add suffix (FM) to model number and add $25.00 to price. For non-metered chassis mounting models, add suffix (S) to model number and subtract $5.00 from non-metered price.
[3] Overvoltage Protection; Add suffix (OV) to model number and add $60.00 to the price.

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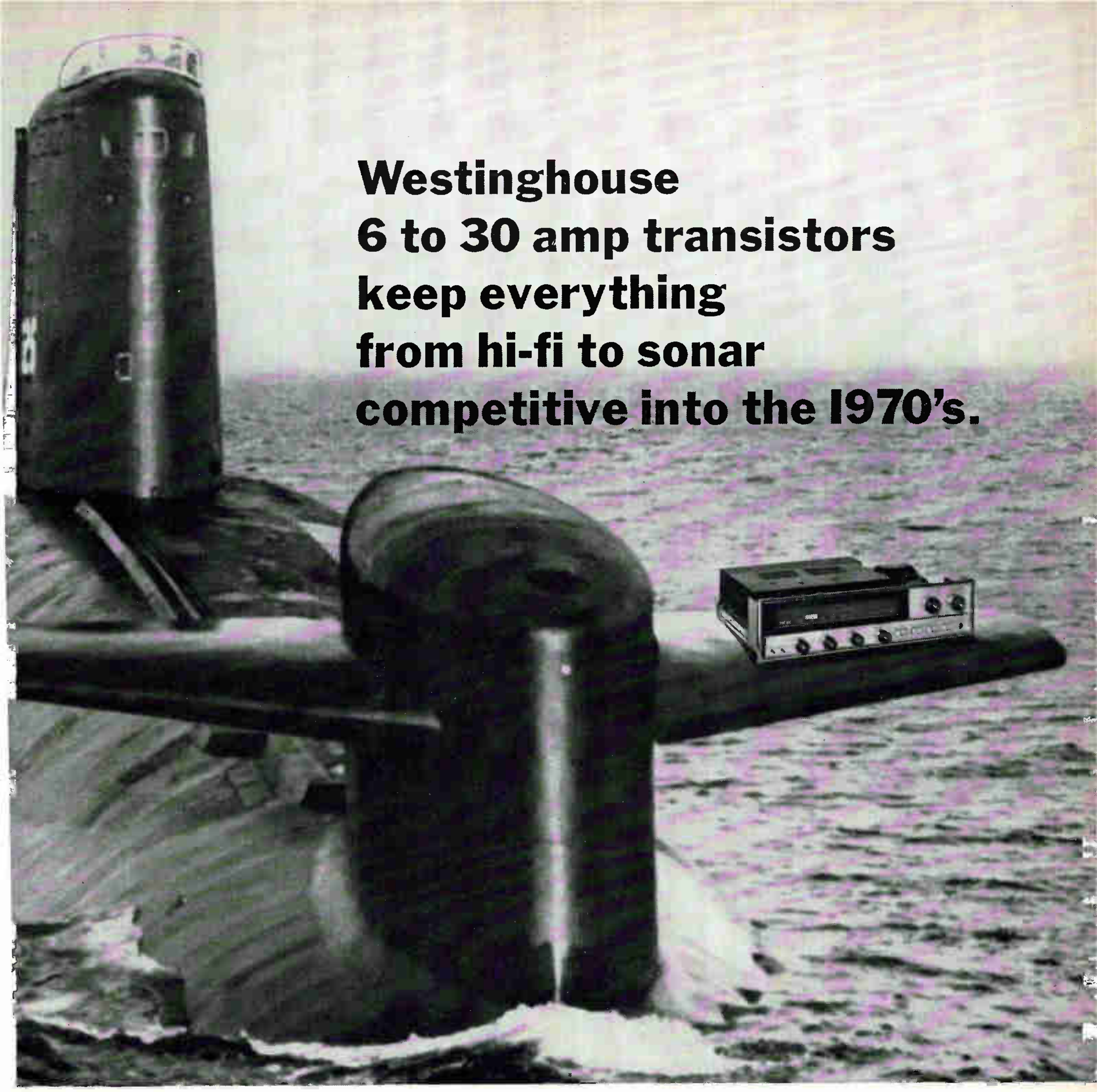
Westinghouse 6 to 30 amp transistors keep everything from hi-fi to sonar competitive into the 1970's.



Look beyond the JEDEC number. Test transistors competitively. Like many of our customers, you'll find that Westinghouse transistors deliver performance bonuses...and at competitive prices.

Peak Power Handling. For example, a manufacturer of hi-fi amplifiers needed transistors that could take the peak power pulses generated by a carelessly-dropped pickup arm. He tested plenty of 2N3055's and chose the Westinghouse product. It solved his problem best. It also offered the exclusive Westinghouse Lifetime Guarantee.

Westinghouse 2N3055 Series transistors feature DC power dissipation ratings to 117 W., V_{CE} from 55 to 140 V., gain from 18 at 3 A. to 20 at 4 A.

Cool-Running Reliability. A sonar manufacturer needed kilowatts of power output with tight Navy performance and reliability specifications. His solution: Westinghouse's 2N2757 Series Lifetime Guaranteed transistors.

Their low saturation voltage (typical 0.4 V. @ 10 A.), and low thermal impedance (0.5° C. per W.), insure cool running. This, plus demonstrated freedom from second breakdown, makes them ideal for repetitive switching into inductive loads. Perfect for inverters and regulators as well as sonar amplifiers.

Westinghouse 2N2757 Series transistors feature 250 watt power dissipation capability, V_{CE} from 50 to 250 V., gain from 10 at 10 A. to 10 at 25A.

Broad Line. Between these extremes, Westinghouse has a complete transistor line ranging from military types to plastic-case types. And most have the unique Westinghouse Lifetime Guarantee identified by this symbol ✤ on the case.

Send for our Semiconductor Condensed Catalog now. Meet the transistors, rectifiers, and thyristors for now and 1970. Call your Westinghouse distributor. Or write Westinghouse Semiconductor Division, Youngwood, Pa. 15697.

✤ Westinghouse warrants to the original purchaser that it will correct any defects in workmanship, by repair or replacement f.o.b. factory, for any silicon power semiconductor bearing this symbol ✤ during the life of the equipment in which it is originally installed, provided said device is used within manufacturer's published ratings and applied in accordance with good engineering practice. The foregoing warranty is exclusive and in lieu of all other warranties of quality whether written, oral, or implied (including any warranty of merchantability or fitness for purpose).

You can be sure if it's Westinghouse

SC 2086

Circle 247 on reader service card

100 μv resolution auto polarity-display storage overrange digit

[$595]

The new Hewlett-Packard 3430A Digital Voltmeter is a high-performance utility instrument ideal for production line work, repair or inspection stations, in the lab or for quality control. It offers the highest value available today in terms of price and performance.

- **100 μv sensitivity for low-level measurements**
- **Auto polarity**
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- **RATIO measurement option**

Nowhere else can you get these extra "luxury" features at such a low cost. High-speed measurement, 100 mv-1000 v, accuracy 0.1% of full scale ±1 digit, plus the 4th digit for overranging. Measure to ±500 v dc with respect to ground. No worry about circuit loading with the high input impedance. High stability with the voltage accuracy guaranteed to 3 months, one-year warranty on the instrument. The only DVM of its type available with ratio measurement capability, at an accuracy of ±0.15% ±1 digit. With the ratio option 01 ($80), you can normalize transducer dc outputs without taking time for recalculation. It offers all polarity combinations. The bonus amplifier output, ±0.1% accuracy, increases testing flexibility.

Call your Hewlett-Packard field engineer for a demonstration or write for complete specifications: Hewlett-Packard, Palo Alto, California 94304, Tel. (415) 326-7000; Europe: 54 Route des Acacias, Geneva.

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1648

Microwave switch is integrated by microstrip

Interconnections printed on a ceramic base and elimination of diode packages improves isolation and raises speed of S-band device

High isolation, fast switching speed and low insertion loss have been achieved by putting an S-band switch and its driver circuit onto ceramic substrates and interconnect components with a microstrip transmission line. Because the assembly is a hybrid integrated circuit, it's also small—about one-sixteenth the size of its predecessor, also made by Microwave Associates, Inc. The company claims it's the first commercially made IC that operates at microwave frequencies.

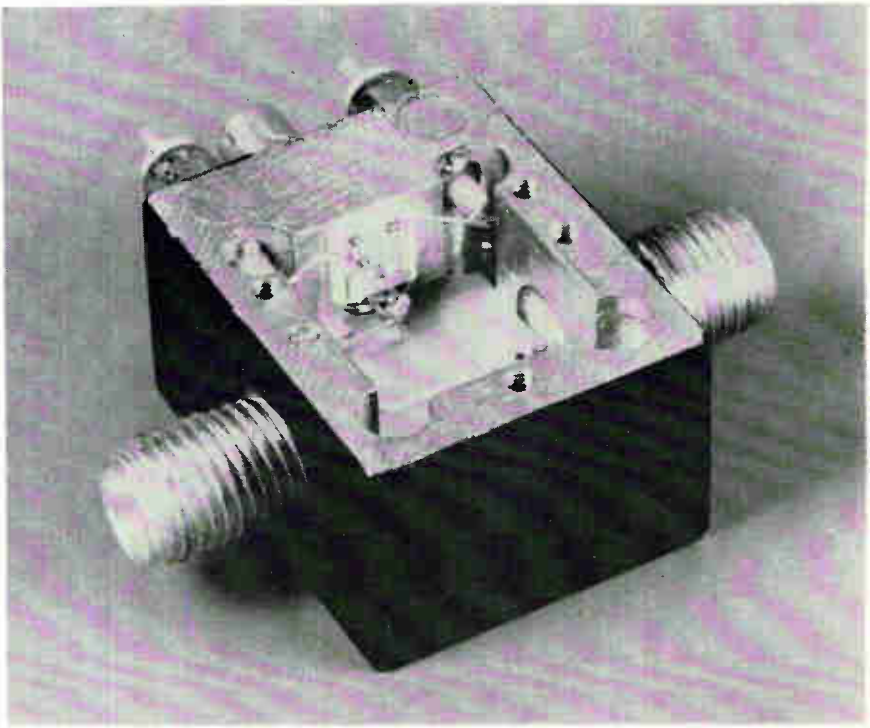
It has always been difficult to get high isolation and speed with low insertion loss in solid-state microwave switches. With discrete components, parasitic capacitance from the diodes' packages increased the over-all capacitance. The capacitance could be reduced by using several series-connected diodes. But the more numerous the diodes, the higher the insertion loss and the longer the time required to remove the injected charge.

The company solved this circular problem by getting rid of the diode packaging and by using only two diodes, specially made p-i-n chips, mounted directly onto the microstrip transmission line. The resulting circuit switches in 20 nanoseconds, with 50-decibel isolation and 1.75-db insertion loss.

The driver circuit's bipolar signal quickly removes the injected charge in the diodes during turn-off. The importance of the driver's closeness to the diodes is shown by comparison tests. Using the internal driver, the switching speed is nominally 20 nanoseconds (in experimental models, the time has been halved). When the same switch was actuated by an external driver connected by a 10-inch coaxial lead, the best speed possible was 30 to 35 nsec.

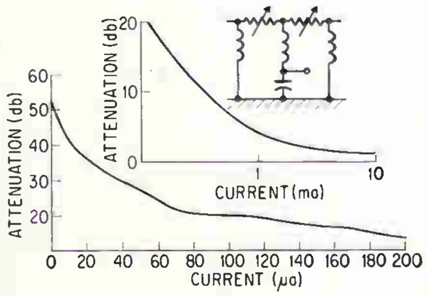
One major factor in reducing size stems from the high dielectric constant of the ceramic substrate. Alumina—which has a dielectric constant of close to 9—was chosen. Since wavelength is proportional to the square root of the dielectric constant, the microstrip was trimmed to about one-third the size of one with a conventional dielectric.

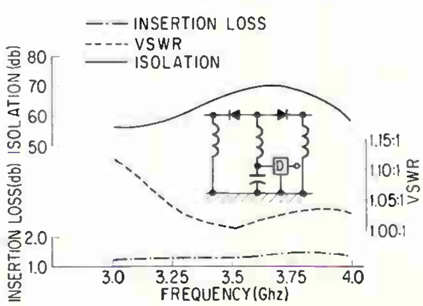
The microstrip is formed on the alumina board by depositing a silver circuit pattern and ground plane. When the structure is fired at high temperatures, the resulting bond forms a strong base for soldering and welding the components and leads. Since the microstrip can



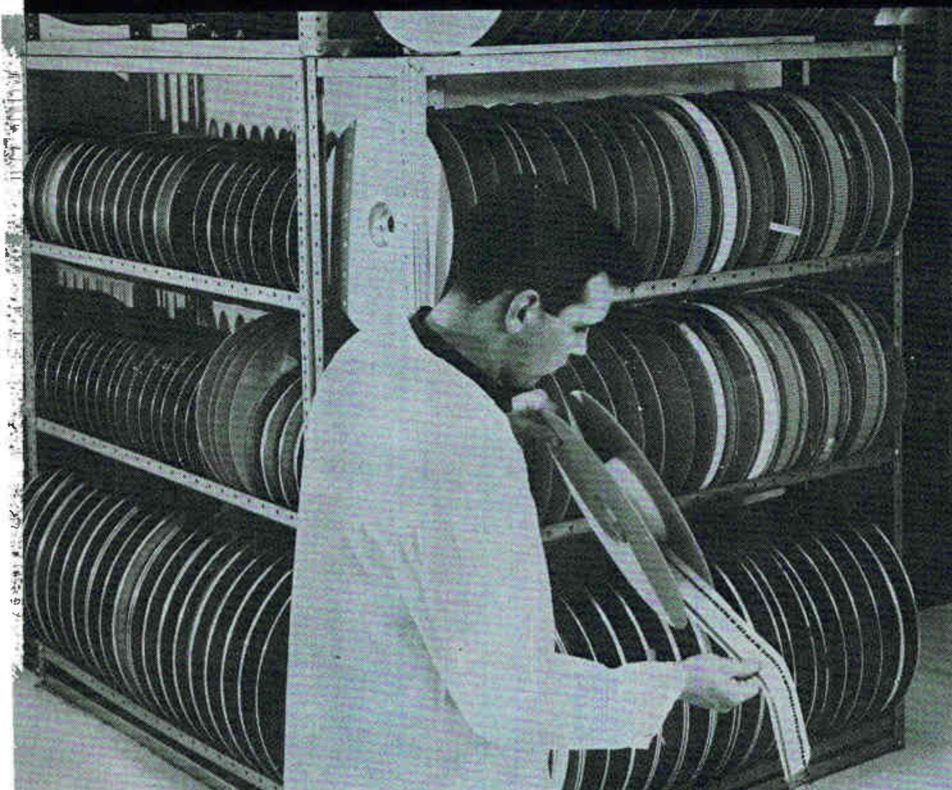
Specifications

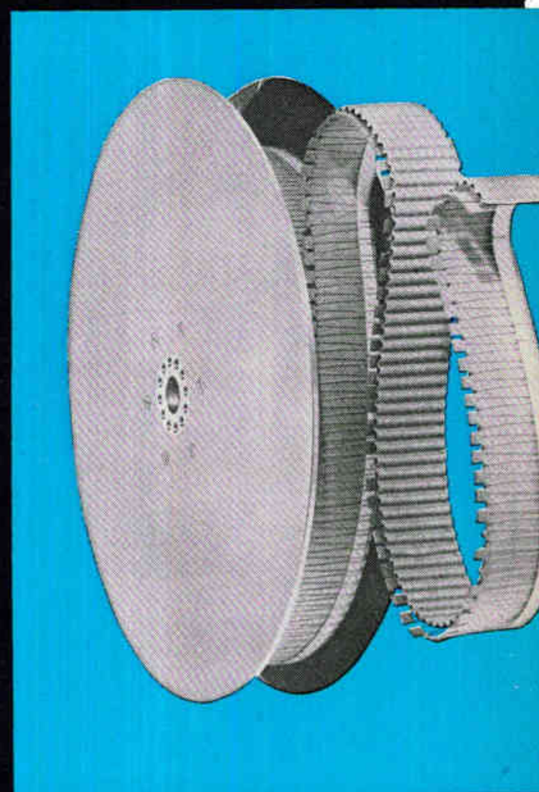
Frequency	S band
Bandwidth	1 Ghz
VSWR	1.5 max.
Isolation	50 db
Insertion loss	1.75 db max.
Switching speed	20 nsec
Power handling	
continuous wave	0.5 watt
peak	25 watts
Size	0.875 x 0.675 x 0.55 in.
Weight	0.5 oz
Price	
with driver	$375
without driver	$295
Delivery	60 days





Reel fast delivery of ceramic capacitors . . . the result of Mepco's automated production techniques





Mepco's subminiature Ceramic Capacitors meet the standards of military specifications, yet are designed and priced for high-volume industrial-commercial programs.

