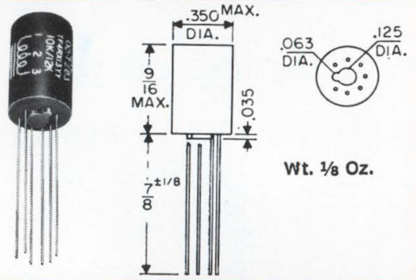
PIONEERS IN MINIATURIZATION

NEW DO-T200™ SERIES

ULTRAMINIATURE TRANSISTOR TYPE AUDIO TRANSFORMERS



U. S. PAT. NO. 2,949,591; others pending.

This DO-T200 series of transistor transformers and inductors has been newly added to the UTC lines of stock items available for immediate delivery. These transformers provide the unprecedented power handling capabilities and the inherent reliability found only in the basic structural design of the UTC DO-T Family of miniature transformers. This reliability has been dramatically proven in the field.

Leads are 7/8″ long, .016 Dumet wire, gold plated, and may be either welded or soldered. They are uninsulated and are spaced on a .1″ radius circle, conforming to the termination pattern of the "TO-5" cased semiconductors and micrologic elements.

DO-T200 series of transformers are designed for Class R application. On special order they may be designed to Class S Specifications. No additional life expectancy is gained by using Class S insulation systems at Class R temperatures.

In pulse coupling impedance matching applications, (when measured with a 30 microsecond input pulse voltage wave), typical values for these transformers are: 5% or less droop, zero overshoot, and less than 10% backswing.

Special unit modifications, such as additions and deletions of leads, changed lead lengths, different impedance ratios and incorporation of electrostatic shields, etc., are available in these constructions.

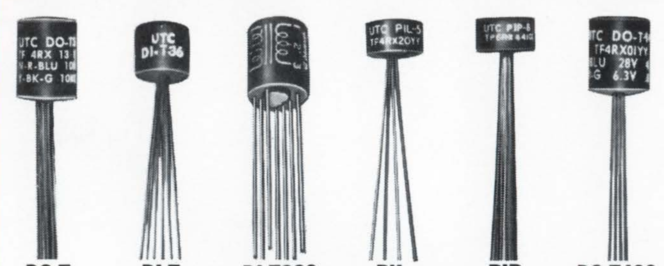
- **Manufactured and successfully tested to complete environmental requirements of MIL-T-27B**

- **Most Ruggedized MIL Structure, Grade 4, Metal Encased**
- **Immediate Delivery From Stock**
- **Full Conformance to MIL Mounting Requirements**
- **Solderable and Weldable Leads**
- **Hermetically Sealed**
- **Straight Pin Terminals**
- **Excellent Response**
- **High Efficiency**
- **Low Distortion**

Type No.	MIL Type	Pri. Imp.	D. C. ma‡ in Pri.	Sec. Imp.	Pri. Res.	Mw Level	Application
DO-T255	TF4RX13YY	1K/1.2K CT	3	50/60	115	100	Output or matching
DO-T275	TF4RX13YY	10K/12K CT	1	1.5K/1.8K CT	780	100	Interstage
DO-T277	TF4RX13YY	10K/12K CT	1	2K/2.4K split	560	100	Interstage
DO-T278	TF4RX13YY	10K/12.5K	1	2K/2.5K CT	780	100	Driver
DO-T283	TF4RX13YY	10K/12K CT	1	10K/12K CT	975	100	Isol. or Interstage or Pulse
DO-T288	TF4RX13YY	20K/30K CT	.5	.8K/1.2K CT	830	50	Interstage
DO-T297	TF4RX16YY	200,000 CT	0	1000 CT	8500	25	Input and Chopper
DO-T200SH	Drawn Hipermalloy shield provides 15 to 20 db shielding through side of case						

‡DCma shown is for single ended useage. For push pull, DCma can be any balanced value taken by .5W transistors.
Where windings are listed as split, 1/4 of the listed impedance is available by paralleling the winding.

THE DO-T FAMILY OF COMPONENTS



DO-T DI-T DI-T200 PIL PIP DO-T400

All these hermetically sealed, ultraminiature transistor transformers & inductors are to MIL-T-27B, Grade 4, Class R, Life X. Except PIP: to MIL-T-21038B; Grade 6, Class R, Life X.

DO-T Flexible leads. Freq range 300 CPS—10KC & up. Power up to 1/2 W. Size 5/16 dia x 13/32″ h. Wt approx 1/10 oz.

DI-T Flexible leads. Freq range 400 CPS—10KC & up. Power up to 1/2 W. Size 5/16 dia x 1/4″ h. Wt approx 1/15 oz.

DO-T200 Series. See above

DI-T200 Series Straight pin gold plated. Dumet leads. Freq range 400 CPS—100KC. Power up to 500 mw. Size 5/16 d x 3/8″ h. Wt approx 1/15 oz.

PIL Inductors range from .025 hy to .8 hy, DC 0 to 10 ma. Transformers from 500 ohms to 10,000 ohms impedance. Freq range 800 cps—250 KC; power up to 100 MW. Size 5/16 dia x 3/16″ h. Wt 1/20 oz.

PIP (Pulse) Flexible leads. Wide application pulse transformers, to MIL-T-21038B specifications. Size 5/16 dia x 3/16″. Wt 1/20 oz.

DO-T400 (Power) Flexible leads, power transformer. Power output 400 mw @ 400 cycles. Size 5/16 dia x 13/32″. Wt 1/10 oz.

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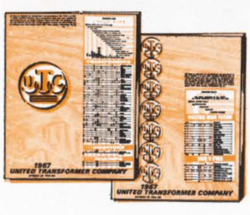

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The new Hewlett-Packard 7850 Series Rectilinear Fluid-Process Recorder produces ultra-clear traces on Z-fold paper or rolls. The numbered Z-fold pages offer more convenient access to recorded data. Contactless pen tip sensing and a low-pressure ink system produce traces of constant width throughout the recorder's variable speed ranges of .025 to 200 mm. per second. Designed with modular, solid-state electronics, the 7850 Series Recorder provides high-resolution, permanent, rectilinear recording of up to eight variables from dc to 160 Hz.

A wide selection of 8800 Series Preamplifiers provides signal conditioning to the driver-amplifiers which drive the recording pens of the recorder.

The 7850 Series system includes a preamplifier power supply, a driver amplifier power supply and a cabinet to house the complete unit. The frequency response of the recorder is 160 Hz for 10 div p-p deflection and 60 Hertz maximum for full scale deflection. Maximum ac or dc non-linearity is 0.5% full scale. Additional features include: 14 electrically-controlled chart speeds; built-in paper take-up; low ink supply warning light; plug-in ink supply cartridge that may be replaced while the recorder is in operation and complete modular construction of all components for easy maintenance:

For complete information on the 7850 system, optional and related equipment, contact your local HP Field Office or write Hewlett-Packard Company, 175 Wyman St., Waltham, Mass. 02154.

HEWLETT hp PACKARD

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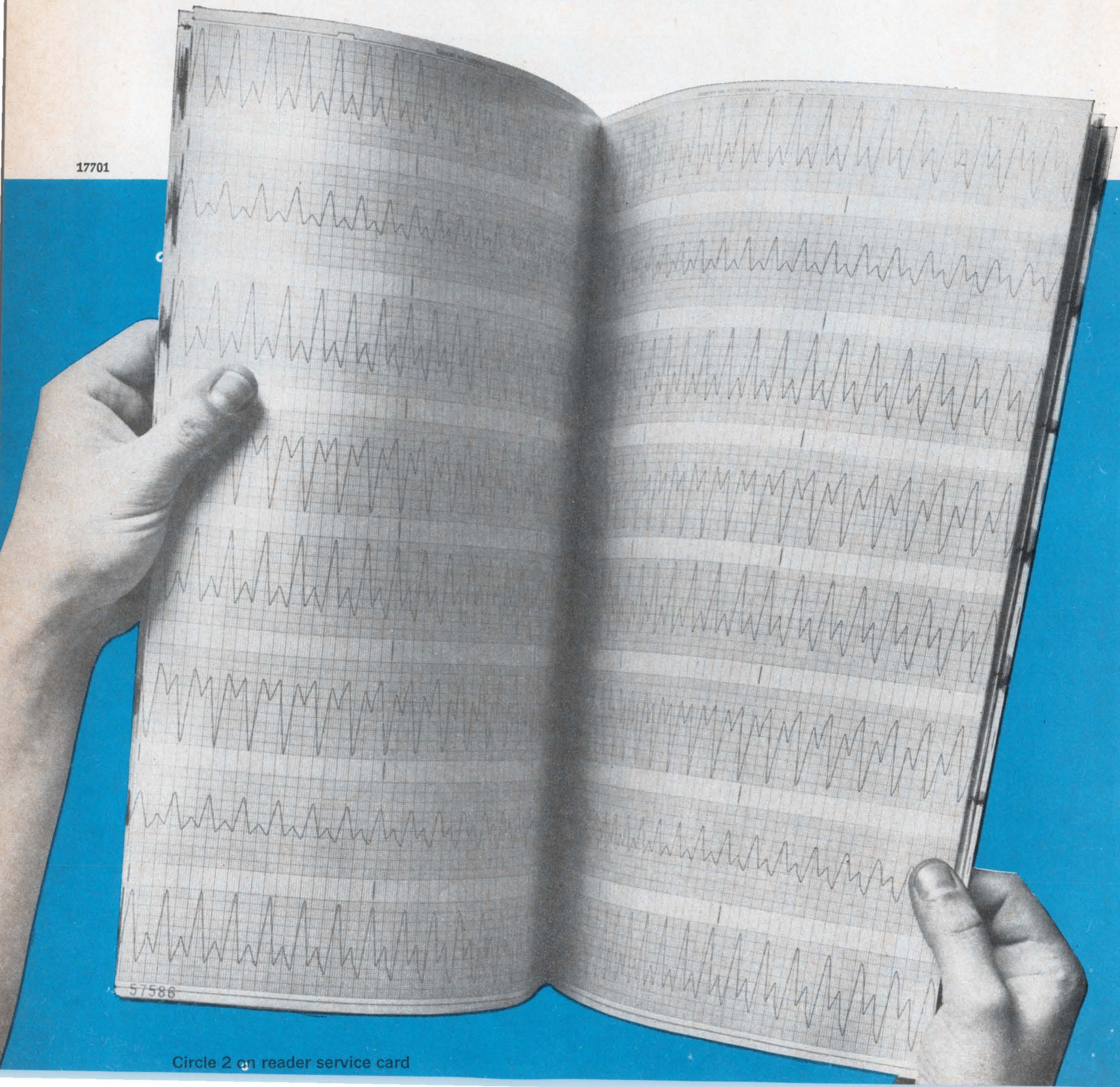

Circle 2 on reader service card

Electronics

Electronics: November 13, 1967, Vol. 40, No. 23

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Readers Comment

No exceptions

To the Editor:

I would like to correct one statement made in the article "Strengthening a link . . . or replacing it" [Aug. 21, p. 39] to the effect that everyone except Amphenol would be forced to requalify as suppliers of MIL-C-26500C. This is not the case. Amphenol, as well as all other potential suppliers of a connector qualified to MIL-C-26500C, will have to qualify by running the required tests in the manner specified. As a matter of fact, we have already asked permission to start such qualification testing at Amphenol.