- Conformal epoxy enclosure offers excellent environmental protection and unusually high body insulation.
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- Delivery weeks ahead of usual industry standards.
- Dimensions as small as .100″ x .100″.
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ings in both ends of the shield, and an aluminum bar stock attached to the outer wall perimeters provides the spacing between shields. To simplify tube installation, all lower shield cylinders are cemented in position with epoxies and remaining components are detachable. Shielding qualities are not affected by ordinary shock.

After proper heat treatment of magnetic components, the Netic shield sections are cadmium plated to minimize rusting with no periodic annealing required. The outer shield has a baked wrinkle enamel finish.

Prices, beginning at $350, depend on complexity and size. Delivery is four to six weeks depending on structural modifications required.

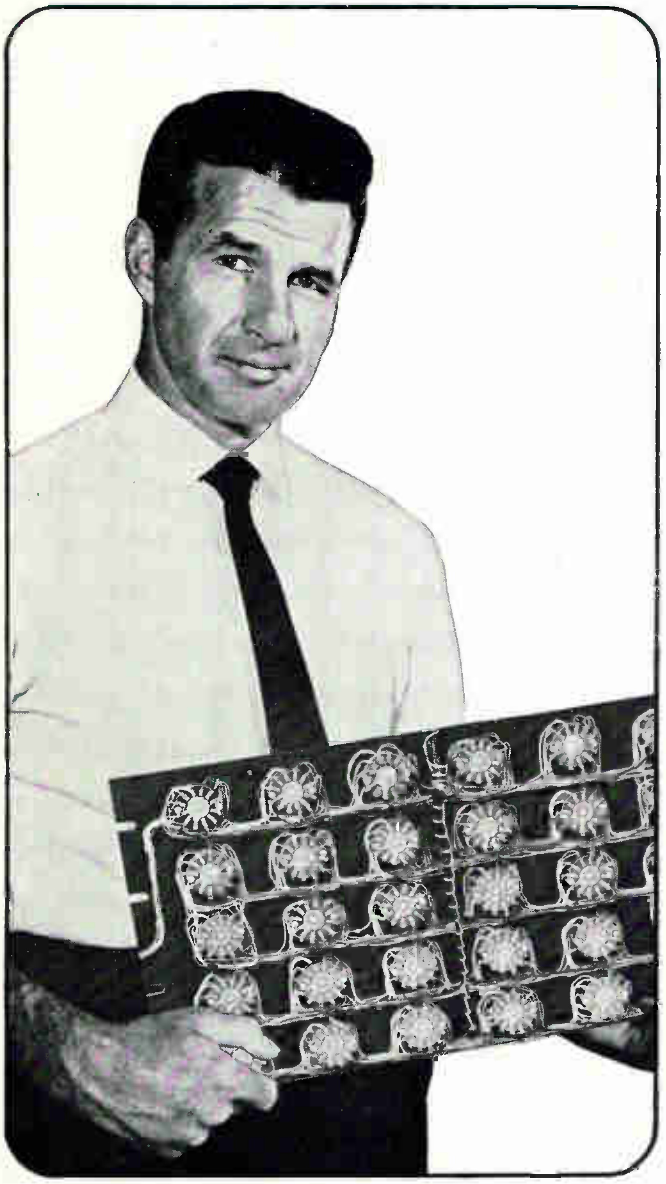
To be exhibited at the IEEE show.
Magnetic Shield Division, Perfection Mica Co., 1322 North Elston Ave., Chicago, Ill., 60622. [352]

Vacuum dielectric gives long life to relay

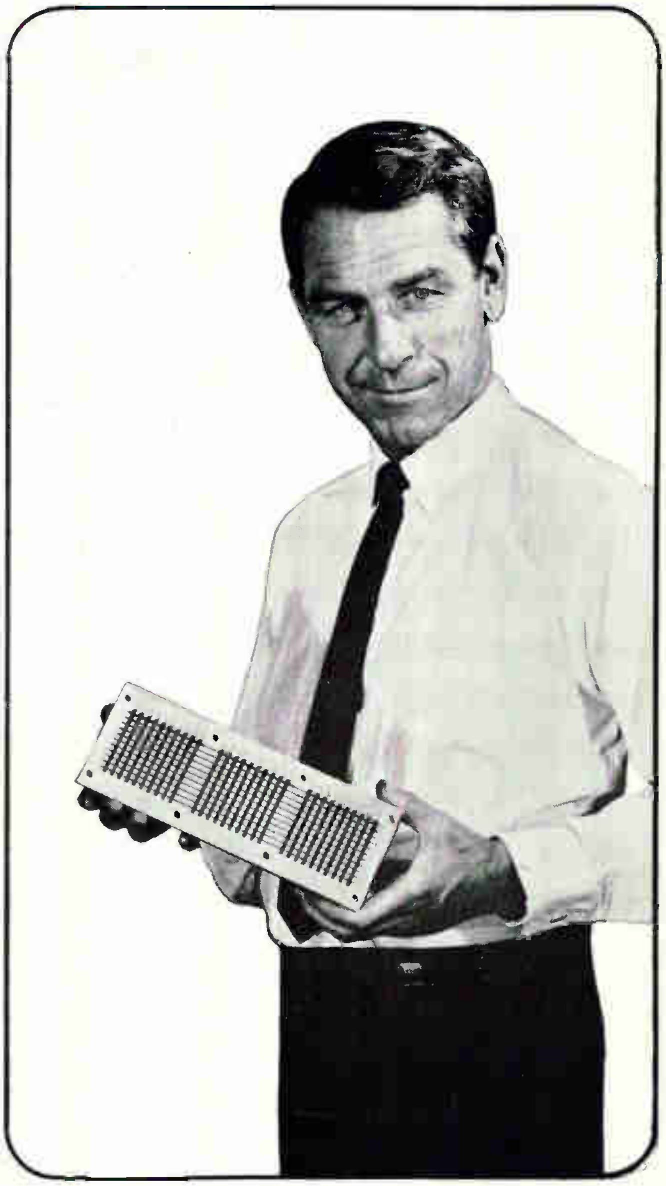
Interrupting resistive power, carrying high r-f currents and withstanding high voltage, are features of the RF1D vacuum relay.

The relay interrupts 1,000 watts of d-c power for over 100,000 operations at a maximum of 1 amp or 2 kv. It also withstands 4 kv peak test voltage and carries r-f currents of 4 amps rms at 16 Mhz. This is

TWO ENGINEERS WITH THE SAME PROGRAMMING PROBLEM



USING ROTARY SWITCHES requires 330 soldered joints . . . over 8 hours of labor . . . occupies 293 square inches of panel space . . . costs $88.00 installed.
(*That's $0.29 per switching point.*)



USING CHERRY SELECTOR SWITCH requires no soldering . . . less than 5 minutes of labor . . . occupies 41 square inches of panel space . . . costs $32.95 installed.
(*That's $0.11 per switching point.*)

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WRITE TODAY for full details on the totally new Cherry Selector Switch. It may change all your old ideas about programming devices.

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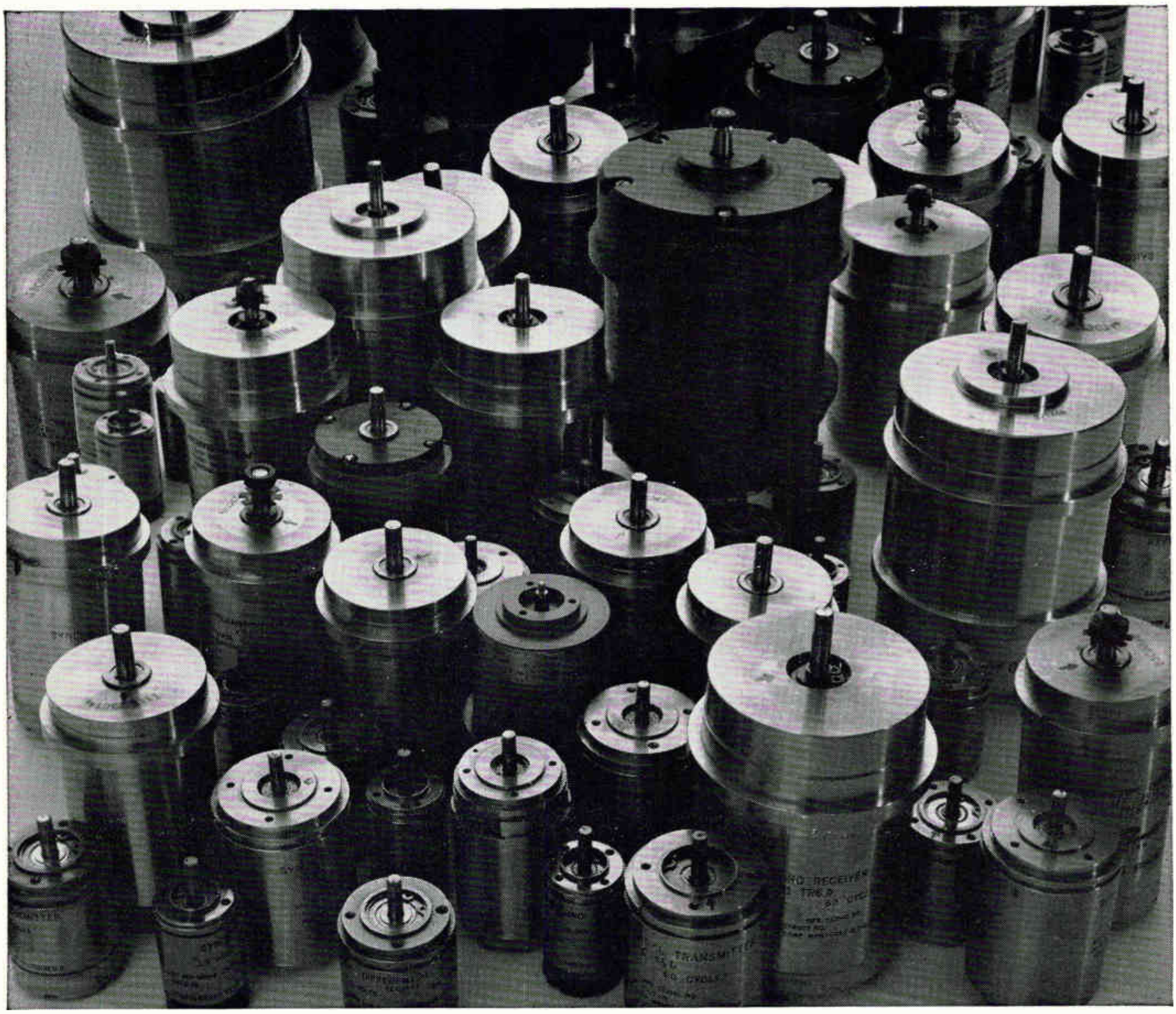
Circle 259 on reader service card



How the leading, one-source supplier of Mil-Spec synchros will solve your design problems: by the numbers.

Bendix® Mil-Spec synchros total 107 different synchro models—cover 11 major military specifications—and include nine primary sizes, ranging from the dwarf Size 08 (our most recent addition) to Size 37 (see chart for both).

What the numbers mean to you is simple: you now have a single source of supply for virtually every Mil-Spec synchro you'll ever need—and nearly all the others, just in case.

What the numbers mean to us is simple, too: Bendix Mil-S-20708 synchros are consistently chosen for use on ground support equipment and navy ships. That's a record we intend to keep.

There's more: a valuable asset called experience. Ours began in the 1920's with the original synchro concept. Since then we've helped develop nearly every major military spec in use. Today, we'll provide everything from Mil-Spec to our famous Autosyn® line to special, custom-made synchros for the unique problem.

What it all boils down to is this: when you need a Mil-Spec synchro (or any other kind), call the leader in synchros at (717) 278-1161. Or write for our 42-pg. catalog. Flight & Engine Instruments Division, Montrose, Pa.

Size	Max. Diameter (In.)	Typical Weight (Oz.)	No. of Models
BuWeps 08	0.750	1.6	3
BuWeps 11	1.062	4.4	10
BuWeps 15	1.437	9	19
BuWeps 18	1.750	17	16
Ordnance 23*	2.250	21	20
BuWeps 23	2.250	31	20
BuWeps 30	2.962	99	2
BuWeps 31	3.100	65	10
BuWeps 37	3.625	124	7

*MIL-S-12472, 16892, 20708, 2335; MS-51080, 51081, 51082, 51083.

Bendix Aerospace Products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DC Power Supply Modules
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If you'll circle Reader Service #25,
we'll send you one by return mail.

We've got a chip on our shoulder!

Not enough of you know that we are one of the industry's leading manufacturers of high-quality 930 DTL digital integrated circuits. Well, we are.

Who has a larger more modern facility devoted exclusively to the manufacture of these kinds of microcircuits? (We don't dilute our efforts with the manufacture of a thousand other semiconductor components.)

Who has better yields in this DTL line? (Our manufacturing capability is unsurpassed, and we invite you to inspect it for yourself.)

Who can give you better delivery on these products? (It's pretty hard to beat our *immediate* delivery!)

Who can offer you better prices? (Try us on a quantity bid.)

Who has a more substantial name behind them than the "Stewart-Warner" name—a name associated with the manufacture of quality products for more than 85 years? (We'll be around to keep you supplied with microcircuits for years to come.)

Why have we got a chip on our shoulder? Not enough of you have tried our 930 DTL monolithic circuits, and that's too bad. We know you'd like our product, available in all the standard packages. So why not help us take the "chip" off our shoulder and put it in your equipment. Send for our 20-page "Composite Data Book" for the industry's best coverage of the 930 DTL series.

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or conversely, feeding one signal channel to a large number of outputs.

The switch consists of from one to ten 2-pole wafers with 64 ways per wafer. Information can be accurately fed to computers and data logging instruments, display oscilloscopes or trip level controls at 640 points per second, per wafer. Action is break before make. Scanning speed is 30 to 120 rpm at 50 hz.

Switching contacts and brushes are 0.015 in. 24-K electrodeposited gold to reduce self-generated noise to less than 3 μv. Disk flatness is controlled to a 4-microinch finish and the insulating medium has no effect on contact performance. Each switch wafer is fitted with four printed-circuit edge connectors for input cables. Solder terminals are provided for output cables.

Normal method of connection is by printed socket, but the unit can be modified to meet customer requirements. Synchronization of any number of scanners and random access can be achieved by incorporating a 64-bit binary coded disk and logic module. A mounted 45 v single-phase synchronous motor drive is also available.