J.E. Atkinson
Vice president
Amphenol Connector Division
Chicago, Ill.

New light

To the Editor:

"Is Einstein wrong?" was the heading you gave to a letter from Pascal M. Rapier [July 10, p. 4] discussing the article "Settling on the moon" [May 15, p. 110].

Rapier had suggested that either Einstein's theory "that the phase of a light signal is independent of velocity . . ." is wrong or that "the lunar soft landings whose velocity and range data were obtained from radar doppler techniques . . . impossible under Einstein's theory" were fakes.

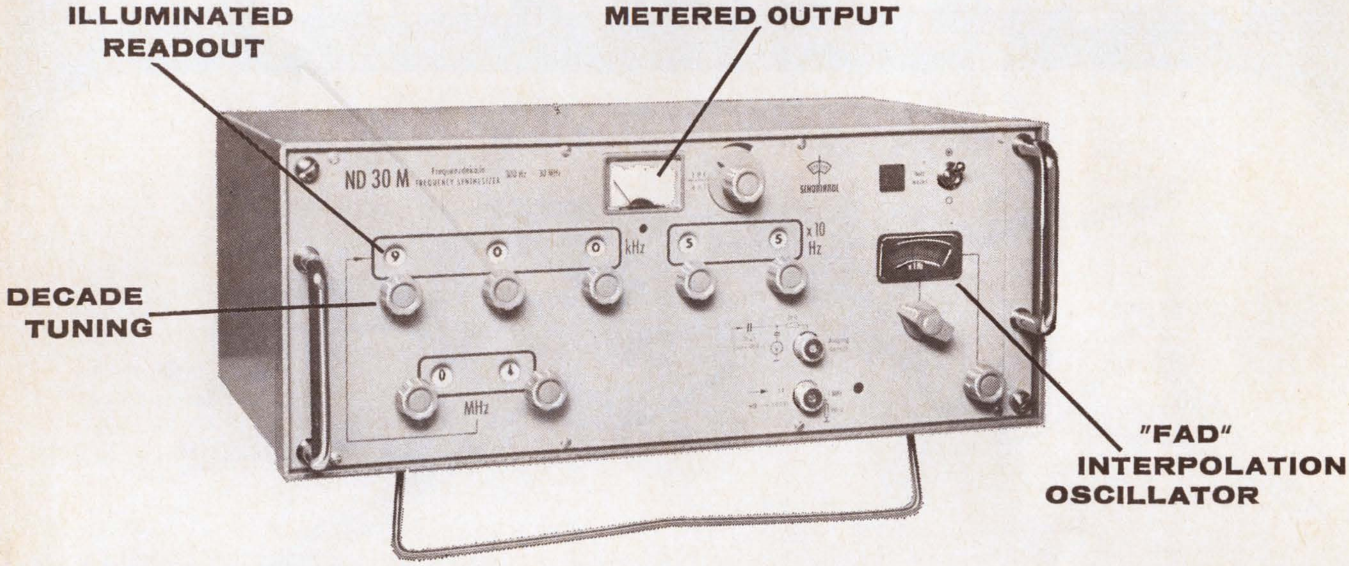
C. J. Badewitz, the author of the article, replied that Einsteinian doppler shifts encountered in the Surveyor approach velocities differ from such shifts calculated by means of classical theory by a completely negligible amount.

Neither of these gentlemen appears to have read "Light Velocity and Relativity," by Arthur S. Otis. This 130-page booklet presents some half-dozen disproofs of the postulate questioned by Rapier. One of them concerns the doppler shift.

The postulate is: the velocity of light is constant in all inertial systems.

Dr. Otis argues thusly: since light velocity $v = \lambda f$, and since λ

300 Hz to 31 MHz



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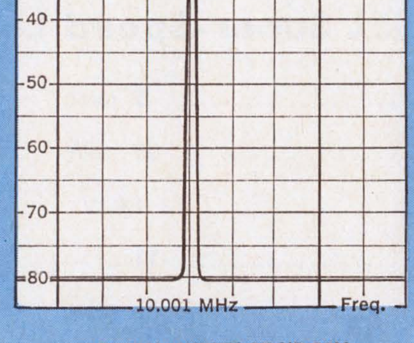

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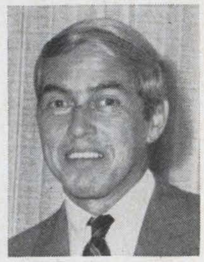
People

Intersil Inc.'s appointment of **Ward Gebhardt** as marketing director without a product reflects the optimism that prevails at the fledgling semiconductor firm started by Jean Hoerni, developer of the planar process, founder of Amelco Semiconductor, and guiding spirit behind the entry of the Union Carbide Corp. into semiconductors. Though Intersil has only 15,000 square feet of plant facilities and some $2 million in backing, Gebhardt left a comfortable spot as marketing manager for discrete components at the semiconductor division of the Fairchild Camera and Instrument Corp.


Ward Gebhardt

"We already have some proposals out, trying to find out who wants what," Gebhardt explains. "Our present plant is strictly for research and development and prototype fabrication. But we are geared for fast expansion. The R&D is not so far beyond the market that we can dispense with a marketing man. You need one for long-term planning, to help in the language and pricing for bidding on specific circuits."

Gebhardt has known Hoerni since 1963, when both did some consulting work for Union Carbide. The chance to work with Hoerni at Intersil—where the financial rewards for success could be enormous—may have dictated the decision to leave Fairchild.

To **Theodor F. Hueter,** the field of ocean engineering appears to be "at the Sputnik 1 hour," poised for exciting thrusts, but saddled with the omnipresent brake on funding imposed by the war in Vietnam. The 50-year-old Hueter, an acoustics ex-


Theodor F. Hueter

People

pert, was recently chosen to head Honeywell Inc.'s Marine Systems Center.

The Center consists of two facilities—the West Covina, Calif., headquarters and a site in Seattle. Total employment for the two installations has grown from about 750 two years ago to some 1,300, and Hueter looks for it to reach 2,000 once the Vietnam conflict subsides. He expects to get a good share of military business. For example, there are the Navy's DX destroyer program in which Honeywell would probably compete for antisubmarine warfare hardware development, and an improved version of the Navy's Asroc antisubmarine rocket, which was developed by the Marine Systems Center.

One of **Lee Rice's** first moves as senior vice president of the Ogden Corp. of New York will be to get the company into the electronics business. "We plan to acquire several electronics companies by mid-1968 and exceed $250 million in electronics sales by the early '70's," says the Washington-based executive.


Lee Rice

Rice says he plans to "create a broad technology base as a viable business and to serve Ogden's other activities," which include shipbuilding, metals and food processing, biomedicine, water treatment, chemicals, and demolition. Ogden now has technical laboratories in Los Angeles and Sunnyvale, Calif., and Long Island, N.Y., which provide environmental and functional testing for aerospace and oceanographic equipment.

The electronics companies Rice has in mind will include a mixture of "those concerned with advanced development and those dealing in a product line, mainly in the areas of pollution control and for the chemical industry."

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Meetings

Computer Conference, American Federation of Information Processing Societies; Convention Center, Anaheim, Calif. **Nov. 14-16.**

Meeting of the Anti-Missile Research Advisory Council, Advanced Research Projects Agency; U.S. Naval Postgraduate School, Monterey, Calif., **Nov. 14-16.**

International Exhibition of Industrial Electronics, Swiss Industries Fair, Basle, Switzerland, **Nov. 14-18.**

Missile System Meeting, American Institute of Aeronautics and Astronautics; Monterey, Calif., **Dec. 4-6.**

Symposium on Theory and Measurement of Atmospheric Turbulence and Diffusion in the Planetary Boundary Layer, Atmospheric Sciences Laboratory of the Army Electronics Command; Sandia Base, Albuquerque, N.M., **Dec. 5-7.**

Vehicular Conference, IEEE; New York Hilton, New York, **Dec. 5-7.***

Symposium on Reliability, IEEE; Sheraton-Boston Hotel, Boston, **Jan. 16-18.**

Power Meeting, IEEE; Statler-Hilton Hotel, New York, **Jan. 28-Feb. 2.**

Aerospace and Electronic Systems Convention, IEEE; International Hotel, Los Angeles, **Feb. 13-15.**

International Solid-State Circuits Conference, IEEE; Sheraton Hotel, Philadelphia, **Feb. 14-16.**

Scintillation and Semiconductor Counter Symposium, IEEE; Shoreham Hotel, Washington, **Feb. 28-March 1.**

International Convention and Exhibition, IEEE; New York Coliseum and New York Hilton Hotel, New York, **March 18-21.**

Symposium on Microwave Power, International Microwave Power Institute, Statler Hilton Hotel, New York, **March 21-23.**

Joint Railroad Conference, IEEE; Conrad Hilton Hotel, Chicago, **March 27-28.**

International Magnetics Conference, IEEE; Sheraton Park Hotel, Washington, **April 3-5.**

Business Aircraft Meeting and Engineering Display, Society of Automotive Engineers, Broadview Hotel, Wichita, Kan., **April 3-5.**

Short Courses

Low Frequency Standards, U.S. Dept. of Commerce, National Bureau of Standards, Washington, **Dec. 11-13;** $90 fee.