Suggested applications include scanning, multiplexing, distributing, sampling, programing, testing, process control, data logging, transducers, thermocouples, strain gauges and telemetering.
Electro-Tec Corp., Box 667, Ormond Beach, Fla., 32704. **[360]**

Metal-ceramic triodes operate at 250 Mhz

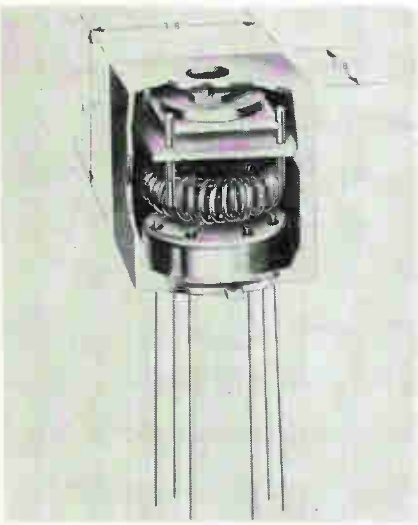
The demand for high frequencies and high power in today's dielectric and induction heating equipment has led to the development of a line of metal-ceramic industrial triodes. These units extend the equipment capability to frequencies greater than 160 Mhz without derating; 250 Mhz with derated operation.

Two families of tubes are available: the series 8731, 8732 and 8733 with 5-kw dissipation and the seadvantage of the mesh design is the increase in contact area from the grid to its external connection which results in excellent heat transfer and insures high thermal conductivity. This construction technique limits the possibility of deformation of the grid or cathode during life, thus minimizing the possibility of grid-to-cathode shorts.

Electrode connections with large contact area achieve low thermal resistance between connectors and the tube. This reduces r-f losses and heat at the connection.

Amperex Electronic Corp., Hicksville, L.I., N.Y., 11802. **[361]**

Phase detector in a square can



Typical of a line of miniature LC circuits is this phase detector packaged in a square can—⅜ in. square and ½ in. high—mounted on a standard 6-pin, TO-5 glass-to-metal-sealed header. A recent application has been in a monopulse radar system for weapons control, in which it detects the output phase difference between two 60-Mhz input signals emitted from an i-f amplifier.

Model MTLCJ013 includes a trifilar wound toroidal inductor and a MT320 Modutrim ceramic variable capacitor which is adjustable from the top. The capacitor uses a proprietary ceramic and patented monolithic rotor for extremely high stability (capacitance drift is 0.75% of nominal maximum capacitance). Operating frequency of the

Control Switch announces

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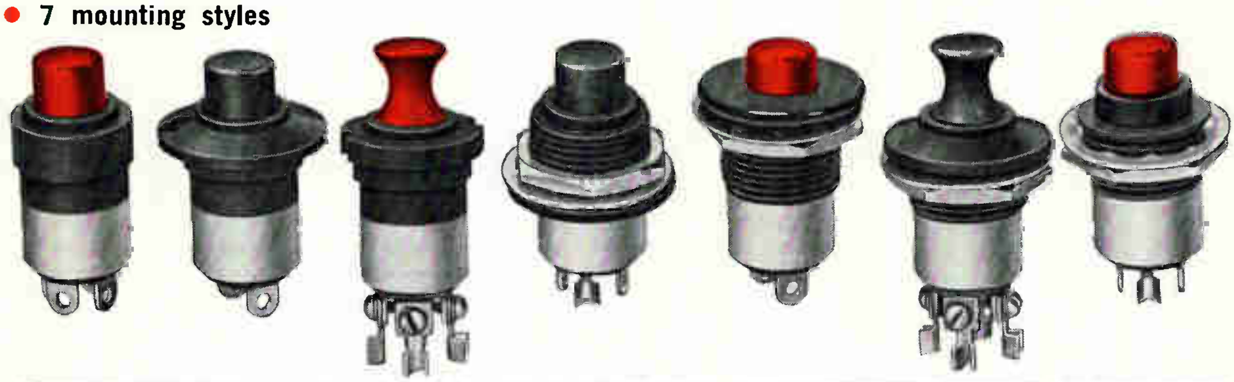
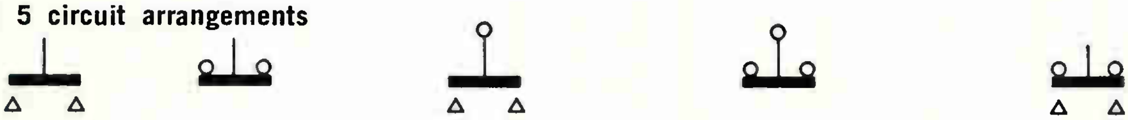
All 110 Versions of MIL-S-8805/3 – MS25089

- **7 mounting styles**



- **5 circuit arrangements**



- **2 button colors.**
- **2 button styles.**
- **Momentary or push-pull actions.**
- **Temperature range: —55°C to 85°C.**
- **Life: 25,000 operations minimum at rated load.**
- **Shock: High Impact, momentary types. 50G, all types.**
- **Vibration: 10 to 500 cps.**

This new Series may include the pushbutton switch you need right now for extreme dependability in military or other equipment. Or the switch that breaks a design block, or sparks a new design idea. The specifications speak for themselves!

Series W190 pushbutton switches are another in a spectacular series of firsts from Control Switch . . . source of the widest selection of high-reliability switches and indicator lights available anywhere. More firsts are coming. Soon! Order Series W190 from your Control Switch distributor, or direct from us.

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CONTROL SWITCH DIVISION
1420 Delmar Drive, Folcroft, Pennsylvania 19032
A Subsidiary of
General Precision Equipment Corp.

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Check Number on Reader Service Card corresponding to number at left below for our Bulletin on new Series W190 pushbutton switches. While you're at it, get all the items listed below:

#483 MIL-S-8805 Bulletin 64
#484 Condensed Switch Catalog 100
#485 Basic Snap-Action Switch Catalog 110
#486 Toggle Catalog 180
#487 Indicator Light Catalog 120
#488 Hermetic Switch Catalog 130
#489 Switchlite Catalog 220
#490 Pushbutton Catalog 190

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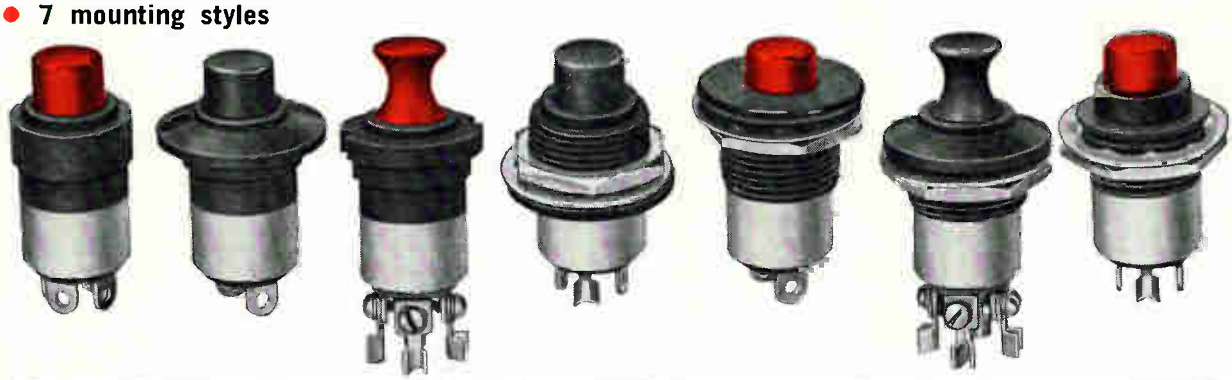
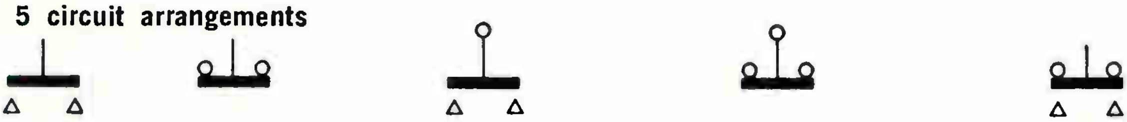
First and only pushbutton switches certifiable to MIL-S-8805

All 110 Versions of MIL-S-8805/3 – MS25089

- **7 mounting styles**



- **5 circuit arrangements**



SP-NO	SP-NC	SP-NO 3 Terminal	SP-NC 3 Terminal	2-CIRCUIT
Single pole, normally open	Single pole, normally closed	Single pole, normally open, three terminal	Single pole, normally closed, three terminal	(may be jumpered for SPDT)

- **2 button colors.**
- **2 button styles.**
- **Momentary or push-pull actions.**
- **Temperature range: —55°C to 85°C.**
- **Life: 25,000 operations minimum at rated load.**
- **Shock: High Impact, momentary types. 50G, all types.**
- **Vibration: 10 to 500 cps.**

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#490 Pushbutton Catalog 190

People who counteract countermeasures count on us.

A traveling wave tube for a missile to enable it to home on a target despite the most sophisticated countermeasures. That's what the OEM design engineer on the phone needed. His frequency, power output, and gain requirements were way out. Like nothing we had, or anyone else had. And his time schedule was tight.

In two days we'd visited his plant. Reviewed the performance criteria. Committed ourselves. Another seven days and we'd submitted complete tube specifications. And ninety days later we delivered the first tube. On time and bug-free.

That's how we do business with everyone. We react fast and we know you can't afford false starts. We'll review your technical requirements and if we can't meet them, we'll say so—on the spot. Or we'll take on your job, and stick with it until our tube is working in your system.

If that's how you like to do business, call us. Or write for complete data on our standard TWT's and other types of high-performance tubes: Dept. EL, ITT Electron Tube Division, International Telephone and Telegraph Corporation, P.O. Box 100, Easton, Pennsylvania.

electron tube division **ITT**

Circle 277 on reader service card

Semiconductors

NEW IDEAS IN APPLICATION AND DESIGN

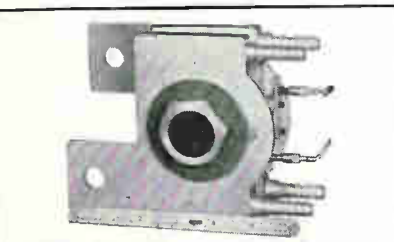
PROVEN PERFORMER FOR HIGH POWER SWITCHING: GE C500X1 WATER-COOLED SWITCH

Even welding locomotives doesn't tax the high power capability of these SCR's.

For seven months one GE C500X1 water-cooled switch has been in use at a large locomotive plant. It operates at 900 amperes RMS and 480 volts, with an on-time of 1.5 seconds and a 25% duty cycle for resistance welding.

The same plant has been using a second C500X1 for five months and expects to install more of them in the future.

C500X1's are also now in use for automotive welding. Other possible applications include particle accelerator power supplies, primary transformer control, static switching, and control of large lighting loads. (Three C500X1's could theoretically control all the lighting in a 60,000-seat stadium.) The C500X1 is rated at 1200 amps



You'll get 1800 volt peak blocking capability from this 1200 amp GE C500X1 water-cooled switch.

RMS with peak blocking capability to 1800 volts in both directions. Surge ratings are 4000 amperes peak for ten cycles and 7000 amperes for one cycle. The device can be used directly in 440 or 550 volt a-c service. Circle number 811.

These are just a few examples of General Electric's total electronic capability. For more information on all GE semiconductor products, call your GE engineer/salesman or distributor. Or write to Section 220-53, General Electric Company, Schenectady, New York. In Canada: Canadian General Electric, 189 Dufferin St., Toronto, Ont. Export: Electronic Components Sales, IGE Export Division, 159 Madison Ave., New York, N.Y., USA.

Lots of new application ideas at GE's IEEE seminars

New application ideas for both standard and exotic semiconductors —ideas that can enhance your solid-state circuitry—will be presented at GE's Semiconductor Products Department IEEE seminars on March 21 at the Barbizon-Plaza Hotel Theater, New York City.

The morning session, titled "Innovations for Industrial Semiconductor Circuits," starts at 9 a.m. and features these subjects and speakers:

The complementary unijunction . . .

Bob Muth discusses new IC fabrication techniques and characteristics of this ultra-stable threshold for timers and oscillators.

Tunnel Diodes revisited . . .

Rick Spofford introduces the first truly low-cost planar tunnel diode.

Opto-electronics . . .

Dick Stasior examines the principles and applications of lasers, light emitting diodes, detectors, light-activated SCR's, and SCS's.

Sophisticated functions using GE's newest plastic semiconductors . . .

Joe Byerly presents some of the new, low-cost circuit approaches now possible with advanced plastic encapsulated semiconductors.

The afternoon seminar (1:30), "Semiconductor Control and Power Conversion Applications," features:

The widening world of the fast recovery rectifier diode . . .

John Hey discusses the unique advantages of fast recovery diodes for both low and high frequency power conversion equipment.

Design/application assistance case histories . . .

Tom Penkalski uses actual cases to illustrate symptoms, analysis, and solutions of semiconductor application problems.

Increased current ratings from PRESS PAK semiconductors . . .

Bernie Jalbert shows how new mounting methods increase power handling capability without increasing pellet size.

Primary phase control of transformer coupled loads . . .

Forest Golden examines trigger circuit and transformer requirements in three phase applications.

Economy control circuits and modules for light industrial and consumer applications . . .

Andy Adem discusses a variety of low-cost reliable motor and temperature controls, and power switching circuit modules.

Low-cost precision power control module using zero-voltage switching . . .

Jim Galloway presents a compact control with 3600 watt capability for a variety of open and closed loop control systems.

You'll also be interested in GE's computer time sharing demonstration. Just feed simple design or specification problems into one of the four consoles at the exhibit and the pre-programmed computer will recommend a solution.

All this and more is waiting for you from GE's Semiconductor Products Department at the IEEE show.

GENERAL ELECTRIC

Circle 279 on reader service card

are packaged in hermetically sealed metal cases and come in three sizes: TO-46, TO-18 and TO-5. Specifications are essentially identical, except as package size increases, so do average current and power ratings.

The silicon planar passivated construction employed provides long-term parameter stability and inherent reliability. The units are available in anode voltage ratings from 30 to 200 v and feature peak forward currents to 40 amps, maximum trigger currents of 200 μa, 8-μsec recovery times, and 0.2-μsec turn-on times.

The scr's are suited for solenoid or lamp driving, sensing, timing, programing, motor control, and other related high-gain, high-output functions.

All are available from stock and are designated as follows: B150 series—TO-46, BA150 series—TO-18, and CD1040 series—TO-5. They are priced at under $1 in 100-lot quantities.

To be exhibited at the IEEE show.
Solid State Products Inc., One Pingree St., Salem, Mass. [367]

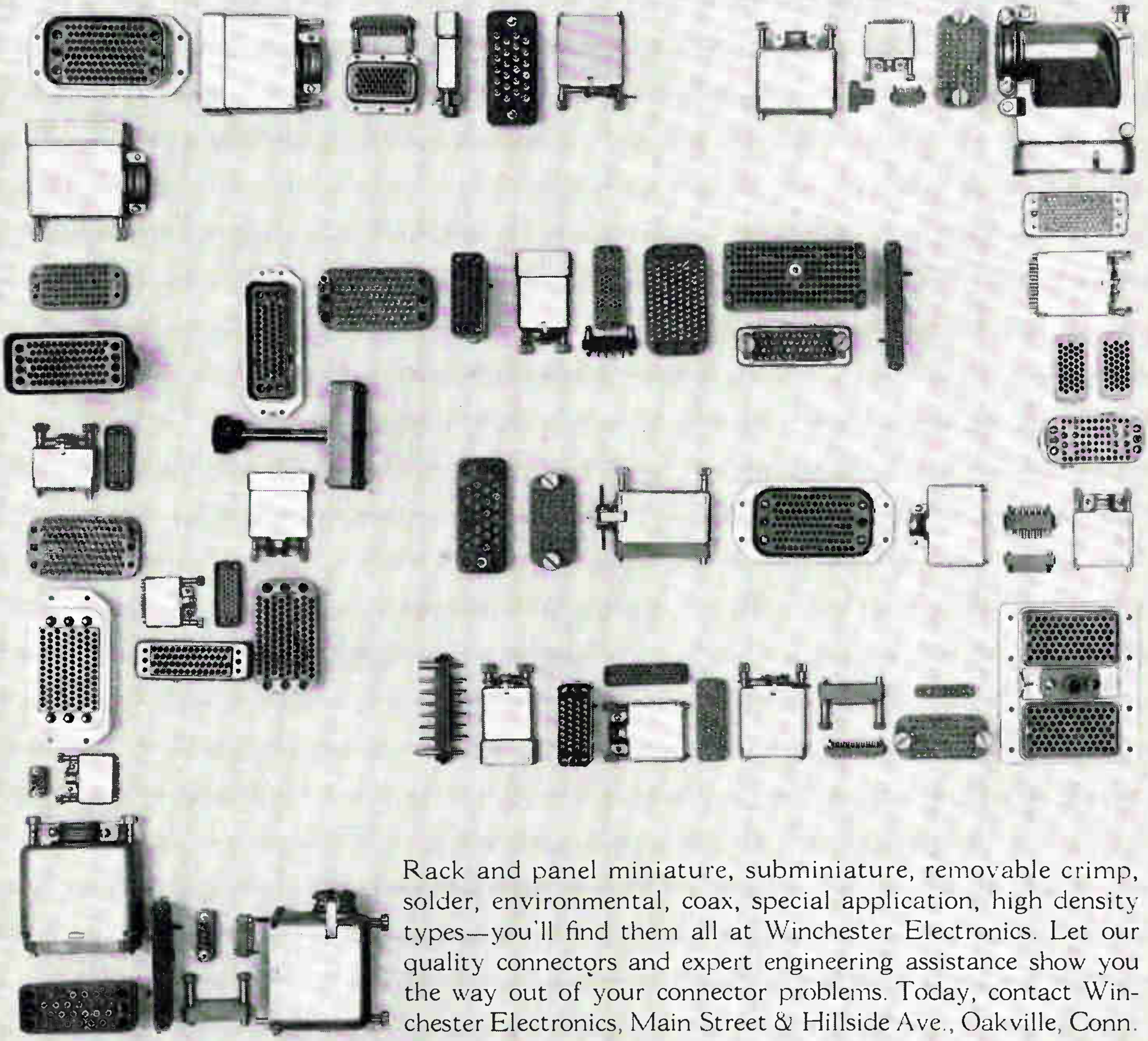
High voltage rectifier stacks

Avalanche silicon rectifier stacks can supply 350 ma at voltage ratings varying from 3,000 to 30,000 volts. Type 35-ST stacks have built-in reverse avalanche voltage characteristic at a minimum of 20% or 2,000 v above the rated peak inverse voltage. All rectifier stacks have a built-in short circuit surge capacity of 15 amps for a maximum of 8 msec.

These high-current stacks are made up of hermetically sealed glass diodes encased in Hysol epoxy which has a dielectric strength of 900 v/mil and electrical insulation resistance of 4.3×10^{14} ohms at 30°C.

Prices start at $2 each for the 3,000-v units in quantities of 100 and run up to $12.50 each for the 30,000-v units.
Atlantic Semiconductor Inc., a division of Aerological Research Inc., 905 Mattison Ave., Asbury Park, N.J. [368]

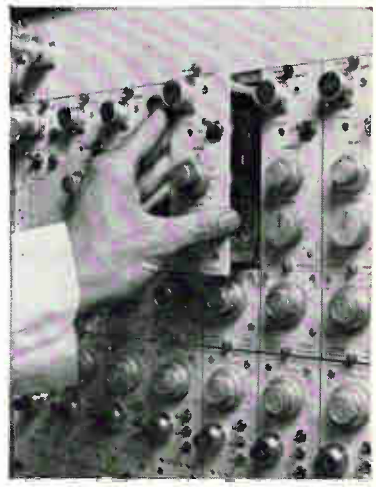
Find your way to Winchester Electronics for the best selection of quality rack and panel connectors.

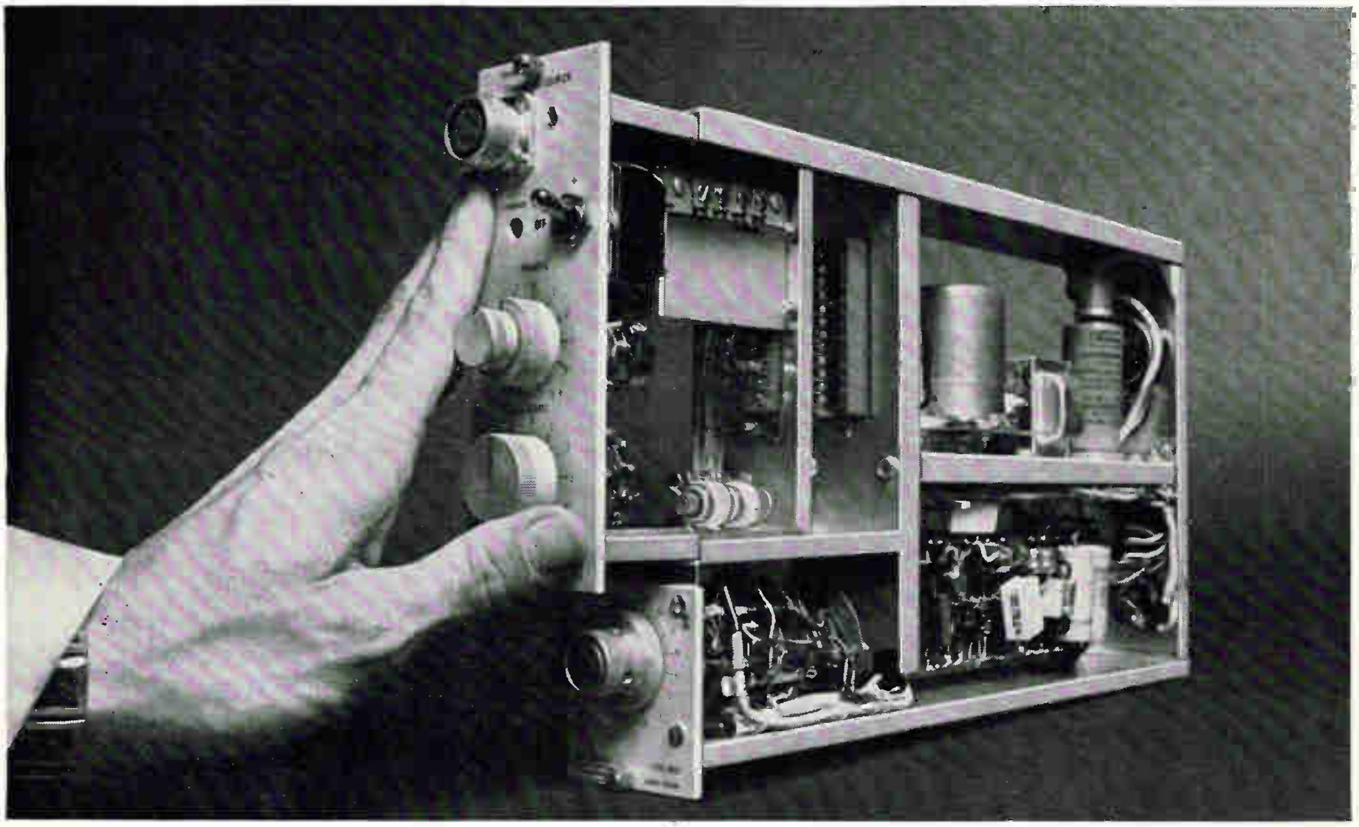


Rack and panel miniature, subminiature, removable crimp, solder, environmental, coax, special application, high density types—you'll find them all at Winchester Electronics. Let our quality connectors and expert engineering assistance show you the way out of your connector problems. Today, contact Winchester Electronics, Main Street & Hillside Ave., Oakville, Conn.

WINCHESTER ELECTRONICS
DIVISION OF LITTON INDUSTRIES

Signal conditioning is a push-in with these input couplers





Record directly . . . strain . . . pressure . . . displacement . . . temperature . . . or any other phenomena that can be transduced into an electrical signal. The Beckman 9800 Series Input Couplers (over 30 of them) plug directly into the preamplifier in the Dynograph® Recorder, averting heavy expenditures for specialized amplifier systems when your application needs change.

Low-cost versatility . . . a simple change of couplers adapts the recorder to your particular requirement. They provide all the signal conditioning required for recording, including computation, demodulation, rectification, etc. Additionally, they supply the excitation and calibration signals necessary for many types of transducers . . . such as strain gage and reluctance gage.

Your Dynograph Recorder, with no complicated and expensive amplifier system changes, can readily meet your recording requirements today . . . and tomorrow.

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The Electronic Instruments Division manufactures electronic counters, oscillographic recorders, and systems components.

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Circle 285 on reader service card

Others make promises... Nexus delivers

Why is it that NEXUS can usually deliver operational amplifiers, even when others can't? Mainly because we are set up — from teletype machine to shipping dock — to handle the extra-big orders . . . the special orders . . . the rush orders . . . the extra-small orders . . . as well as routine business. Here's how we do it —

Computerized order processing — An IBM system eliminates paperwork bottlenecks, slow-downs, and human error. Your order is normally processed and in the works within minutes after we receive it.

Automated production — A completely automated line permits fast, error-free assembly of large production orders — fast change-over for special orders.

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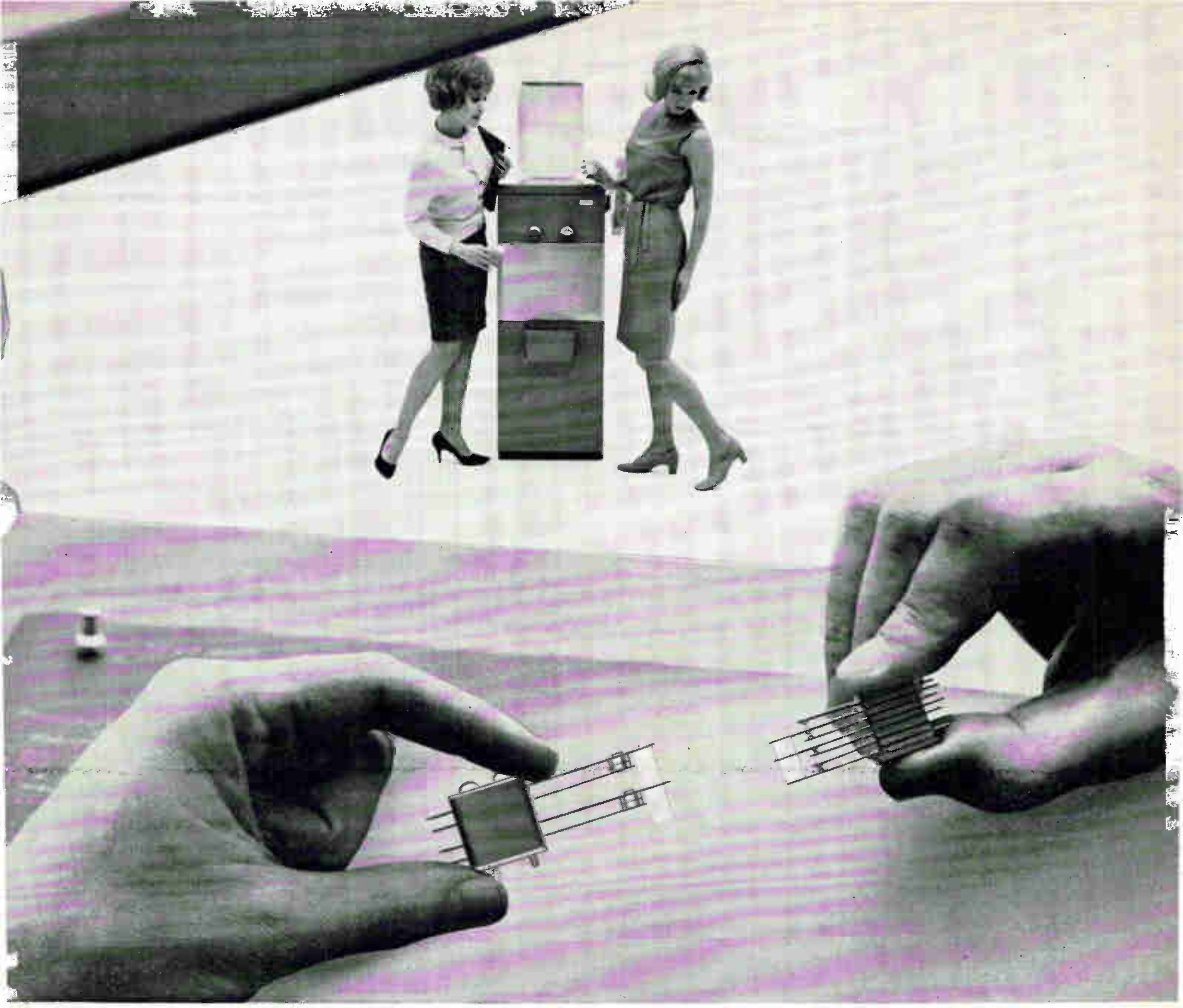
Booth #4D25/4D27 at IEEE — Paris Component Show April 5-10



It's time you learned the difference between MOLDED and STACKED

On the one hand, there's the molded switch. And on the other, the stack switch. Both extremely able performers. The stack switch, which is probably more familiar to most people, does the job it was designed to do—and does it well. Perhaps that's why it's always been (and still is) so popular.

Then, about a year ago, something new was added . . . the molded switch—which does everything the stack switch does, and because of its solid, one-piece design, is easier to handle. The molded switch not only saves time on your production line—cutting labor costs and speeding delivery—but it's so well put together that its alignment never wavers. No wonder the molded switch gained enthusiastic acceptance throughout the industry as soon as it was introduced.

We recently increased our molded switch line so that we now have models available to cover most requests for this type of switch. These switches can be used anywhere conventional-type switches with ¼" or ⅜" mounting are now being specified. Models range in amperage from 1½ to 12½, and lifters from 1/16" to ½" can be supplied. A snap-on lifter is available for special applications.

We'd like you to see the difference in molded switches for yourself. Drop us a line, and we'll send you a free sample plus our new catalog, which gives a complete breakdown of all the contact combinations we currently have available.

After all, seeing is believing.

Be Seeing You at the IEEE Show, Booth 4E04 and 4E06

GUARDIAN® ELECTRIC

Manufacturing Company • 1550 W. Carroll Avenue, Chicago, Illinois 60607

Circle 289 on reader service card

nas. It is also useful for reflectivity measurements and for gauging phase delay, impedance and insertion loss of microwave components.

In measuring phase with the series 1750, a comparison is made between the phase of a heterodyned 1-khz test signal and the phase of a second 1-khz signal derived from a reference r-f signal at the other input. The 1-khz phase reference can be delayed in steps of 0.1°.

Phase differences are converted to d-c voltages that are then displayed on the meter or are available at the recorder-output terminal. This d-c signal is linearly proportional to the phase delay between the two input signals.

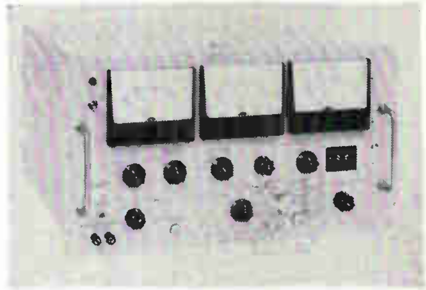
Except for an oscilloscope monitor and a triode cavity local oscillator, all the circuitry in this receiver is transistorized. The new system weighs only 90 pounds, compared with the 500 pounds of Scientific-Atlanta's earlier 1650 series. Except for external mixer circuits to heterodyne to 45 Mhz, the receiver includes all circuits for measuring over the entire band.

To be exhibited at the IEEE show.