Process Control, University of Wisconsin's Department of Engineering, Madison, Wis., **Dec. 13-15; $70 fee.**

Automation and Publishing, The American University's Center for Technology and Administration, Washington, **Jan. 15-18; $175 fee.**

Call for papers

Colloquium on Information Retrieval, University of Pennsylvania's School of Electrical Engineering; University of Pennsylvania, Philadelphia, May 3-4, 1968. **Dec. 1** is deadline for papers to David Lefkowitz, Moore School of Electrical Engineering, University of Pennsylvania, Philadelphia, Pa., 19104.

Power Meeting, IEEE; Sherman House, Chicago, June 23-28, 1968. **Feb. 9** is deadline for submission of papers. Authors should advise the technical conference services office of IEEE if they expect to submit a paper.

Conference on Precision Electromagnetic Measurements, IEEE; National Bureau of Standards Laboratories, Boulder, Colo., June 25-28, 1968. **Feb. 12** is deadline for submission of summaries and abstracts to Donald King, Aerospace Corp., Box 95085, Los Angeles, Calif. 90045.

* **Meeting preview on page 16.**

Meeting preview

Crowded spectrum

As is becoming usual when land mobile radio users gather, frequency congestion will be a major topic of discussion at this year's annual IEEE Vehicular Conference, Dec. 6 to 8. At the New York meeting, W.L. North of the Federal Communications Commission will report on a study of the problem in a 34-mile-square area including metropolitan New York.

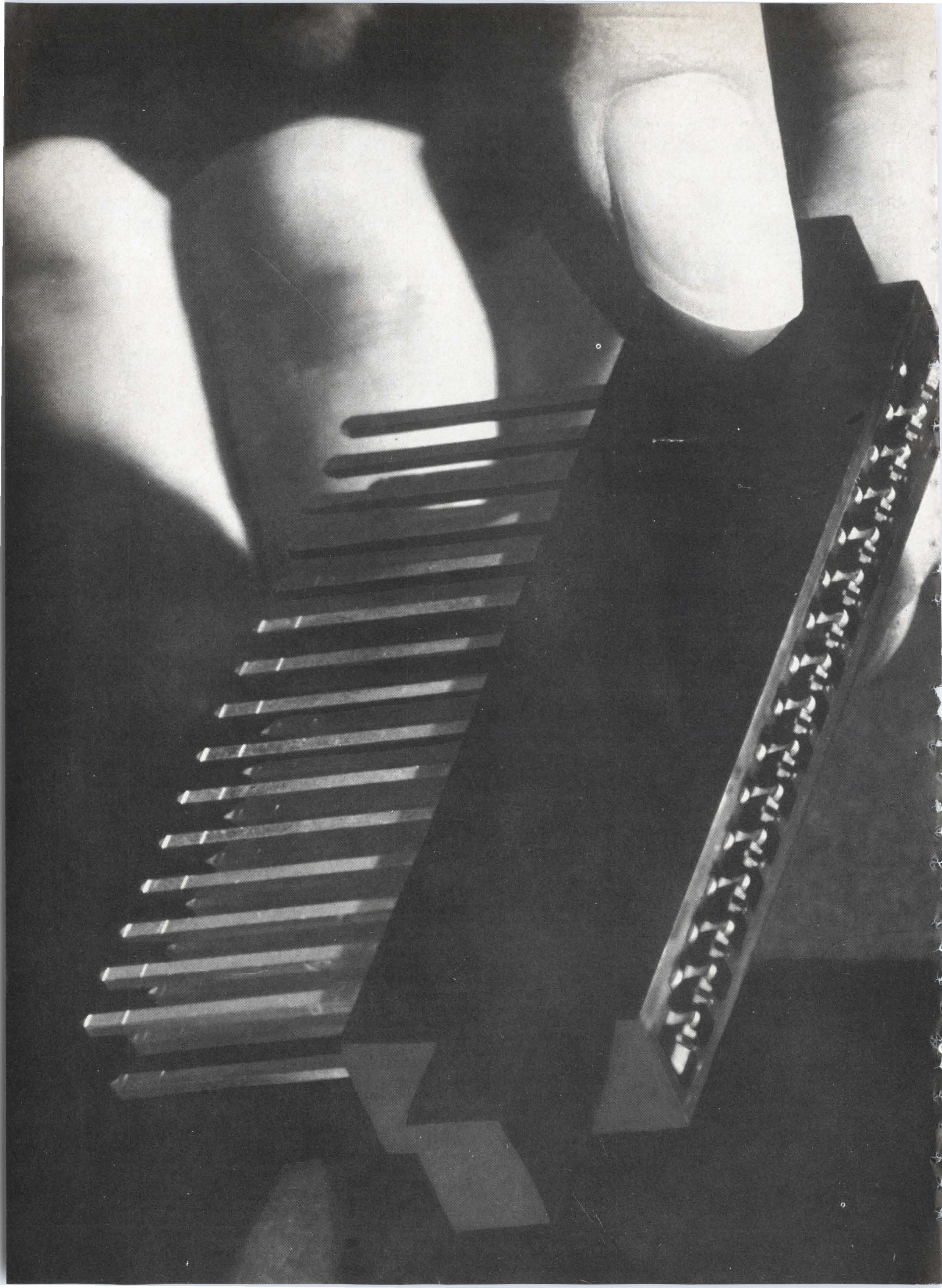
North recommends the use of computers to plan frequency assignments, two-frequency systems to ease intermodulation problems, and cooperative base stations. With all this, however, he warns that additional frequencies will be needed in the New York area by around 1975-77.

Equipment scored. At the same session, R.C. Eldridge of the British Columbia Telephone Co. will blame the height and power of many base-station transmitters and the sensitivity of receivers for much of the traffic interference and, in the long run, for reducing the number of available channels.

To extend the range of highway and railroad communication systems with fixed transmitters, a solid state repeater with a stable gain of 140 decibels at 450 megahertz can amplify attenuated signals. J.G. Churcher will describe the device, which was developed in England at Pye Telecommunications Ltd.

Also on the agenda are reports on two mass-transportation radio communications systems that will operate in the 150-Mhz band. C.E. Paul of Bell Telephone Laboratories will outline the projected radio telephone service on a high-speed train planned for runs between Washington, D.C., and New York. And Seymour Dornfield of the New York City Transit Authority and G.H. Kamerer of the Radio Corp. of America will describe a radio system to be installed in New York's 4,000 buses.

Plaudits. At a session on reliability, Otmar Schreiber of the General Instrument Corp. will praise the contributions of thermoelectric generators to very-high-frequency communications.



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- For Automatic Fine Tuning in VHF *and* UHF receivers
- Dual phase detector with differential output amplifier
- Compensated reference voltage supply
- Operating temperature range −55°C to +125°C
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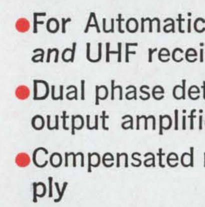
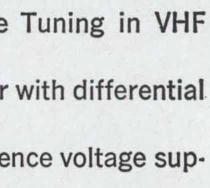
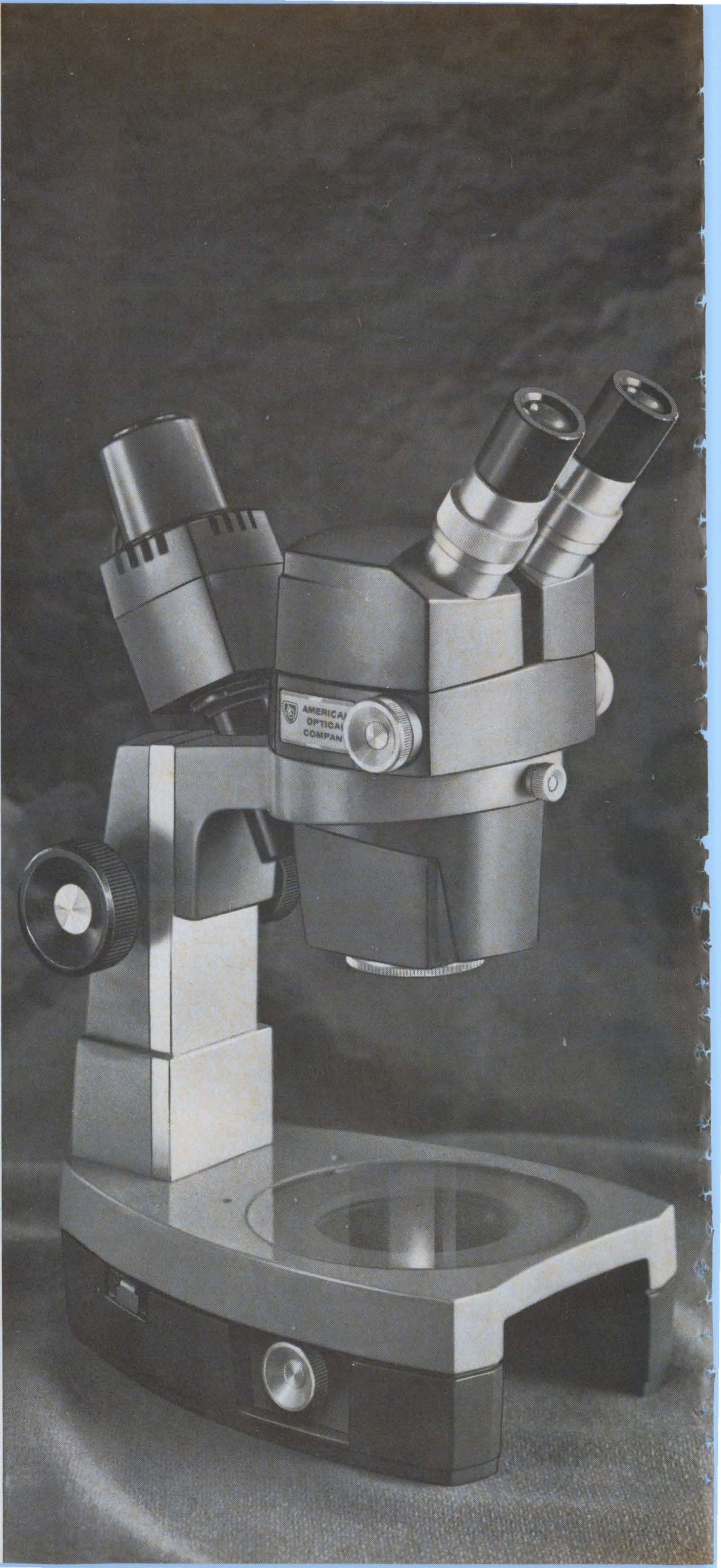
- Output offset voltages between terminals #4 and #5 1.5V max. @ $V_{CC} = 10V$
- Input impedance 2K Ω typ



RCA CA3034 in 10-lead TO-5 package. Price $1.75 (1000+)



RCA CA3034V1 with preformed leads. Price $1.75 (1000+)



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

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

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

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

INDIANA GENERAL

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

its dome. **The company plans a sales push for its multifunction radar,** good for mapping and navigation, terminal landing, weapons delivery, and limited station keeping.