Specifications

Frequency range	100 Mhz to 40 Ghz
Typical sensitivity	120 db below a milliwat at 2 Ghz
Phase resolution	0.1°
Dynamic range	60 decibels
Size	15 x 20 x 22 inches
Weight	Approx. 90 pounds
Cost	Less than $20,000

Scientific-Atlanta Inc., Box 13654, Atlanta, Ga. 30324 [371]



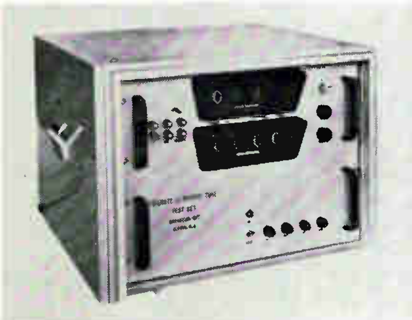
Sensing envelope delay over extended range

An instrument to measure delay distortion over the entire 30-Khz to 5-Mhz range has heretofore been unavailable. Instruments manufactured in Germany cover only portions of the range. Now, a device developed by the Wiltron Co., employs crystal controlled frequency and counter techniques to obtain very stable and accurate time delay measurements. The instrument is specifically designed for delay distortion application.

The unit has crystal controlled reference delays in 10-μsec steps up to 200 μsec for use in offsetting the time delay. This permits precision measurement on a sensitive scale. The most sensitive scale is form and $11.35 for the stainless. Substantial quantity discounts apply. Delivery is from stock.

To be exhibited at the IEEE show. Harrel Inc., 16 Fitch St., E. Norwalk, Conn., 06855. [373]

Relay characteristics measured automatically



An automatic test set makes possible accurate measurement and visual readout of transfer time and bounce time of electromechanical relays. The equipment offers a clearly visible, in-line decimal readout in milliseconds of operate time (or release time) and bounce on two separate displays.

Operate time is the interval between the application of voltage to the relay coil and the first contact closures; bounce time is the interval from initial contact closure until the final contact closure. Operate times and bounce times from 00.01 msec to 99.99 are measured simultaneously, in one relay cycle. A ×10 multiplier switch increases the maximum time for both measured times by a factor of ten.

The unit's circuitry is all solid state, including power supply, and is housed in a desk-top cabinet. It operates on 115 v a-c power. Panel dimensions are 8¾ by 19 by 17 in.

To be exhibited at the IEEE show. Datascan Inc., 1111 Paulison Ave., Clifton, N.J., 07013 [374]

Audio oscillator spans wide range

Band switching is not required in an audio oscillator that covers from 10 hz to 50 khz in one turn

MAGNETIC SHIELDING

TAILOR MADE... QUICKLY...BY YOU...

Ideal for initial experimental evaluation. Also for production applications. Eliminate interference in your display or system by wrapping permanently effective Netic Co-Netic Magnetic Shielding Foils around offending components. Presto! No more interference. Easily shaped with ordinary scissors to your outline.

Co-Netic and Netic foils are not significantly affected by dropping, vibration or shock and do not require periodic annealing. High attenuation to weight ratio performance. Available in any required length in thickness from .004" in rolls 4", 15", and 19⅜" wide.

Foil Performance Evaluation

Spiral Counter Spiral Cable Shielding

Adhesive backed Foil

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Pre-punched insulating wafers to electrically isolate transistors, diodes, etc. from heat sinks.

Corrugated mica to reduce handling and fabrication costs for thermal elements.

All grades of mica offered.

Immediate delivery from stock on many items.

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1322 No. Elston Ave.
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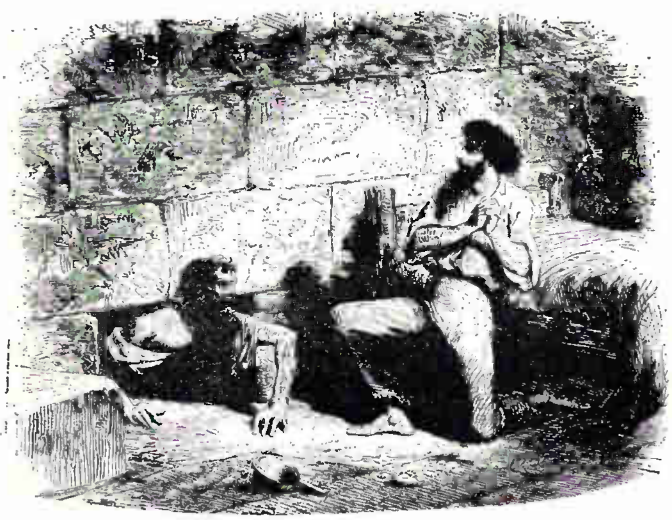
Phone: 312, EV 4-2122

Circle 512 on reader service card



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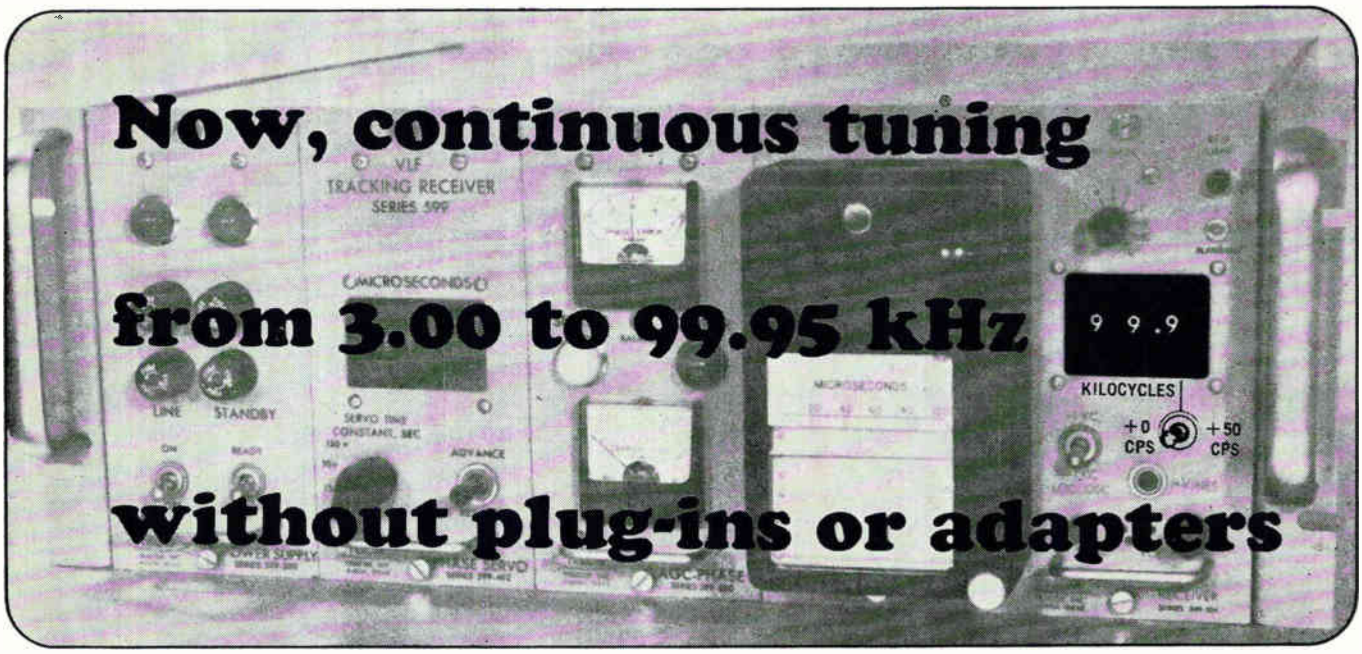
ELECTRICAL DISTRIBUTOR: JOSEPH KURZON, INC. 112 West 31st St., New York, N. Y. 10001



TFA 366A

IN THE NEW TRACOR MODEL 599-J
FULL-FREQUENCY-RANGE
VLF RECEIVER

you'll find these unique features: High image rejection over full tuning range . . . 60 db 3-30 kHz, 50 db 30-99.95 kHz. ☐ Tuning in 50 Hz increments. ☐ Tracks even with signal 50 db down in noise in 1kHz band width. ☐ Standard features include all-electronic servo with non-granular response, easy access via modular construction, and 10 nanovolt sensitivity. ☐

Full details from: Tracor, Inc.
6500 Tracor Lane☐Austin, Texas
78721 ☐ AC 512 926-2800

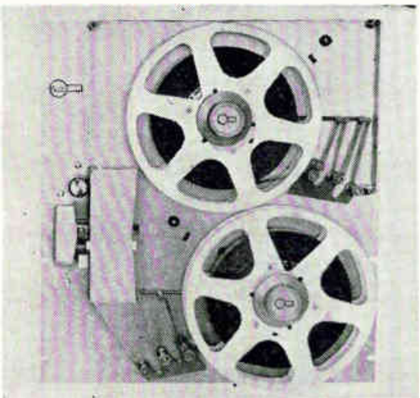
DCF-77	JG2AS	OMA	MSF	WWVB	HBG	CYZ-40	FTA-91
77.5 kHz	40.0 kHz	50.0 kHz	60.0 kHz	60.0 kHz	75.0 kHz	80.0 kHz	91.15 kHz
Mainflingen, Germany	Kemigawa, Japan	Podebzady, Czech.	Rugby, England	Fort Collins, Colorado	Prangins, Switzerland	Ottawa, Canada	St. Andre of Corcy, France

NOW TRACK WITH ONE RECEIVER THE FULL VLF RANGE

Time & Frequency Instruments by **TRACOR**

REPRESENTATIVES IN PRINCIPAL CITIES

Tape reader-spooler is compact and fast



A compact, punched-tape reader and spooler reads 500 characters per second optically, and winds the tape on 10½-inch reels at 50 inches per second. The unit is only 21 inches high.

The all solid state electronics portion is in a common chassis with a choice of output signals available. The reader-spooler operates continuously at 500 characters per second or at any slower speed asynchronously. It is available in both unidirectional and bidirectional configurations and can read tape loops if required.

The spooler portion rewinds in either direction independently at high speed, and has a soft take-up feature that precludes the possibility of breaking the most fragile of paper tapes.

The RRS-502-10½ is priced at $3,435 in low quantities with substantial discounts available for higher quantities. Deliveries are 10 weeks after receipt of order.

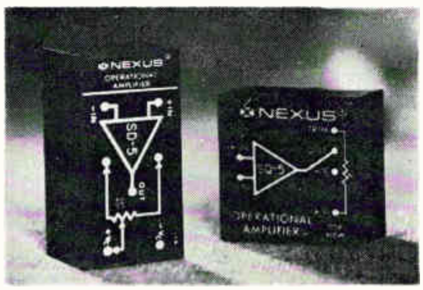
To be exhibited at the IEEE show.
Remex Electronics, a unit of Ex-Cell-O Corp., 5250 W. El Segundo Blvd., Hawthorne, Calif., 90250. [378]

Operational amplifier sells for under $10

Suitable for many noncritical industrial applications, a new general-purpose operational amplifier offers the peak performance among units in its price range. The SD-5 will sell for $9.75 in quantities of 10 to 99.

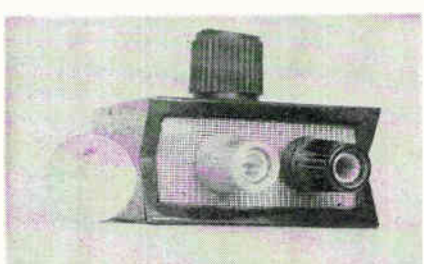
This encapsulated unit avoids the need for external components. It is fully protected for input overdrive and indefinite short circuit to ground. Stability with a variety of feedback elements is insured by internal compensation for a controlled —6 db/octave gain bandwidth roll-off.

Typical performance of the SD-5 (at 25°C) includes a supply voltage of ±15 v; output, ±10 v at 2.2 ma; open loop d-c gain, 10,000; offset voltage change, 30 μv/°C; offset current change, 1.5 na/°C; input offset current, 200 na; frequency limit for full output, 20 khz; unity gain crossover frequency, 1.5 Mhz; common mode input impedance, 20 megohms; differential input impedance, 200 kilohms. The unit measures 1.55 in. long, 0.78 in. wide and 0.60 in. high.



To be exhibited at the IEEE show.
Nexus Research Laboratory Inc., 480 Neponset St., Canton, Mass., 02021. [379]

Tiny circuit breaker protects power supply



A solid state circuit breaker smaller than a pack of cigarettes provides high speed overload protection for open-loop gain of 140,000.

The ADO-29 economy version ($45) of the hybrid amplifiers has 25 μv/°C drift, a gain of 140,000, and the 10^{12}-ohm input impedance.

Price of the ADO-26 is $98; and the ADO-27 is $70 in quantities of 1 to 9.

To be exhibited at the IEEE show. Fairchild Instrumentation, a division of Fairchild Camera & Instrument Corp., 475 Ellis St., Mountain View, Calif., 94040. [381]

Programable attenuator is light & dependable

Intended for incorporation into sophisticated test and communications assemblies, a programable attenuator weighs only 12 lbs and measures 7¾ x 5½ x 10½ in.

Model 2163/1M2 covers d-c to 1 Ghz, accepts 1-2-4-8 binary coded decimals, and has a range of 139 db in 1-db steps. Accuracy at 1 khz is ±0.5%, ±0.1 db to 120 db; at 1 Ghz it is ±1%, ±0.2 db to 100 db.

Setting speed is less than 100 msec and at no time during switching is the attenuation less than the initial or final programed value. High reliability is achieved since the only moving parts are a number of solenoid-microswitch assemblies having a maximum displacement of 0.015 in.

To be exhibited at the IEEE show. Marconi Instruments, 111 Cedar Lane, Englewood, N.J., 07631. [382]

Operational amplifier in minute package

The incorporation of thin-film hybrid circuitry has resulted in a velope regulation, margin-checking, turn-on and turn-off sequencing, and remote sensing. Also provided are automatic current limiting, interlocks, and high pulse load capabilities.

All control components are mounted on two printed wiring boards that are removable through the rear panel. Designed for 19-in. rack mounting, the compact supply has a panel height of 7¼ in. and is 7½ in. deep.

Total power output is 312 watts, and the supply uses system air flow for cooling.

Advanced Development Corp., 2014 W. 139th St., Gardena, Calif., 90249. [384]

Amplifier-demodulator for control systems

A miniature, solid state a-c amplifier-demodulator performs in extreme operational environments with the accuracy of laboratory-type instruments. It weighs less than 6 oz and occupies only 2.5 cu in. The unit operates either as an a-c to d-c converter or as a phase-sensitive synchronous detector for gyros, synchros, and linear variable differential transformers.

Providing a high input impedance and low output impedance, with input, output, and power supply isolated, the unit converts phase-sensitive, suppressed-carrier a-c input signals into a linearly proportional bipolar d-c output signal.

Typically incorporated in control and instrumentation system applications, the unit can operate f-m subcarrier oscillators, meters, or recorders. The unit, D6076, also can serve as a linear differential d-c current drive for an integrating

injection of precise calibration signals. Available modifications include controlled high- and low-frequency rolloffs; remote switching of gain and low-frequency rolloff and power output stages for driving very long lines.
Ithaco Inc., 413 Taughannock Blvd., Ithaca, N.Y., 14850. [386]

Operational amplifier develops low voltage

Low voltage and low current drift are offered in a general purpose operational amplifier. Type H6020 develops less than 5 μv/°C and 0.5 na/°C of voltage and current drift respectively.

Bandwidth is greater than 5 Mhz; common mode rejection ratio, greater than 80 db; and input wideband noise, less than 5 μv rms. The output is ±10 v at ±2 ma.

The amplifier is available in three modular packages, the smallest measuring 1x1x2/5 in. Price, in quantities of 1 to 4, is $45.
Union Carbide Electronics, 365 Middlefield Road, Mountain View, Calif., 94040. [387]

Block tape readers improve programing

Photoblock punched tape readers can now be supplied with silicon latching output circuits. Block tape readers sense up to 40 eight-bit lines in each frame. This large frame capacity—up to 320 bits—provides an economical method of programing automatic test equipment and process control and is urgent when more information is required than can be obtained from a single-line punched tape reader.