Motorola readying 3rd generation ECL

A third-generation emitter-coupled-logic line will be introduced next year by Motorola Semiconductor. **The company is aiming the MECL-3 integrated circuits at the ultrahigh-speed computers expected to be introduced in 1970 or 1971.**

Motorola seeks a 1-nanosecond typical propagation time; switching speed of the MECL family now on the market is 5 nanoseconds. Jim Burns, manager of IC marketing, says the current-mode line will include flip-flops that operate at frequencies between 200 and 400 megahertz.

By the skin or the teeth

A hearing aid that uses the teeth and the skin to conduct sound is being developed by a small New York City electronics company, Intelectron Corp. **The development is significant because it could result in a hearing aid considerably smaller than those currently in use.**

In the Intelectron model sound is not produced by the motion of air as it is in conventional hearing aids which use loudspeakers—but through bone conduction. Consequently, the hearing aid has smaller parts.

In one model, a radio-frequency receiver is placed in a patient's tooth; the "sound" is then conducted through the tooth to the ears' nerves. And in an earlier model, which was used for rehabilitating the hard of hearing, an electrode is attached to the patient's skin.

Due for mailing

President Johnson's spending freeze so far has held back the Post Office from issuing contracts from its $18 million R&D budget this year, **but department officials are hopeful that they can start letting the first of some 100 to 150 awards by the end of the year.** The Post Office also promised the 300 industry representatives attending a briefing earlier this month a list of R&D contracts it will put out for bids.

Addenda

A sweeper plug-in, developed at Hewlett-Packard Co.'s Loveland, Colo., division, contains the first integrated circuit turned out by the new IC facility there. **Construction of the facility began only last spring.** The IC is a diode chain used to give a logarithmic shape to the dynamic response of the instrument. . . . Interior Secretary Stewart L. Udall is trying to interest Westinghouse and General Electric in **establishing electronics plants in "new towns" that might be built on Indian lands in New Mexico and Arizona.** He's citing as precedent the dozen electronics firms attracted to another new town, two-year-old Reston, Va. . . . Happy days are here again at Autonetics where officials, winding up development tests on four programs, are **anticipating orders for more than 2,000 airborne computers.** The computers, all members of the D26J family, will go on the Condor and short-range attack missile (Sram), both air-to-surface weapons, and the FB-111 and the RF-111 aircraft. . . . Litton Industries has won a hot contest to build the Army's Tacfire (tactical fire direction system). Under an award that could reach an estimated $50 million, the firm will build a system to provide automatic data processing for all elements of information needed by an artillery officer. Burroughs and IBM were the losers.

Why Bunker-Ramo chose TTL complex functions for new NC systems

These low-cost numerical control systems offer as standard most of the functions normally found in far more expensive equipment. They are the first such systems to employ ICs for all non-power functions. Shown with Dean W. Freed, General Manager of the NC Division, the Bunker-Ramo 2100 (right) is a two-axis positioning and straight-cut control, while the 2200 (left) is a three-axis positioning and straight-cut control, with optional two-axis incremental slope and arc capability.

Series 74 complex-function TTL integrated circuits from Texas Instruments have enabled Bunker-Ramo to further improve reliability and performance, while reducing size and cost of the numerical control systems shown above.

Series 74 TTL offered many performance as well as cost advantages. These included higher noise immunity and faster speed, plus the economies made possible by complex-function circuits.

High noise immunity

Since numerical control systems usually operate in an electrically noisy environment, the high noise tolerance (typically one volt) and the low input impedance (70 to 150 ohms) of Series 74 circuits are big advantages. Bunker-Ramo engineers found that this reduced shielding and line-filtering requirements, while simplifying many associated design problems.

High speed

TTL's high speed gives important design advantages, even though today's NC systems often do not

Do ICs really cut costs?

The answer is an emphatic yes! That's no promise. It's a fact... with proof to back it up.

We've gathered some of the proof in the folder pictured at the left. This 6-page brochure describes how other industrial manufacturers have achieved revolutionary product advances with ICs. Like these OEMs, you too can significantly reduce equipment size and weight . . . make major performance improvements... achieve new systems capability... *dramatically reduce costs!* For your copy, check No. 200 on the TI information service card.

But that's not all! Check number 202 for the 48-page brochure that contains performance, application, and catalog information on all 180 Series 54/74 TTL ICs.

An 84-page report provides results of TI's "Tougher-than-military" testing program. It's yours for the asking. Check number 203.

A new 24-page color brochure that gives information on all plastic-encapsulated semiconductors—including Series 54/74 ICs—is also available. Check No. 204.

Please send the following:

- 200 ☐ 6-page case history brochure
- 201 ☐ 48-page complex-function IC data book
- 202 ☐ 48-page TTL brochure
- 203 ☐ 84-page IC plastic package reliability report
- 204 ☐ 24-page plastic S-C brochure
- 205 ☐ 16-page "Total Reliability at TI"

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Any really successful reliability program must start with correcting the causes of failure *before they occur in the field,* and TI's Reliability Analysis Laboratory... established in 1962... has been examining the "where, what, when, how and why" aspects of IC failures for more than five years.

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Typical of these quality-analysis studies is the X-ray video monitoring facility shown at the left. This important analytical tool permits full 360° observations in both vertical and horizontal planes. It reveals failure mechanisms that might otherwise escape detection.

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Quality analysis is only one of many steps taken by TI to ensure reliability of integrated circuits. Other important steps are described in a new 16-page brochure in full color... *Total Reliability at TI.* Check number 205 on the TI information service card for your copy.

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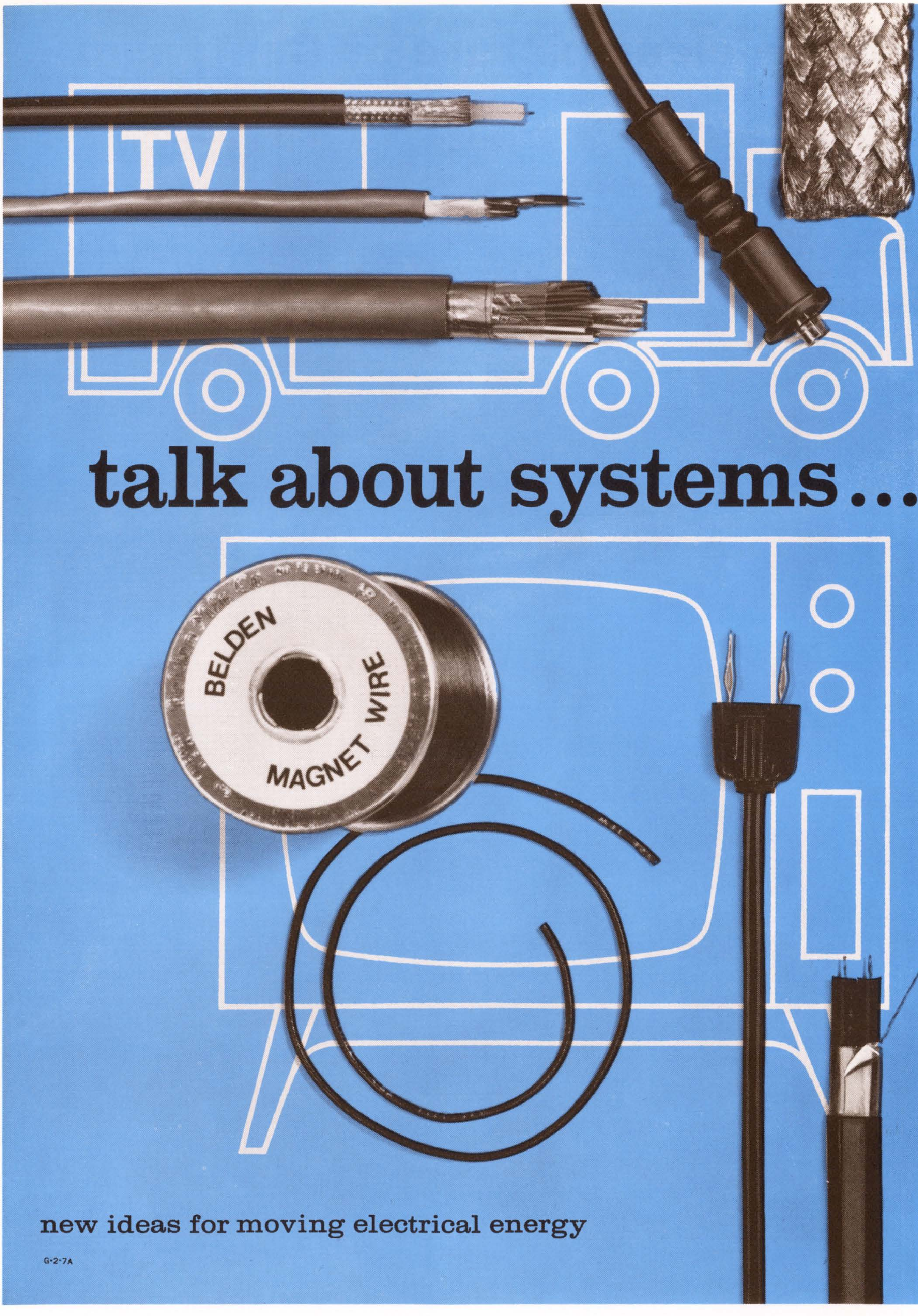
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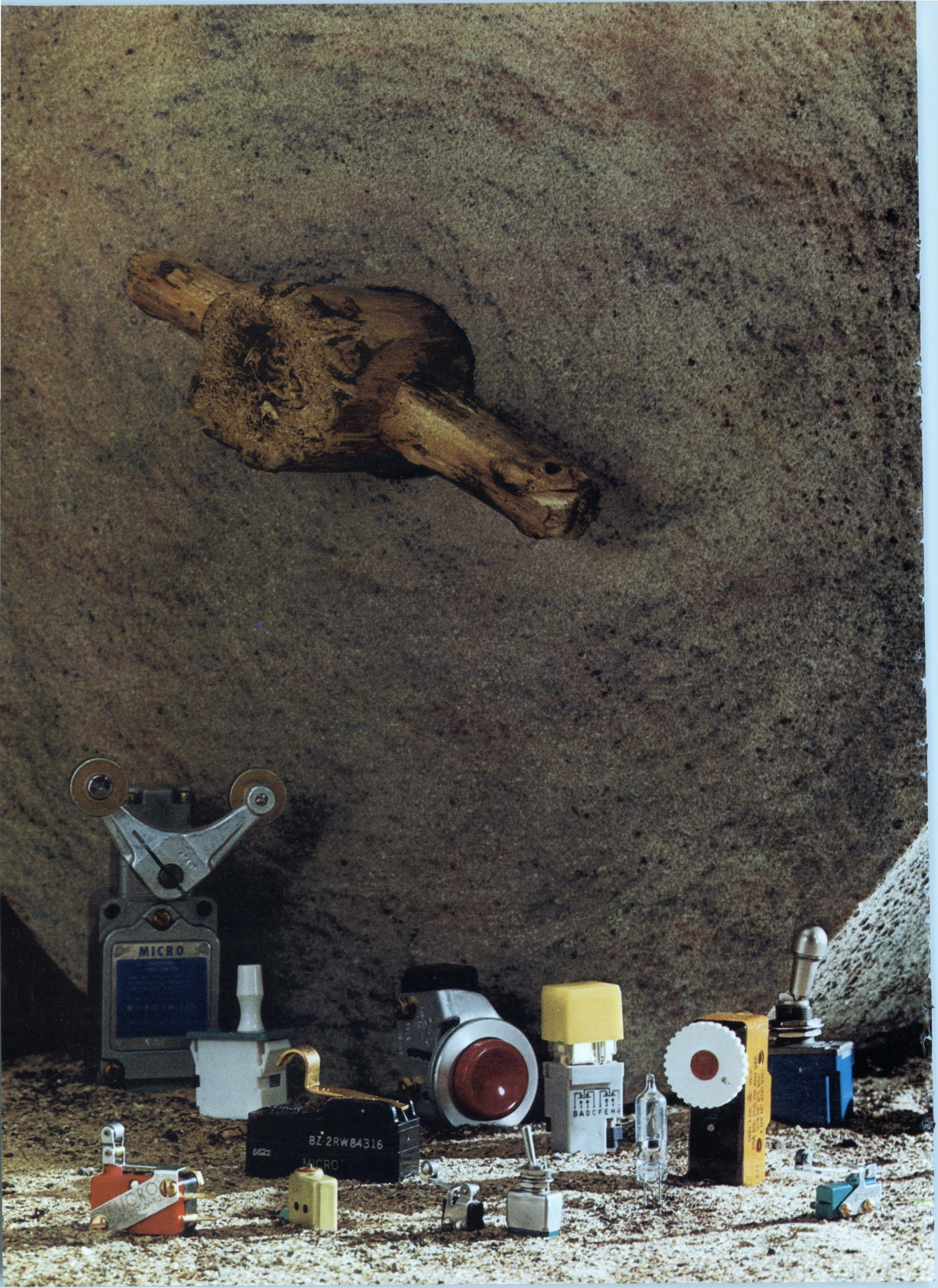
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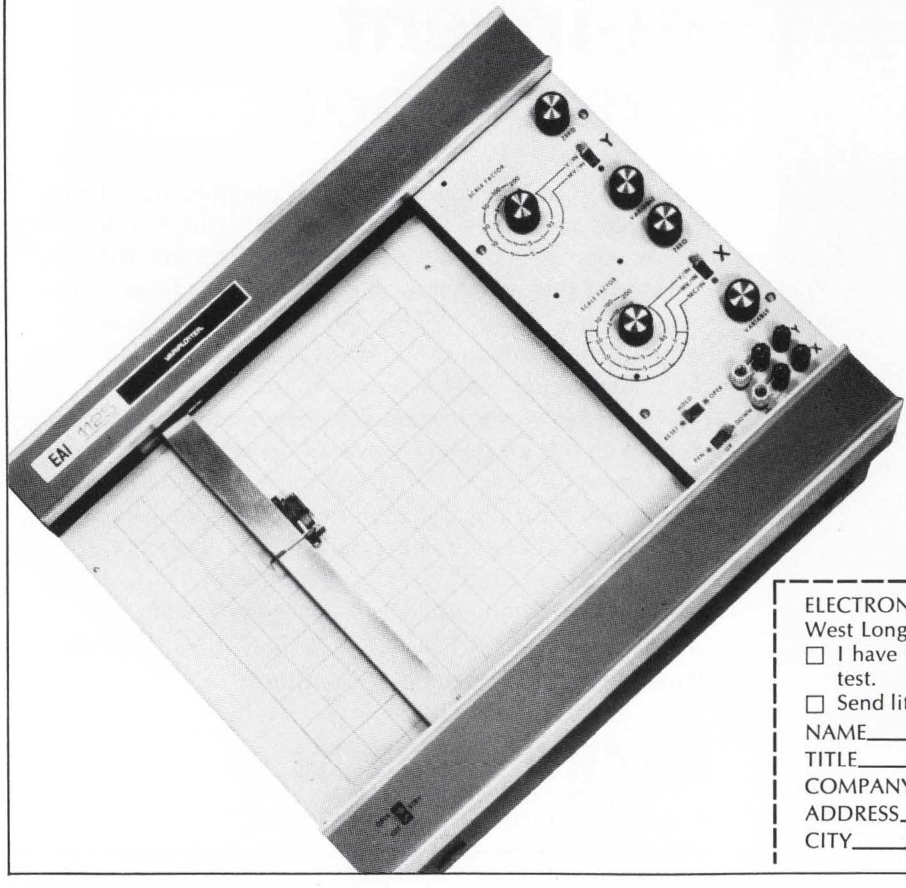

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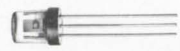

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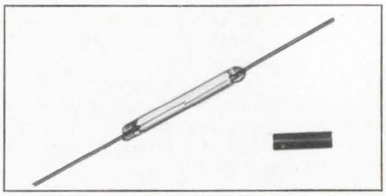
Bias your reed relay with Lodex® permanent magnets



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New full line of high-performance, regulated d-c power supplies

GE d-c power supplies are available in a wide selection of 50 Hz and 60 Hz models with output voltages ranging from 10 to 200 VDC. Each unit features static-magnetic circuitry for long-life reliability and holds d-c output voltage to within ±1% despite incoming line-voltage fluctuations over the rated range of 97 to 130 volts. Other advantages include:

- operation from —10 to 40C ambient.
- total ripple content: 1% rms or less.
- plus or minus grounded installation.
- overload protection to 200% of rated load.

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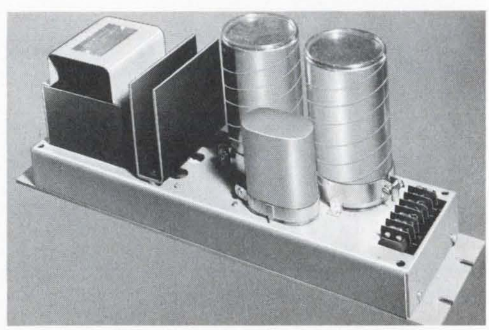
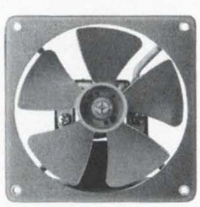


Typical power supply, model 9T66Y989

New cooling fan assemblies for electronic equipment cabinets



100 CFM assembly

New 100 CFM (and similar 90 CFM) fan assemblies are powered by reliable GE shaded-pole motors and measure slightly under 4¾-inches square. 500 CFM assemblies are powered by GE unit-bearing, 4-pole, shaded pole motors and measure less than 6¼ inches deep with a 10-inch diameter fan venturi. Both units require only simple ON-OFF switches for operation and are designed for years of quiet, dependable continuous-duty operation without maintenance.
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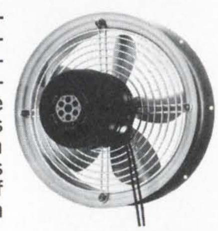

500 CFM assembly

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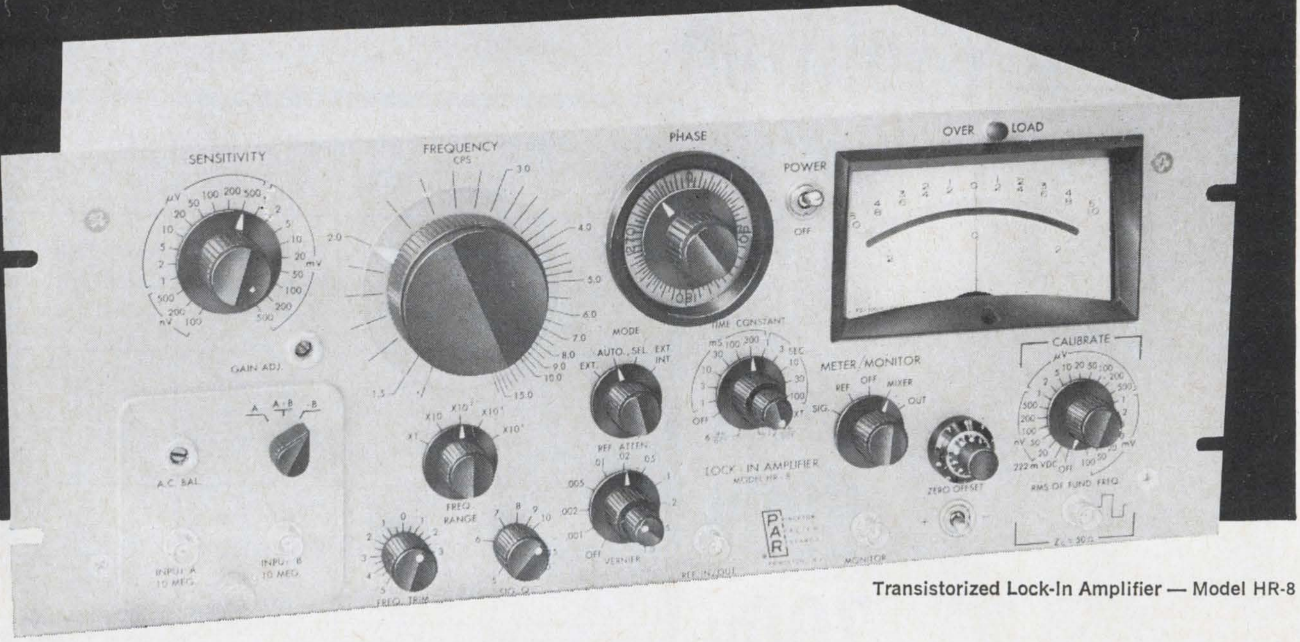
GENERAL ELECTRIC