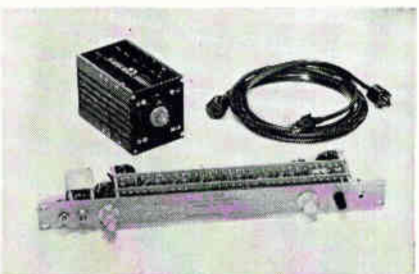
The new latching output cir-

°C drift, 50 na initial offset at 25°C. The differential and common-mode input impedance is 1 megohm and 100 megohms and the output is ±1.5 v, 2.5 ma.

Besides conventional instrumentation uses, model 150 has a wide range of applications in upgrading or retrofitting existing instruments and systems. The inputs are floating with respect to ground (with the battery pack). The device can make measurements of high voltage cables; increase range, sensitivity and input impedance of d'Arsonval meters; turn d-c meters into wideband a-c instruments; raise input impedance of chart recorders and other apparatus; and operate remotely from sun-powered photovoltaic cells.

Analog Devices, 221 Fifth St., Cambridge, Mass., 02142. [389]

Low-noise amplifiers aid geophysical work



Nine high-gain solid state amplifiers can be used with acoustical instrument systems in the geophysical field and other applications. Series 505 amplifiers feature a wide dynamic range of 60 db which allows reception of greatly attenuated signals. The units can also handle large signals (200% overload) without blocking.

Typical amplifier gain is 10^6; response, 1 hz to 100 khz; noise, 0.1 v per 5,000 ohms output impedance. The input impedance on most models is adjustable from 50 to 1,000 ohms. Required power is 22.5 v d-c, 30 ma. With the company's 506 power supply the amplifiers can be operated on standard a-c current.

The amplifiers fit a standard 19-in. rack panel. They are 1¾ in. high and 4½ in. in over-all depth.

Prices range from $385 to $455.

Alpine Geophysical Associates, Inc., Oak St., Norwood, N.J. 07648. [390]

and nonstandard telemetry and communications signals. The receiver is capable of receiving frequency, phase, and amplitude modulated r-f carrier signals.

The modular construction affords modifications for a wide variety of special-purpose applications at minimum cost.
Defense Electronics Inc., Rockville, Md. [393]

X-band antennas designed for aircraft

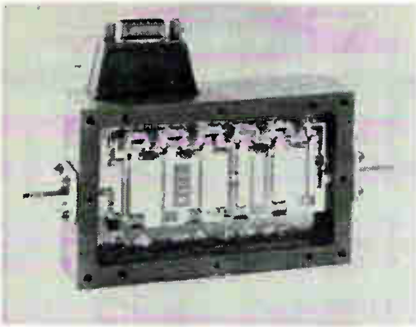
Beacon antennas—both stub and dipole—that operate from 8.5 to 9.6 Ghz are specifically designed for high performance aircraft.

The stub type has a pattern similar to a quarter-wave monopole. The dipole's pattern is similar to a half-wave dipole over a ground plane and provides excellent horizon coverage. Units weigh less than 0.4 lb each and are vertically polarized. Maximum vswr is 1.5:1.
Transco Products Inc., 4241 Glencoe Ave., Venice, Calif., 90291. [394]

High power capability in 4-port circulator

High peak and average power capability are features of a 4-port, liquid-cooled circulator. Model 336180 can handle 20 Mw of peak power and 20 kw of average power while maintaining a low insertion loss of 0.5 db maximum.

The unit can also be used as an isolator by terminating the appropriate ports. Operating in the fre-



and frequency coverage from 0.5 to 2.4 Ghz.

The amplifiers are small, reliable, have low power drain and are unaffected by temperature and other environmental conditions. Using microminiature silicon transistors and what are claimed to be unique stripline and printed circuit techniques, mean-times-between-failures of over 10 years are achieved. All units are packaged in rugged machined aluminum housings.

Prices start at $695. Delivery takes 4 to 6 weeks.

RHG Electronics Laboratory, Inc., 94 Milbar Blvd., Farmingdale, N.Y., 11735. [397]

Microwave transistor intended for S band

Development of a microwave transistor that offers a maximum frequency of oscillation (f_{max}) of 4.5 Ghz is announced. An f_{max} specification rather than f_t is used because it is more indicative of power capability at any frequency. Maximum power dissipation at 25°C case temperature is 300 mw.

Model MT1062 is intended for use in preamplifier and local oscillator applications through S band. It can deliver a calculated maximum available gain of 7 db at 2 Ghz and 3.5 db at 3 Ghz. This is achieved by the manufacturer's ability to photomask very narrow base-widths of about 2 microns (in production quantities) which reduce collector-to-base time constants, yielding higher f_{max} values.

Guaranteed over the full military temperature range of —55° to +125°C, the MT1062 in the TO-51 stripline package is priced at $42.50 each in lots of 10 to 99.

Fairchild Semiconductor, a division of Fairchild Camera and Instrument Corp., 313 Fairchild Drive, Mountain View, Calif. [398]

Circle 315 on reader service card

to high volume production of printed circuits using flatpacks or other miniature multiple-lead components.

The model 950, SRM/FPR contains an a-c power supply, a programer-controller for actuating the head, a dual reflow solder head that will handle all 14 leads of a flatpack at one time, a holding and locating fixture for the board, a swing-away component loading device, cooling equipment, and a console-type work table.

The operator manually positions a flatpack in the loader and moves it under the reflow head. The machine is actuated for automatic pickup of the component, positioning, and reflow soldering at a predetermined location on the board. The entire cycle, including loading, takes from 10 to 15 seconds, depending upon the dexterity of the operator. The basic machine will accommodate a printed circuit board up to 5 x 7 in. in size, although it may easily be modified to hold a much larger board.

A special feature of the model 950 allows the machine to be reversed in cycle so that it can be used to remove multiple-lead components for repairs.

Price is $6,360; delivery, six to eight weeks. The manufacturer also offers a free course in microjoining processes for purchasers of the machine.

To be exhibited at the IEEE show. Weltek, a division of Wells Electronics Inc., 1701 S. Main St., South Bend, Ind., 46623. **[402]**

Rapid testing, sorting of diodes in production

Testing and classifying diodes and rectifiers on production lines and at incoming inspection stations is done with a family of instruments. Designed for application with fast has an extremely narrow "C" type head for easy accessibility and unlimited visibility. Quick change, positive-locking, color-coded dies cannot be installed incorrectly. In addition, the tool is designed for both automatic and manual operations.

Featured with the Y40LH Hypress is a line of termination rings for the cable shields called Hyring. The rings come in 22 sizes and are capable of terminating conductor bundles ranging from 0.430 in. to 2.905 in. in diameter. The Hyring line is color-coded with an ink that will not chip, flake, or peel after crimping, or in any way interfere with the conductivity of the crimped assembly.

Burndy Corp., Norwalk, Conn. [404]

Automatic, high-speed thin-film evaporator

A fully automatic high-vacuum evaporator for producing thin film components can reach to pressures of less than 5 x 10^{-8} torr in a 20-inch diameter bell jar. Fast cycling time is achieved with liquid nitrogen and a 1900-liters-per-second oil diffusion pumping system. The pumping system is made fail-safe with an interlocked automatic valve control.

The model BA-510A's many accessories include single or multiple electron sources, an 8-position mask-substrate changer, optical and conductance thin-film monitors, rotary cage motor and planetary gear drive.

Bendix-Balzers Vacuum, Inc., 1645 St. Paul St., Rochester, N.Y. [405]

To order reprints: Fill in, cut out coupon below, insert in envelope and mail to: **Electronics Reprint Dept., 330 W. 42nd Street, New York, N.Y. 10036**

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mixtures of high-purity organic solvents and activating ingredients. The nonflammable liquids remove resist films quickly and completely without causing damage to delicate surfaces.

Solution CB-1 was especially formulated to strip Kodak Photo Resist and other photosensitive resists of this family from p-c boards. Solution A-20 was developed to strip Kodak Metal-Etch Resist and Kodak Thin Film Resist from silicon, silicon oxide, aluminum and other metals commonly used in manufacturing both discrete semiconductor components and integrated circuits.

While CB-1 is used full strength at room temperatures, A-20 is most effective when used full strength at 90° to 100° C. The latter solution, however, may be used at a lower temperature if the characteristics of the polymerized resist film permit. With both solutions, the product to be stripped is immersed in the solution for several minutes, then washed in a direct stream of ordinary tap water. Mechanical scrubbing is not necessary for complete cleaning of the p-c boards. Allied Chemical Corp., Industrial Chemicals Division, P.O. Box 353, Morristown, N.J., 07960. [408]

Zinc oxide crystals show high resistivity

Large single crystals of zinc oxide have been grown by the hydrothermal method which allows a doping agent to be added during the growth process to control con-

New Books

Semantic arbiter

Electronics and Nucleonics Dictionary, third edition
John Markus
McGraw-Hill Book Co., 743 pp., $16.50

Language changes, warns an ad for Merriam-Webster's newest desk dictionary, adding that your dictionary should change too. As every electronicker knows, this warning is even more pertinent for that segment of the language describing electronic phenomena and devices than it is for the language as a whole. And now, Cooke and Markus' excellent dictionary, first published in 1945 and revised and expanded to include nucleonic terms in 1960, has been revised again, this time by Markus alone.

It is regrettable that books are not published with more speed. Markus continues to use "cycles per second" instead of "hertz." He is, however, fighting a battle that has already been decided. Although the dictionary received, in late December, a 1966 copyright date from the Library of Congress, the book reflects usage common in early 1966. That's why the old definition of hertz still stands. It is also the reason why the book doesn't differentiate between "integrated electronics" and "microelectronics" as recommended by the Institute of Electrical and Electronics Engineers last fall. Fortunately, we have grown up expecting hysteresis in hard cover books and are accustomed to relying on periodical publications for news of changes in approved terminology.

The book's type is easy to read, and items being defined are printed in bold letters. The drawings are clear, and the paper used is heavy enough to minimize printthrough from the other side. Markus' spelling and hyphenation of terms, while not necessarily that employed by a particular magazine or company, has the decided virtue of consistency. He also clearly marks commonly used words which are trademarks, to avoid, as he says in the preface, "unpleasant correspondence with lawyers representing the owner of the trademark."

The following comments are quibbles—nitpicking, so to speak—and are prompted only by a hope for an impossible perfection. Why is a phonograph record a "disk," when Webster, the New York Times and this magazine (to name just three authorities) distinguish it from other types of thin, circular objects by calling it a "disc"? Why does the definition of "umbilical cord" mention only the type used to test a missile and not include the lifeline that connects an astronaut to an orbiting spacecraft?

There is an error in the definition of picosecond; it is called one-millionth of a second, instead of one-millionth of a microsecond. The prefix "nano-" is curiously defined as "one-thousandth of a millionth," instead of the simpler "one-billionth."

The dictionary, Markus states in his preface, is meant for technical writers and advertising copy writers as well as for engineers and technicians. Hence, one questions the omission of "trade off"—a term which engineers know, but one which is not in the latest Webster's dictionary. The definitions of "electrical" and "electronic" are adequate for the engineer, but a paragraph elaborating the difference would greatly aid a new man in a public relations department.

The electronics engineer who wants to find out about some nucleonics terms may be similarly confused. For example, the definition of a "quark" as "a postulated but as yet undiscovered heavy triplet" makes sense to a high-energy physicist who knows that a heavy triplet is one of three nuclear particles, each of which is heavier than a proton. But "triplet" is defined only as "three radio navigation stations operated as a group"; "heavy triplet" is not defined.

Markus also falls into the trap of too narrowly defining some terms. For instance, after a clear explanation of how the Gunn effect works, he adds the gratuitous comment that "frequencies range from 500 to 7,000 Mc, depending on the thickness of the block." Recently one company built a Gunn-effect device which oscillates at 30 gigahertz [Electronics, Jan. 23, p. 26] and the new AEL model PAR 1612A S-Band

Avalanche Diode Pumped Parametric Amplifier

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The avalanche diode-pump makes possible an all-solid state design, at low cost and eliminates the need for a pump klystron with its bulky power supplies. For the first time, parametric amplifier noise figures can be achieved in a package comparable to tunnel diode amplifiers. Check these features . . .

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  Power Supply—3¼" x 3¼" x 5"
- Weight: 3 pounds including Paramp and Power Supply
- Price: $4,595. standard model
- Delivery: 90 to 120 days

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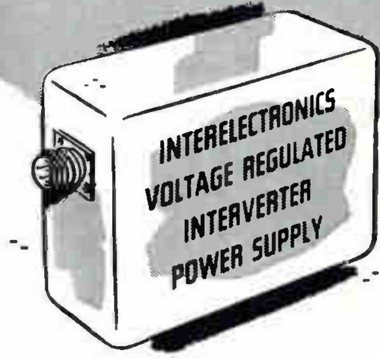

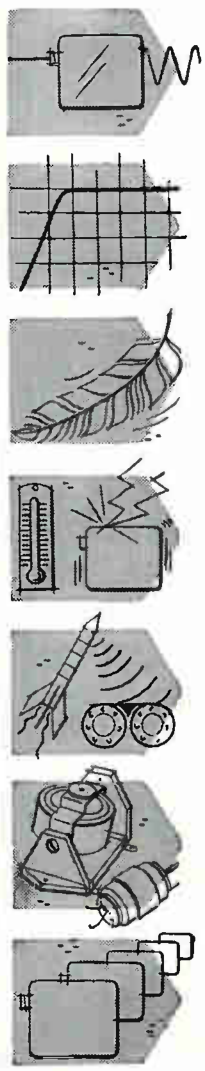

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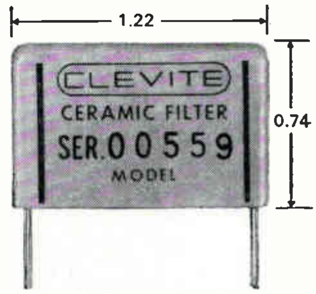
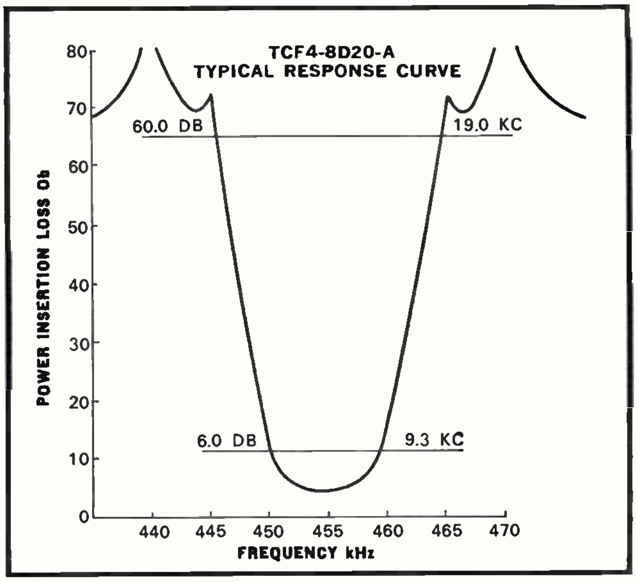


Clevite's computer-designed TCF ceramic filter.