New PAR Lock-In Amplifier Measures Signals in the Presence of Noise by Crosscorrelation



Transistorized Lock-In Amplifier — Model HR-8

The PAR Model HR-8 Lock-In Amplifier represents a significant advance in signal processing equipment for experimentalists who must measure low-level signal intensities in the presence of noise. It employs the theoretically optimum technique for signal recovery, and can be incorporated into a large class of experiments in which the signal of interest is, or can be made periodic, and in which a reference voltage related in frequency and phase to the signal can be obtained. The Model HR-8 first amplifies and bandlimits the input signal and then crosscorrelates it with the reference signal, suitably phase shifted and shaped. The crosscorrelation of input and reference signals yields a DC output voltage proportional to the signal of interest, while the crosscorrelation of the reference and noise results in no net DC voltage. The system can also be described as a continuously integrating, highly sensitive, phase conscious voltmeter, the response of which is "locked" to that particular frequency and phase at which the signal information has been made to appear.

Technical Features:

Frequency Range: 1.5 cps to 150 KC continuously tunable in 5 ranges.

Time Constants: 11 values in 1-3 sequence extending from 0.001 to 100 seconds. Single or double section RC filtering.

Pre-Amplifiers: Interchangeable low-noise pre-amplifiers, operable either within the HR-8 or remotely, are used.
Type A: Differential 10 megohm input.
Type B: Low impedance transformer input for low source impedances.

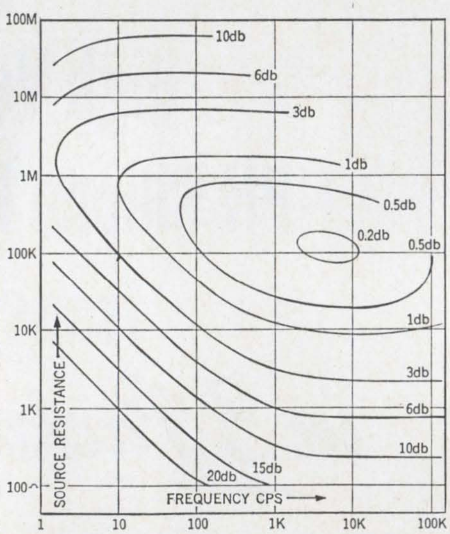
Sensitivity: 21 calibrated full scale ranges in 1-2-5 sequence.
With Type A Pre-Amplifier: 100 nanovolts to 500 millivolts rms.
With Type B Pre-Amplifier: 1 nanovolt to 5 millivolts rms.

Output: ±10 volts full scale, single-ended with respect to ground. Will drive galvanometric and servo recorders.

Frequency Selective Amplifiers: Notch network in negative feedback loop used in both signal and reference channel tuned amplifiers. Reference channel Q of 10. Signal channel Q adjustable from 5 to 25 with calibrated dial (no gain change with Q adjustment).

Phase Adjustment: Calibrated 360° phase shifter, providing continuous rotation as well as a four position quadrant switch which shifts phase in 90° increments.

Price: $2,250 with either Type A or Type B Pre-Amplifier.



Contours of constant noise figure for a typical PAR Type A preamplifier plotted to show dependence on frequency and source resistance at 300° K. Amplifier operated single-ended.

Write for bulletin No. 120 on the HR-8 or ask for information on PAR's complete line of Lock-In Amplifiers and accessories.

PRINCETON APPLIED RESEARCH CORP.
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tract called for power consumption of less than 10 watts. Librascope has demonstrated operation at ½-watt including peripheral electronics. Flight hardware is scheduled for delivery by August or September of 1968.

▪ A 4,096-word, 36-bit nondestructive readout memory module as the main internal memory for a variety of space computers. Dimensions will be 6x6x4 inches, including all electronics and an auxiliary power converter. The contract calls for six flight hardware units to be delivered by April 1968.

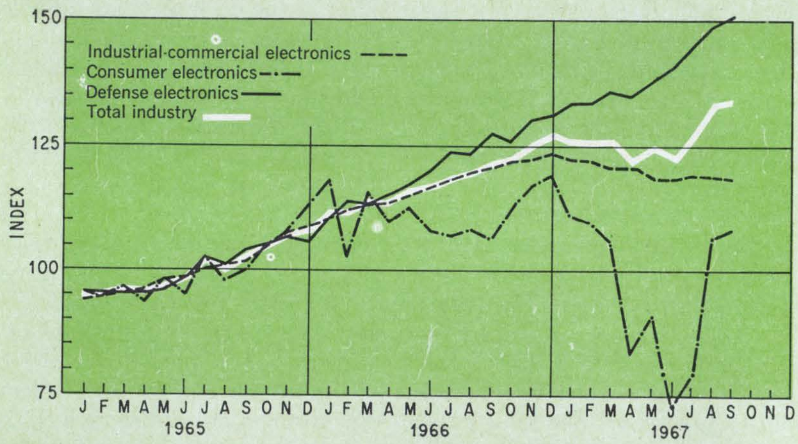
▪ A contract for 200-memory element arrays of 4,320 nine-bit words for a missile program. The memory will be loaded before launching and continuously read during flight as the program memory for a space-borne telemetry system. Power consumption requirement is less than 3 watts.

▪ A contract for a memory for an airborne computer. Basically it will be a permanently woven, read-only memory, although parts of it will have both read only and nondestructive readout on the same plane. Requirements include operation at one-microsecond rate, average total power dissipation of less than ½-watt, density of 2,500 bits per sq. in., and absolutely fixed and nonvolatile data storage. A prototype will have an 8,192-bit capacity.

▪ A contract for several hundred 60,000-bit memory stacks for an orbiting satellite that will have to operate on less than two watts for up to three years. Flight hardware is scheduled for qualification later this year. The system will be used as a sequencer or programmer for telemetry transmission.

Electronics Index of Activity

November 13, 1967



Segment of Industry	Sept. 1967	Aug. 1967*	Sept. 1966
Consumer electronics	**107.8**	106.7	105.9
Defense electronics	**150.7**	149.0	127.3
Industrial-commercial electronics	**118.6**	118.9	120.6
Total industry	**134.1**	133.0	121.6

Electronics production in September rose for the fifth consecutive month, climbing 1.1 points from August and 12.5 points from the September 1966 level. Consumer production, which had spurted 27.2 points in August, advanced only 1.1 points in September. However, that was enough to put this index at its highest level since February's 109.8. Defense electronics output also went up in September, but the 1.7 point gain was the smallest month-to-month increase since May. Industrial-commercial volume slipped 0.3 point from August and 2 points from the year-earlier pace to a level 4.8 points off its record high of 123.4 in December 1966.

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

Solid state

Hot dice

There are now two ways to slice a silicon wafer — the conventional way and the new Air Force way. The new way promises to boost yields to 100% from the present 60% to 90%.

Traditionally, integrated circuit manufacturers dice the wafer by scribing it with a diamond-tipped needle and then applying bending stresses. Although engineers have long been trying to perfect a thermal slicing technique, they've been unsuccessful. Spokesmen at Radio Corp. of America, Bell Laboratories, Texas Instruments, and International Business Machines Corp. agree that they're no closer to thermal slicing than they were a year and a half ago.

Now it turns out that an engineer at Tinker Air Force Base, Okla., has overcome thermal-slicing hazards—such as alteration of wafer geometry and silicon contamination—by conducting the process in an inert nitrogen atmosphere, using an 0.0005-inch-wide tungsten ribbon. The flat, homogeneous ribbon is stretched across the wafer in a lattice conforming to the desired slicing configuration and a-c current is applied to the wire. The wafer, hot on one side and cold on the other, then breaks along the wire lines. The Air Force engineer, Edwin B. Lyons, says that the thermal method is just as rapid as the diamond scribe.

Space electronics

New twist

Having gained a lead in the communications-satellite field with a simple design that stabilizes a craft by spinning it, the Hughes Aircraft Co. has come up with an approach that can result in the first spin-stabilized satellites with solar paddles, and in more accurately aimed antennas with sharply increased effective radiated power. So urn I launch vehicles, beyond those needed for the Apollo manned lunar landing effort. This, he said, would allow at least one attempt to conduct the two highest priority items in the applications program—the orbital workshop and the Apollo Telescope Mount.

Farsighted. But researchers at Douglas Aircraft Co. are looking beyond the Apollo Telescope Mount toward the period 1970-1980, and trying to come up with an evolutionary orbiting observatory plan to fit the spacecraft that will be available then. The space agency's Marshall Space Flight Center has provided $475,000 for Douglas, a component of McDonnell Douglas Corp., to analyze the needs of a manned orbital support facility for future astronomical research from space. The three-phase study began last December and is to be completed next February.

Although none of the three phases is complete, the effort is far enough along for its director at Douglas to comment on results to date. Harry L. Wolbers, program manager for space station subsystem analysis at the Douglas Space Systems division, Huntington Beach, Calif., says the study has three phases. Task A is to define the astronomers' research objectives; Task B is to recommend instrumentation to implement those objectives; Task C is to develop a flexible plan that accommodates the outputs of Tasks A and B in the space vehicles that will be available from 1970 to 1980.