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T500A	500	8¾" h x 21" d
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T1200A	1200	14" h x 21" d
T1750A	1750	14" h x 21" d
T2500A	2500	14" h x 21" d

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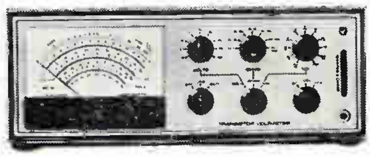
What's New With HEATH At IEEE

Preview of New Heathkit®/ Thomas "Theatre" Organ
All solid-state; 19 voices; 2 amplifiers; 200 watts peak power; instant-play "Color-Glo"; horseshoe console; flip-type tabs; chimes; rotating Leslie plus main speaker systems; preassembled cabinet & bench.
Kit TO-67 . . . . $995



Preview of New Heathkit Solid-State High Impedance Volt-Ohm-Milliammeter
Full scale ranges down to 150 mV & 15 ua; all-silicon plus FET's; AC and DC powered; 6" meter; new unitized construction.
Kit IM-25 . . . . $80
Assembled IMW-25 . . . . . $115

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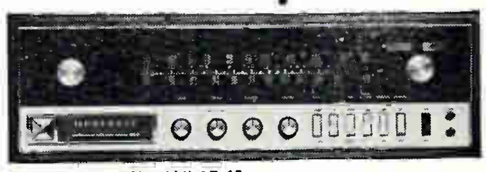

Preview of New Heathkit AR-15 Solid-State 150-Watt AM/FM Stereo Receiver
Two Integrated circuits and crystal filters in the IF section; preassembled FET FM tuner; positive circuit protection; 2 calibrated tuning meters; "black magic" panel lighting; All-silicon transistor circuitry.
Kit AR-15 (less cabinet) $329.95

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Kit TA-16 . . . . $129.95

New Heathkit Deluxe 80-10 Meter SSB Transceiver
Front panel switch-selection of standard USB/LSB 2.1 kHz SSB filter or optional 400 kHz CW filter; 180 watts P.E.P. — 170 watts CW on 5 bands; operates PTT or VOX.
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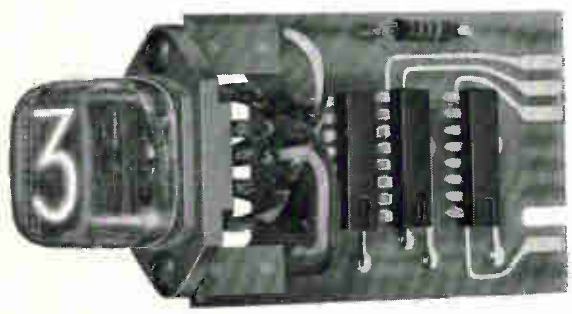

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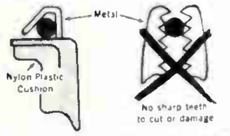

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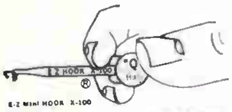

Hold between the thumb and two fingers (like a hypo dermic needle). Press on Q Ball with thumb until hook is exposed. Release pressure, to close.

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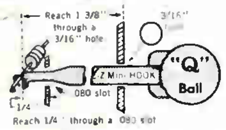

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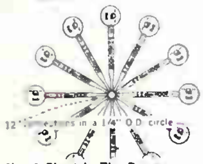

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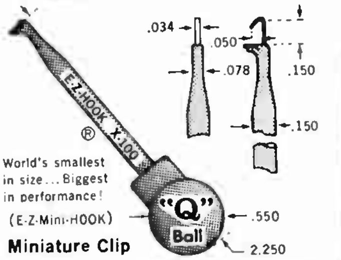

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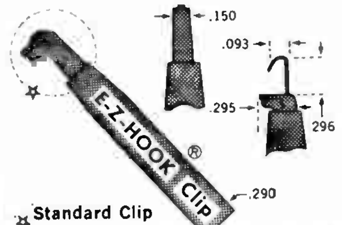

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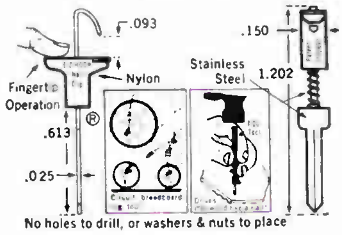

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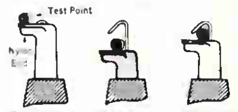
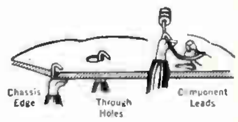


To connect ... Place Nylon end on Test Point... Press on test point until hook extends over it... Slide hook over test point and release!

Easy To Use



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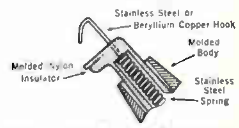

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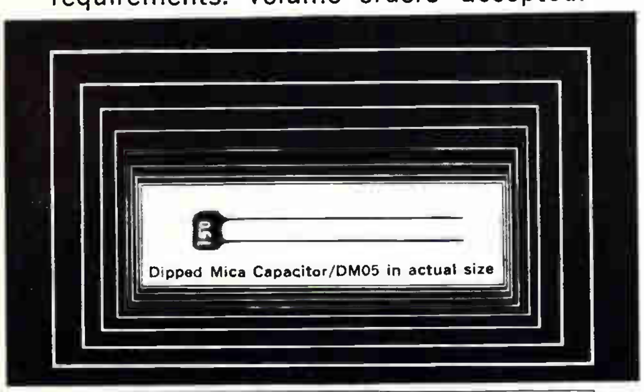

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				L Max	W Max	T Max	L Max	W Max	T Max	L Max	W Max	T Max
DM 05	200	130	–	7.0	5.0	3.5	7.0	5.0	3.5	–	–	–
DM 10	440	390	330	8.5	5.5	3.5	8.5	5.5	3.5	8.5	5.5	3.5
DM 15 (CM05)	2000	1200	510	13.0	11.0	6.5	12.5	10.5	6.0	12.0	10.0	5.5
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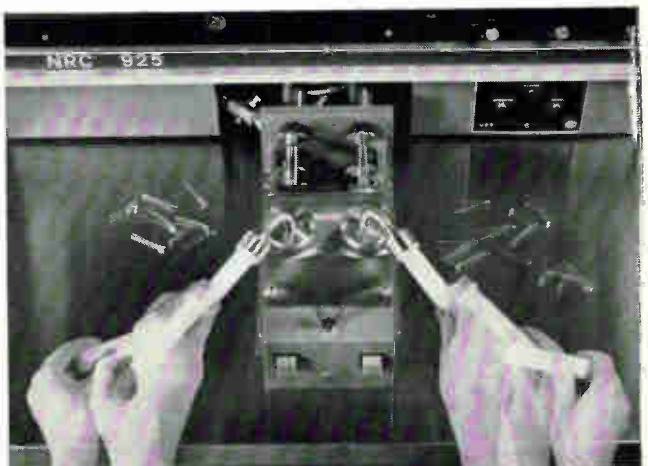

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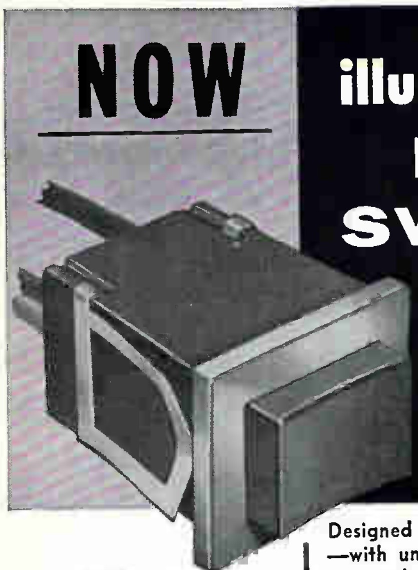
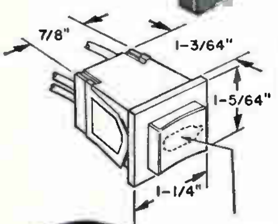
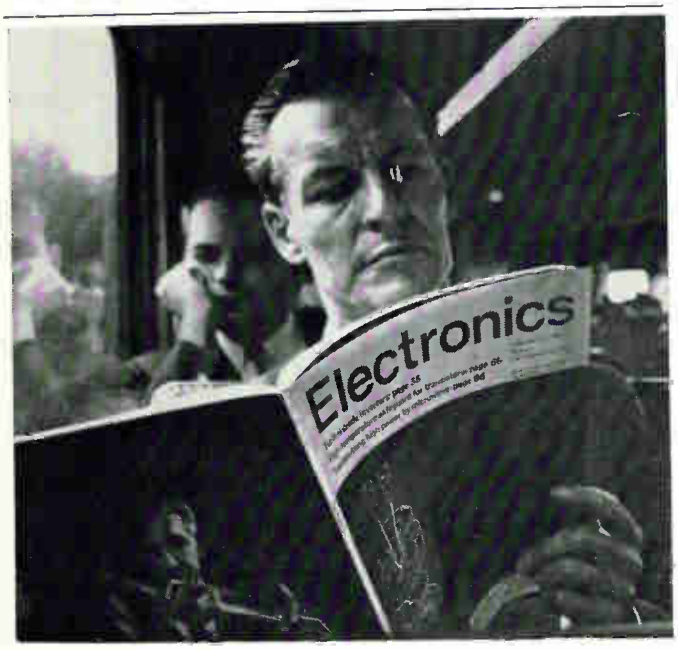
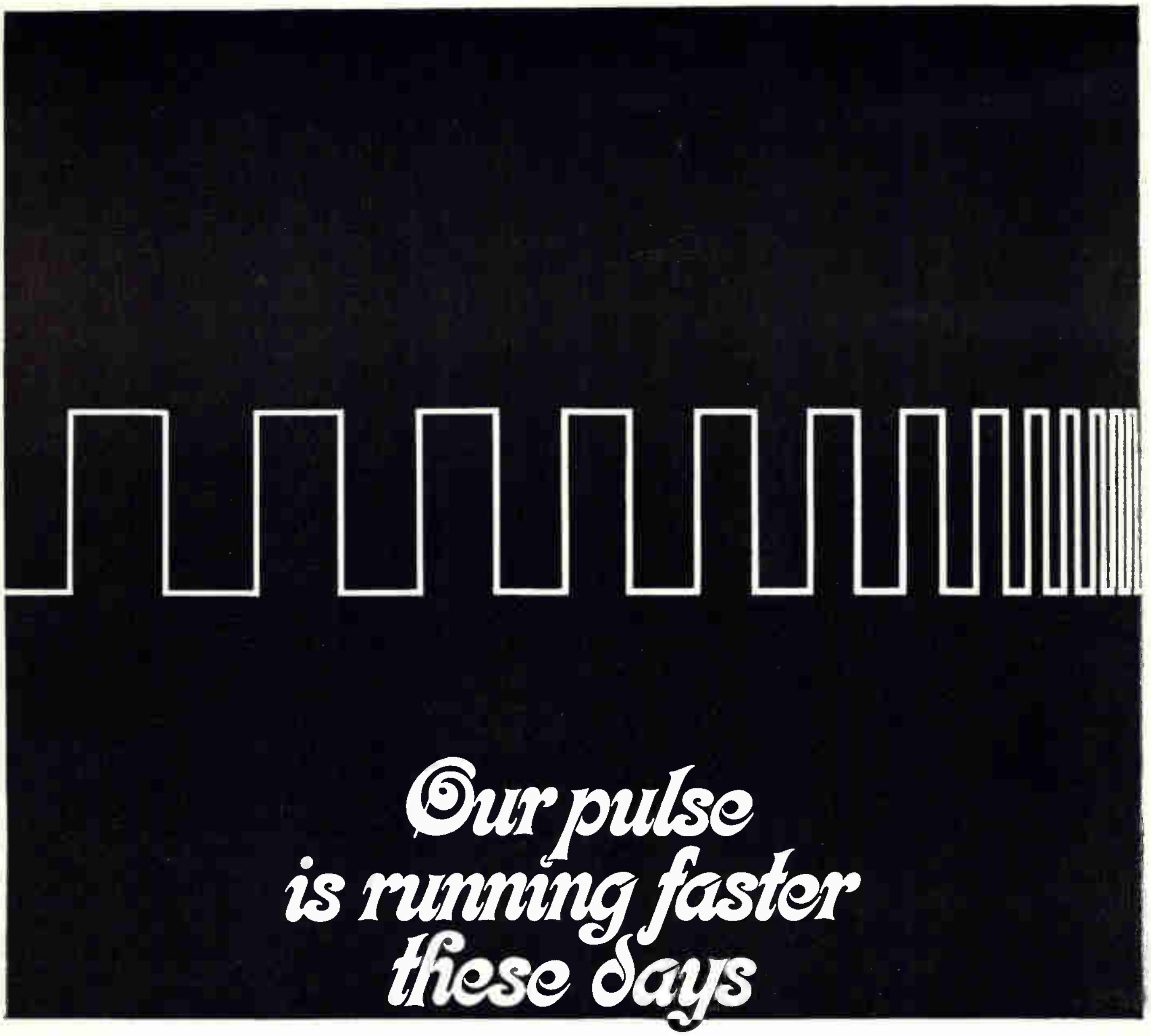



7/8"
1-3/64"
1-5/64"
1-1/4"
NEON BULB


Electronics



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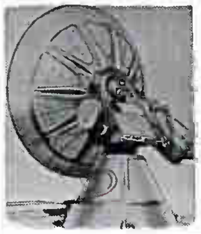

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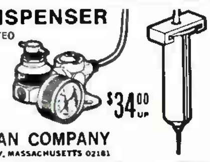

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CIRCLE 968 ON READER SERVICE CARD

Newsletter from Abroad

March 6, 1967

Five nations plan '69 communications satellite launch

There's a good chance that the first all-European telecommunications satellite will be in service before 1970. The Scandinavian countries, together with Italy and Belgium, expect to nail down an agreement next month with the European Launcher Development Organization for a mid-1969 launching of an experimental satellite the five nations plan to build.

The booster would put the satellite—dubbed F-9 because it will be the ninth ELDO launch—into a polar orbit with an apogee of 2,500 miles and a perigee of 250 miles. Because of the varying altitude, the capacity of the satellite would range between 60 and 240 channels.

Instead of the traveling-wave tubes used so far for satellite transmitters, the F-9 will have a solid state transmitter built by Sweden's L.M. Ericsson Co. The associated receiver will come from the Danish government's microwave laboratory, and the microwave beacon from the Bell Telephone Mfg. Co., a Belgian subsidiary of the International Telephone and Telegraph Corp. The Italians will build the satellite airframe and a second transponder unit. The Norwegians will supply the telemetering facilities.

Defense R&D cuts hurt West German avionics producers

Most West German electronics companies expect their avionics business to plummet this year. Some anticipate a drop of as much as 60% in their sales to the aircraft industry, and several are shifting emphasis to the production of tank equipment.

The dismal outlook stems from a decision by the Kiesinger government to cut back sharply on development of military aircraft. This year's budget earmarks only $75 million for R&D in this field, compared to $89 million last year. And $45 million of the 1967 allotment will cover work done last year. Because the remaining $30 million can't support the aircraft industry's current research effort, the government urged aerospace firms to trim their work forces by 15%. As a result, some 1,200 scientists and engineers will be laid off by the end of this month. Another wave of layoffs may follow in June.

Rental returns worry Japanese computer makers

A rise in turnbacks of rented machines in recent years has Japanese computer makers uneasy. For the fiscal year that ends this month, returned data-processing equipment will total about $12 million, compared with an estimated $80 million of new machines leased. The percentage of returns—15% this year—has been increasing steadily since the first turnback of a rented machine in 1961.

To ease the sting, Japanese computer firms are plumping for a faster writeoff of rented units. The government-sponsored Japan Electronic Computer Co., which buys computers from the six native computer makers and leases them, currently depreciates new equipment at a rate of 15% over the first six years and 10% for the seventh year. The computer makers are pressing for a five-year writeoff. At the same time, they have asked the Ministry of Finance for a tax writeoff on returned computers they carry in stock or resell at a loss. Japan Electronic Computer has the right to unload a returned computer—at its depreciated value—on its manufacturer.

The six Japanese computer makers last fall moved to forestall future

New ECI satellite ground terminal at St. Petersburg will enable our space communications specialists to conduct real-time experiments with advanced satellites.

Electronics Abroad

Volume 40
Number 5

Switzerland

IC time

New timekeeping techniques, now in the research stage, will depend heavily on integrated circuits for extremely low-power logic.

At the Neuchâtel Horological Electronics Center, the research and development arm of the Swiss watchmaking industry, engineers are working on a timepiece based on a small quartz-crystal oscillator. It will make obsolete "electronic" tuning fork wristwatches like the Accutron of the Bulova Watch Co. and the Horological Center's own improved versions of the Accutron which the Swiss will show next month at Expo 67, the Montreal World Fair.

The Swiss versions use integrated circuits and have tuning forks with a circular or H-shape rather than the U-shape of the Accutron's fork. For its part, Bulova sees no particular advantage in an IC for a tuning-fork watch. William O. Bennett, the company's vice president for research, points out that the circuit has only three components: a transistor, a capacitor, and a resistor. He maintains IC's have an edge only for circuits with many components. Bulova incidentally, owns a Swiss watch company and thus indirectly has a hand in the Neuchâtel work.

Divide and conquer. The all-electronic watch the Swiss have as their goal will use an 8.2-kilohertz quartz oscillator as the basic timekeeping element. The crystal output will be counted down to one hertz by binary dividers.

"This is the classical way of dividing down," says project engineer Fred Leuenberger, "but the power consumption goal is quite unique." The aim is to do the whole thing with 10 microwatts. "We are now high by a factor of two," says Leuenberger, "because we have not yet optimized the circuits."

The next-generation timepiece will use integrated circuits fabricated by quartz isolation techniques adapted from the "epic" technique of Motorola Inc. [Electronics, April 6, 1964, p. 29]. The Swiss use a single crystal material on a polycrystalline substrate and the two are insulated by a thermally grown silicon dioxide layer.

The crystal now being developed is three-quarters of an inch long, suitable for use in a man's watch but too big for a woman's. A 1.3-volt battery provides power.

Hands off. At present, says Leuenberger, there are no short-term plans for "display" beyond the conventional hands. The quartz oscillator divides down to the low frequency, and this triggers a step motor that moves the hands.

But eventually, says Leuenberger, the all-electronic watch will have no moving parts. Techniques for converting electricity into light require too much power, so other possibilities are under study.

These include such electro-optic techniques as using crystals to control the incidence of ambient light and change angles of diffraction in such a way that the pattern will give a readout of time. Also under study is an electro-capillary technique, using a liquid such as mercury in a shaped capillary tube. By application of an electromagnetic field, the liquid metal can be made to appear in small windows to indicate minutes and hours.

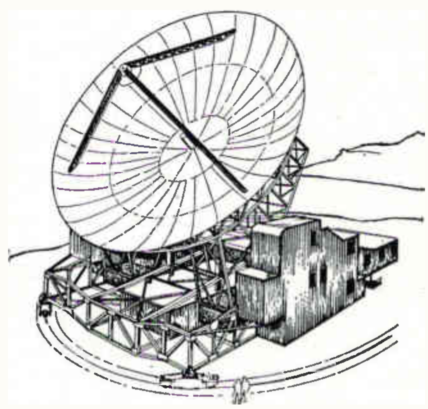
"The principle is not new, but this sort of thing is a long way off as far as power requirements are concerned," says Leuenberger of the capillary readout. The IC logic available to control it requires too much power. One low-power avenue the Swiss are trying is complementary metal oxide semiconductor circuits, using a pulsed power mode and therefore essentially zero standby power.

Great Britain

Dishing it up

An inordinate bustle is in store for the Marconi Co. over the next 13 months. Marconi in mid-February landed a $4 million contract to add a new terminal with a 90-foot antenna to Britain's satellite communications station at Goonhilly Downs in Cornwall. Marconi has to turn over the station—ready to work—to the government-run telephone system by April 1968.

Although the job involves the biggest antenna dish ever built in Britain, Marconi executives are confident they can make the deadline with a crash production program. Marconi, one of the companies in the English Electric group, previously rushed through four satellite communications terminals with 40-foot dishes in less than a year.



British dish. To tie into the Intelsat 3 satellite system, Goonhilly Downs ground station in Cornwall next year will have a new terminal with a 90-foot diameter stainless steel antenna.

Underlying reason for the tight deadline is Britain's fast-growing overseas telephone traffic. Post Office officials who run the phone system estimate they'll need about black-and-white standard in from 10 to 15 years. Both BBC-1 and ITV will have to broadcast in black-and-white on 405-lines the same programs they air in color for perhaps another decade. But after that, the government plans to phase out the 405-line standard.

Japan

Light touch

Even though it cranks out radios, television sets and desk calculators by the thousands, the Hayakawa Electric Co. has become something of a specialist in photoelectric components. At this month's Institute of Electrical and Electronics Engineers convention in New York, Hayakawa will be out to make U.S. equipment makers see the light its way.

The company is introducing a silicon solar cell with a response that peaks in the visible part of the spectrum rather than in the infrared region as conventional units do. Another new Hayakawa device that will bow at the show is a tiny phototransistor that develops an output signal strong enough to drive a relay directly. And Hayakawa will display building blocks that have been used to make up some of the largest earthbound solar batteries yet.

Blue cell. Hayakawa put a twist on a widely used passivation technique to get a "blue" silicon solar cell that has its peak response to light at a wavelength of 0.56 micron, in the visible region. Peak outputs of ordinary silicon solar cells occur at wavelengths between 0.80 and 0.90 micron.

With its fast response to visible light—the rise time is less than 10 microseconds—the blue cell may find wide use in electronic shutters. Other potential applications are exposure meters, flame detectors and spectrum analyzers.

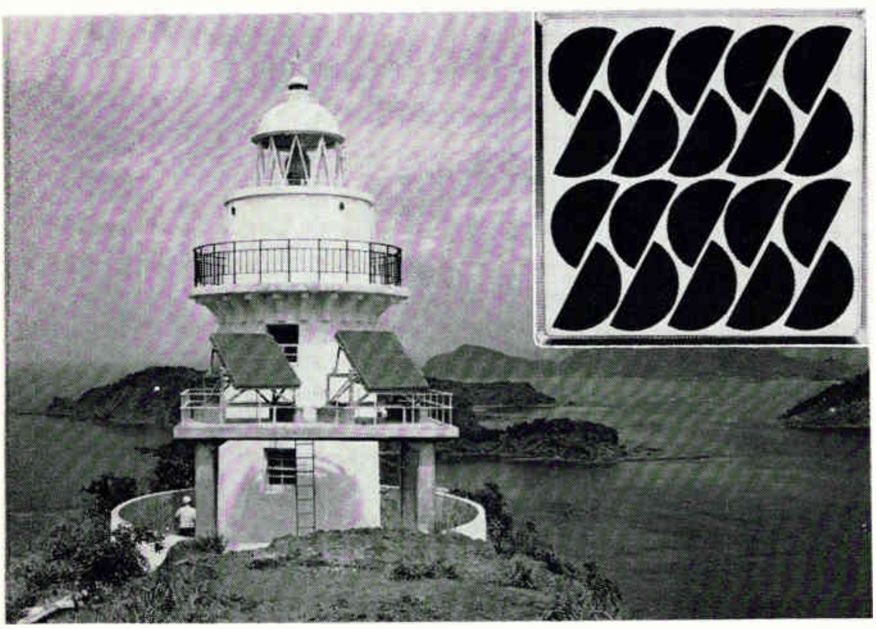
To make the cell, Hayakawa starts with p-type silicon and grows a thermal silicon-dioxide layer atop it—the usual passivation layer. In the process, an n-type inversion layer 0.3 micron thick forms directly beneath the passivation layer. The n-p junction thus lies much closer to the surface than does the junction in an ordinary solar cell, and this results in less attenuation of shorter wavelengths.

To further improve the cell's response to light in the visible spectrum, Hayakawa deposits by vacuum over the thermally grown silicon dioxide layer a second silicon dioxide layer and finishes off the cell with a proprietary epoxy coating. The coating is designed to pass visible light and block out most of the infrared. Optical interference between the three layers gives the cells their blue color.

Miniscule. Hayakawa also has an apparent winner in its minute phototransistor, a chip 650-microns square packaged in a pin-head-size mount. There are many photodiodes as small, but this transistor has a big plus: for many applications, its output needs no amplification. With an illumination of 5,000 lux, for example, the transistor's output current is at least 3 milliamperes, enough to operate a small relay.

Although the device will make its public debut at the IEEE convention, it's already been adopted by one Japanese manufacturer for a card reader. And it seems a likely component for infrared communications gear, control equipment, and pattern-recognition units.

King size. In contrast to the tiny phototransistors, the solar-cell battery packages are king size, each made up of 20 semicircular silicon wafers of 23-millimeter diameter. The package is shatter-resistant plastic, sealed to make it weathertight. Power output is better than 360 milliwatts. From these packages Hayakawa has built panels with outputs as high as 225 watts to power unattended lighthouses off the Japanese coast.



Alone under the sun. Unattended lighthouse off Japanese coast is powered by solar panels that generate 225 watts. Panels are built up of 20-cell packages shown in inset.

France

Millimeter waveguide

Blue-sky thinkers already foresee a time when city dwellers will need transmission lines with megacycles of bandwidth to handle the flow of data for computer-run electronic households. The household hardware still is a long way off, but a likely candidate for the transmission line is in sight.

In a project that's been kept largely under wraps so far, the Centre National d'Etudes des Télécommunications (CNET) is install-

Planck Institute for Radio Astronomy near Bonn is now using a radio telescope that "takes the sun's temperature" at points across the solar surface. With a 33-foot-diameter antenna dish, the telescope picks up signal strength caused by the different levels of light intensity. These readings are then plotted. From the plottings, maps are drawn showing the contours of the sun's hot and cold zones. Daily shifts of these contours—sometimes called coronal condensations—may indicate impending proton shower activity. The telescope is atop Stockert Mountain, about 20 miles southwest of Bonn.

Round the clock. Similar work is being done in the U.S. Under an Air Force sponsored program, the Prospect Hill Radio Observatory at Waltham, Mass., has plotted a number of sun temperature readings using a radio telescope operating on an 8.6-millimeter wavelength and having a 29-foot-diameter antenna dish. By coordinating solar research with observatories around the world, it is possible to provide round-the-clock forecasts as the sun moves across the sky, says Otto H. Nachenberg, the Bonn institute's technical director. But so far the Waltham and Stockert installations are the only ones built for this purpose.

The West German telescope has an aluminum antenna dish whose shape varies by no more than 0.5 mm from that of an ideal parabola. The antenna is equatorially mounted—one axis in the north-south direction and the other perpendicular to it. The telescope has a beamwidth of 3.5 minutes of arc.

As the sun moves across the sky, the antenna automatically follows it. The feedhorn scans the sun in discrete steps of 2.5 minutes of arc from top to bottom in columns from right to left. In this raster-type motion, 80 regions are scanned. It takes about three minutes to cover the solar surface. The antenna movement is controlled by a synchromotor-driven quartz clock, supplied by West Germany's Rhode and Schwarz AG.

Clearer picture. The receiver—designed by the institute—has a 10 decibel noise level and a band-

Glen Cove, N.Y., and Electronic Associates of Canada Ltd. are also manufacturing paper-monitoring devices.

Around the world

Sweden. Saab AB has developed a television tracker to guide missiles and aircraft. With the system, an operator views target sectors on a tv screen and sets a contrast control to select targets. The system then locks onto the target automatically.

Italy. The first satellite launching from Italy's San Marco Texas-tower platform off the coast of Kenya is scheduled for late April. The Italian-built 250-pound satellite—San Marco 2—will be put into an orbit of 155 to 185 miles by a NASA Scout rocket. San Marco 1 was launched in the U.S. in December, 1964, by an Italian crew.

Great Britain. The General Electric Co. (not connected with its U.S. namesake) has found the computer business too rough. The company last month sold its computer-making subsidiary to Elliott-Automation Ltd. for approximately the value of the contracts it had in progress—some $5.5 million.

France. The first phase of France's space program ended last month with two launches and mixed success. The first satellite sent up, D-1C, went into a lower orbit than planned and the French had trouble tracking it with laser stations set up in France, Algeria, and Greece. The second satellite, D-1D, went into an orbit with a 1,900-kilometer apogee. This was not as high as planned but high enough for laser tracking from the three stations. The next all-French satellite launching is expected in the spring of 1969 from the new space center in French Guiana.

Japan. The Keihanshin Kyuko Railway Co. will soon have an unmanned station on one of its commuter lines. The station will have five ticket-vending machines, a bill changer, 10 automatic ticket checkers, and an automatic commutation ticket puncher.

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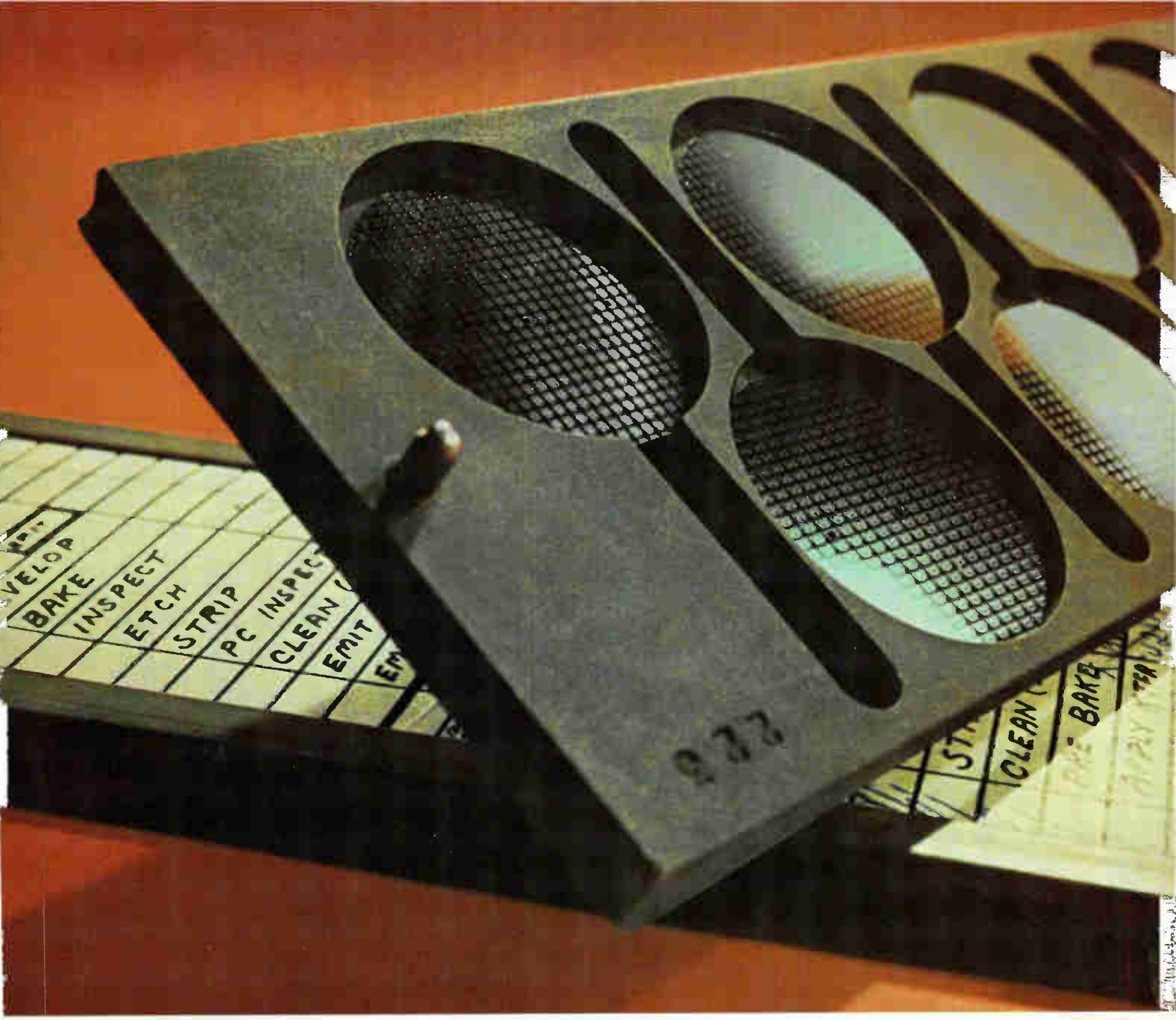

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