Task A is no mean one. Wolbers says his team has conferred with as many astronomers as possible to determine the objectives of greatest scientific significance to be pursued from outside the atmosphere. So far, 92 observation requirements have been suggested.

The output from Task B will be the establishment and evaluation of instrument groups needed to carry out Task A's observation requirements. "We'll conduct a commonality analysis and come up with possibly 10 equipment groups that cover this range of requirements," says Wolbers. Kollsman Instrument Corp. is principle subcontractor to Douglas for this portion of the study.

Cross your H. Of the four antennas being considered for radio-frequency observations—terminated loop types, orthogonal terminated loops, a combination tethered orthogonal loop and terminated loop, and crossed H types—the crossed H is one that looks feasible, says Wolbers. A tethered pair of crossed H antennas, with directivity of 5.9 to 8 decibels and a frequency range from 0.5 megahertz to 10 Mhz, may be as far apart as six miles. An exotic version of the terminated loop shows promise for low-frequency studies down to 0.05 Mhz. The two loops could be as far apart as 25 miles at each end of the supporting structure, and electronically linked to give interferometric data.

Medical electronics

The good old ways

When a hospital administrator installs a computer to help him control soaring operation costs he often finds he's taken on two new financial headaches: the price of purchasing or leasing the equipment with its complex input terminals and the expense of teaching nurses to operate them. But by using old-fashioned punch-card readers instead of those terminals, Medelco Inc., a subsidiary of Scam Instrument Corp., thinks it has a way to avoid those headaches.

The system consists of punch card units for data transmission, a magnetic drum memory for data storage, and an electronic arithmetic unit for data manipulation. It functions as a message center that substitutes written for oral messages and, at the same time, maintains an inventory of material within the hospital, records patient charges, keeps a bed census, and can be used for employee time-card data.

Price is light. Capable of handling all the data requirements for a 432-bed hospital (up to 5,000 transactions a day), the Medelco system will lease for about $5,000, roughly one-third the monthly rental fee of a computer with comparable capacity. It will sell outright for about $200,000. Even hospitals with as few as 50 beds can find Medelco's system an attractively priced answer to many problems. And, although the first system has only recently been placed in operation, Medelco's approach already has advocates. According to Lou Philipps, Medelco's president, the company has a $1 million order backlog for the system.

Dubbed THIS, for total hospital information system, it combines the punch card system and magnetic drum memory to transmit instantaneously information to and from hospital departments. Each order, whether for drugs, hospital services, or special equipment, is acknowledged and stored in the memory to be reported to the accounting department.

Operation is simple. A punched card, made up for the patient when he is admitted, carries information such as name, date, address, doctor, and method of payment—specifying his insurance plan—in typewritten form and in punch-card code. In addition, each nurses' station has a rack of prepunched order information cards covering every service and medication. Similar cards are kept in such areas as X ray and the pharmacy, for all services performed there.

Push, print. When the nurse receives the patient information card and the physician's instructions, she selects the proper order cards from the rack and inserts them along with the patient card into the card reader. Instructions are printed out immediately in all concerned departments, including accounting, and the nurses' station for confirmation and for the patient's chart. If medication is ordered from the pharmacy, the teletypewriter there even prepares labels for the prescription items.

One of the attractive features of THIS, according to Gene Stanos, Medelco's chief engineer, is the fact that the system can be used by personnel who have no prior training. Another plus for the small hospital is that all components are interchangeable, minimizing service requirements.

Not only does the system offer

hospital administrators a means of acquiring budgetary control information, but it reduces clerical work and insures quick, accurate transmission of orders. And with the additional paper work demanded by government medical programs such as Medicare and Medicaid, that's vital.

Advanced technology

Hot spot storage

Optical memories for computers promise to deliver enormous capacity, high density, and dazzling speed. Their potential has attracted the attention of several companies, some of whose attempts to develop such memories have been in vain. One that has succeeded is Honeywell Inc.

Scientists at the company's research center in Hopkins, Minn., have worked out a way to store binary information in a manganese-bismuth film, using a laser capable of operating at two power levels—one for writing in and a lower one for reading out data. The technique works at room temperature and can repeatedly read and rewrite information in the same place indefinitely.

Room-temperature operation is an inherent advantage for the technique over the cryogenic requirements of a europium oxide memory under study at International Business Machines Corp. [Electronics, Sept. 18, p. 45], even though at those low temperatures EuO does work better. And Honeywell has thus far escaped the fate of Itek Corp., which tried to develop a read-only photographic memory but failed [Electronics, March 20, p. 47].

Film property. Both Honeywell and IBM have exploited the magneto-optic properties of their film. The film has a natural ferromagnetic axis that can be oriented perpendicularly, pointing either up or down. If the film is heated beyond its Curie temperature—+360° C for MnBi, and −176° C for EuO—its magnetization plunges. If it then cools in a magnetic field, its intrinsic magnetic vector aligns itself with this external field. And if a beam of linearly polarized light is directed on the film, its plane of polarization is rotated to the right or left depending on whether the magnetization of the film is up or down.

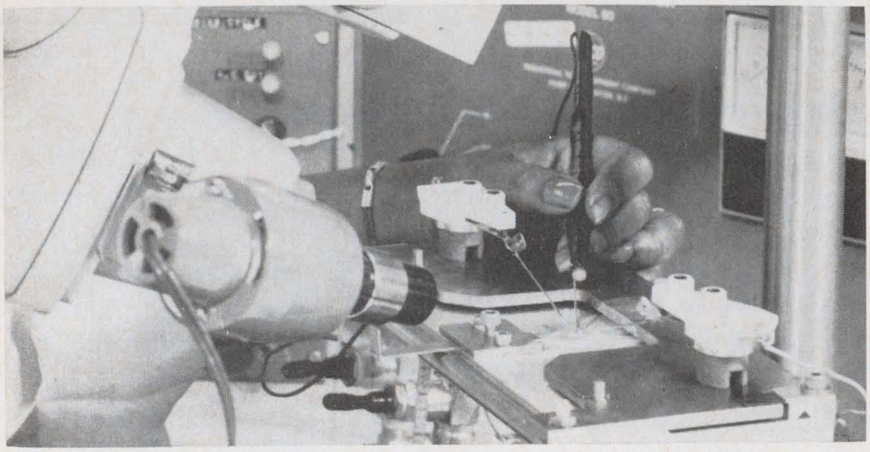
Both MnBi and EuO are capable of rotating the plane several degrees as it passes through a film only 1,000 angstroms (10^{-4} millimeter) thick.

A laser pulse focused on a small area of the film for a microsecond is enough to heat that spot above the Curie point. But a microsecond later, the film has cooled off almost to its initial temperature and is remagnetized. Binary data can thus be written by a laser beam having a few milliwatts continuous power focused down to many kilowatts per square inch. The same beam, throttled back by a modulator, does not heat the film appreciably, but its angle of polarization is rotated so that the recorded data is read out, theoretically at a speed of up to 100 million bits per second.

Stick to a spot. A film of EuO is much more transparent than one of MnBi of similar thickness, and is therefore more easily read—but at cryogenic temperatures. But MnBi's opacity—95% for a reddish light—improves its absorption of the energy in the laser beam. Thus, a small spot heats up quickly without spreading outside the beam area. "In this respect, manganese bismuth is unique," says M. Donald Blue, who heads the project. "We know of no other material that rotates polarized light so well and still has such a high absorption coefficient—and all at room temperature."

A practical limit now appears to be a spot 3 microns in diameter; theoretically, this could be reduced to 1 micron if problems caused by heat diffusion and lens aberrations can be overcome. Three-micron spots 10 microns apart lead to a packing density of 6.25 million bits per square inch.

These figures point to the eventual development of mass memory units with 30 times as much data per unit volume as conventional magnetic disk units, and also to relatively small—but extremely fast—memories in a small volume subsystem.



Tool. End-point sensor can be used for resistor trimming in General Instrument's hybrid IC's after they're packaged.

Integrated electronics

Neat trim

When users of hybrid integrated circuits want premium characteristics they have two alternatives. They can ask the manufacturer to trim component values (for a price) or cut into available space by adding external trimmer potentiometers and precision resistors (also for a price).

Now General Instrument Corp.'s Hybrid Microcircuit department is marketing hybrid IC's—such as regulators and amplifiers—that can be trimmed by the user after the package is sealed.

The company makes the free ends of appropriate cermet resistors available to the user by putting extra leads on the package. Application of high-voltage pulses across the resistors trims the component to desired levels. To prevent harm to other devices in the package that have lower breakdown points, key resistors on the substrate are formed with one end free. Thus the trimming signals aren't coupled to associated circuitry. After application of the pulses, the free end is connected to the remainder of the circuit simply by adding an external wire.

Manufacturing

IC overseer

Has integrated circuit manufacturing grown enough to justify the use of digital computers for controlling test, inspection, and process operations? It's a question some IC makers are starting to ask, and at least one is trying to answer.

In Florida, the ITT Semiconductor division of the International Telephone & Telegraph Corp. started a two-month study last week which could result in the largest commitment so far for computer-controlled IC manufacturing and testing. "If our concept proves feasible, ITT will spend about $10 million for extensive centralized computer IC test equipment in the next five years," says Irwin A. Horowitz, ITT Semiconductors' director of information systems.

Putting control computers into a plant is not a lightly-made decision, such manufacturing plants as refineries and steel mills have discovered. A control computer project takes about two to three years of study, engineering, programing, installation, and—not the least important—a large investment before it becomes fully operative.

Specialists. Now, like most IC makers, ITT uses dedicated test stations, each one doing fixed tasks and directed by a special-purpose computer. In the future, it hopes to direct all of its test stations from two large central computers.

When Horowitz took over his new assignment last June, he made a quick assessment of information needs of the West Palm Beach plant and noted three factors worthy of deeper study:

- The steep growth pattern of IC sales—and more complex IC's in the future—warrants large expenditures for test equipment.
- One-third of the cost of present IC testers goes for special purpose computer-directors, two-thirds for programed power supplies.
- Less than 50% of labor cost is for IC production, the rest for testing and inspection.

Until recently, ITT has been playing catch-up in the IC business, serving as second source for Fairchild-designed devices. This year ITT expects to sell more than 3 million IC's, including diode-transistor logic, transistor-transistor logic, complementary-transistor logic, and linear packages. Next year, volume should rise to 15 million units—including devices of ITT's own design—which will amount to about 7% of total estimated IC sales of $360 million.

Peas in a pod. What Horowitz hopes to do first is consolidate IC testing strategy into two central computers and interface them with numerous satellite test stations, all essentially alike. Flexibility for testing a variety of IC's will thus be accomplished by programing rather than by individual adjustment of electrical and environmental parameters for each type of IC at each station.

Horowitz' study team includes two ITT engineers with hands-on experience in IC testing, two corporate staffers knowledgeable in programing and communication, and two fulltime men and other specialists as needed from the Burroughs Corp. who will aid in specifying computer size and configuration.

Horowitz selected Burroughs after interviewing five computer makers—all of whom offered their men to the team free of charge. He emphasized Burroughs has no assurance it will get the computer order. If and when equipment is bought, vendors will bid to specs developed by the team.

During its study the team will specify computer, interface, and test station sizes and configurations; will consider such related factors as lease or purchase, programing, communications, service, and expandability; and will set up project schedules and manpower needs.

Voila. ITT hopes the system will produce data at each test point which can be fed back for on-line process control, diagnostics to test the test equipment, go/no-go signals, production and labor efficiency data which can also be used to simulate and forecast product throughput, and timely inventory information for its marketing department.

Although it's up to the study team to establish specifics, Horowitz estimates now the job will use, for reliability reasons, two somewhat redundant large computers—"like IBM 360 Model 40's or 50's"—and multi-interface gear under control of supervisory programs.

If the study says yes to computers, ITT will take a fresh look at test stations.

Consumer electronics

Music in IC major

Motorola's Semiconductor division has a major foothold in the lucrative electronic organ market as a result of having produced the first integrated circuits designed expressly for organs—a frequency divider and a dual-gate keyer [Electronics, July 24, p. 96]. But other major IC producers, with the incentive of $200 million worth of electronic organs to be sold this year, have entered the lists.

The first challenge to Motorola came from Philco-Ford [Electronics, Oct. 30, p. 26] in the form of a seven flip-flop, dual in-line frequency divider package priced at 30 cents a flip-flop, compared to Motorola's 50 cents.

Here comes GE. Now the General Electric Co. is sampling a metal-oxide semiconductor IC designed for organs, designated the PA448. It's a six-stage frequency divider available in two configurations: one with each stage cascaded in series, the other with inputs in a 1-2-3 cascaded combination.

Frequency division is accomplished by synchronous sequential logic in which all conditions that could lead to a false output have been eliminated. Divided outputs are fed to a push-pull amplifier that also acts as a buffer. The PA448 will be offered in a dual in-line plastic package. GE says it will be priced competitively with Motorola's MC 1124A per flip-flop but is noncommital about being able to compete with the Philco-Ford price.

Since most of the 125,000 electronic organs made each year use more than 100 flip-flops per organ, IC makers hope to find an outlet for 10 million divider circuits a year.

Short circuited

Earlier this year integrated circuit makers began a big push for the potentially huge tv set and entertainment equipment market [Electronics, June 12, p. 38]. There was plenty of talk about big orders around the corner. Today, six months later, not only are they still around the corner, but Texas Instruments is scrapping its hybrid monolithic series and Fairchild Semiconductor, with inventories of its μa717 sound i-f amplifier built up, has stopped producing it, at least temporarily.

TI developed and manufactured a line of multifunction hybrid IC's for i-f and audio stages in tv sets, radios, and phonographs. The products were sound, and the hybrid approach appeared better than the monolithic construction chosen by its rivals. TI chose hybrids for its pilot HC1000 IC line for good reasons:

- The circuits were offshoots of units being made for IBM's 360 computer.
- Development costs were lower than for monolithics.
- Manufacturing costs for the

low-volume evaluation period were less than for monolithics.

- Diverse semiconductor elements, required to minimize customer redesign efforts but not amenable to monolithic fabrication, could be combined in hybrids.

Failure. The thick-film IC's were priced in the same range as competitive monolithics also aimed at displacing tubes and transistors in tv sockets. Despite this, the products didn't catch on. A TI marketing official admits "the IC's have not satisfactorily met the economic requirements of the consumer electronics industry." The company has dropped the entire hybrid line and is revising its approach to the consumer market.

Realizing it has fallen behind its competitors, TI hopes to get back in contention by developing integrated electronic components providing even more functions in the IC package, such as an entire i-f strip. The integrated electronic components being worked on make greater use of monolithic content and also contain thin- and thick-film circuitry.

Meanwhile, none of the six or more major set makers who sampled Fairchild's μa717 sound i-f amplifier, supplied on a breadboard mockup last spring, has given Fairchild any indication that it will design the 717 into a tv set.

The 717 has also been sampled by the high-fidelity components industry but so far there are no takers. As one leading audio engineer points out, the 717 "does not provide adequate limiting for use as an i-f amplifier in our f-m receivers." Fairchild will only say that it will announce an equivalent IC that is "more flexible" sometime this month.

Avionics

All ahead slow

Competing fiercely for an R&D award that would give the winning firm a running start on another large receiver market to come out of the Navy's Omega program, design teams are rushing to wrap up their bid packages before the Nov. 16 deadline.

The award calls for two computer-equipped engineering models of airborne receivers to be used in the very-low-frequency navigation system. Delivery date will be one year after the contract is signed. The second phase of the contract calls for two prototype receivers for flight tests. The timing depends on when the Navy can get the money to pay for them.

Budget squeeze. Getting enough money for the entire Omega program has been a problem. But Navy officials believe the $2 million presently budgeted for research and development of the airborne receiver will be released despite the spending squeeze caused by the Vietnam war. They concede, however, that both building the airborne prototypes and expanding Omega's ground-transmitter network into a worldwide system will probably have to wait until spending for the war eases [Electronics, Oct. 16, p. 69].

Although no one knows how many sets the Navy and other military services will buy, one company believes total sales will top 5,000 over the next five years.

Estimates of the airborne-receiver price range from $25,000 to $40,000 once production lines are operating, a far cry from the shipboard receiver's hoped-for price of $2,500. The primary difference between the two sets is that the airborne version will be tied to a computer for automatic operation. The Navy hopes Omega will be used in small planes, so is specifying a top weight of 75 lbs., including 30 to 40 lbs. for the computer.

The computer will convert the Omega coordinates it gets from the receiver to latitude and longitude data—something that can be done manually on ships but not by busy pilots. The Navy also wants a receiver that can be plugged into an aircraft's central computer or work alone with minor changes.

Cost secondary. The proposals due this week will be evaluated by the Navy on the basis of technology, not cost. Although the winner will have to compete for production-model awards, it most likely will be selected if past procurement practices prevail.

The Northrop Corp.'s Nortronics division, which is developing the shipboard receiver, the AN/SRN-12, under a contract awarded last summer [Electronics, July 10, p. 48], is believed to have an edge on the airborne unit award. Another company making a strong bid for the work is Pickard & Burns Electronics, a division of the Gorham Corp., teamed with the Kearfott division of General Precision Inc. Other top contenders are ITT, Ryan, and Litton.

Industrial electronics

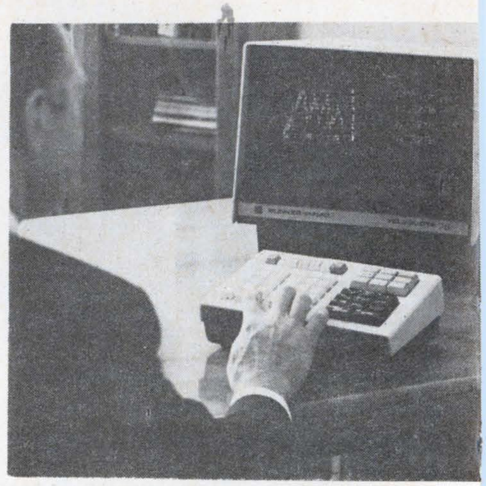
Stock taker

Getting quotes on stock prices to brokers quickly with electronic devices has been a significant factor in the booming sales of stocks around the country. Now the next logical step, which might help spur sales still more, is being taken.

With a desk-top display developed by Bunker-Ramo Corp., Stamford, Conn., a broker not only can ask for the latest stock prices but he can key in a buy or sell order as well. The order will then be automatically switched through the broker's teletype communications system to the floor of the exchange where it is to be executed.

Windows. The display, part of Bunker-Ramo's new Telequote 70 market information system, consists of two six-inch cathode ray tubes placed side by side. On the screens a broker will be able to look at several market services such as the stock tickers from the New York and American Stock Exchanges, Bunker-Ramo's own stock market quote and trend services, and wire service reports of financial news.

In addition, the display can select information from the brokerage house's own computer-based information system, including research reports and records of a customer's portfolio. Graphs of the behavior of the entire market or a single stock can be displayed as well as alphanumeric characters.



Market. Bunker-Ramo stock data system.

Communications

Out of one, many

The search continues for effective ways of getting many frequencies from a single coherent light source. Researchers at Bell Telephone Laboratories think they're on the right road. Their reason: an electro-optic crystal has been used to shift the frequencies of a continuous helium-neon laser over a range of ±45 gigahertz. Previously, electro-optic techniques have only been able to shift laser frequencies 2 kilohertz.

Unlike parametric techniques, which can shift frequencies over a wider range, electro-optic techniques don't require elaborate instrumentation for precise tuning. And parametric techniques can't tune continuous-wave lasers.

Versatile. M. A. Dugay, who refined the electro-optic tuning technique with J. W. Hansen, points out that it can be used in laser communication systems and in multiple resonance studies of the atomic and molecular structure of materials.

In the Bell technique, a mode-locked helium-neon laser emits a wide band of frequencies continuously, locking the phases of these frequencies 10 million times a second. During this time, the frequencies add constructively and destructively, forming narrow light pulses.

dropped when both Houses agreed on a space agency appropriation of $4.6 billion—$502 million less than the requested $5.1 billion. Besides postponing Voyager and some other embryo programs, the reduction in the space appropriation to a level $370 million below last year's funding has already had the following effects:

- Plans are being completed for a layoff of 1,454 NASA employees. Hardest hit of the agency's facilities will be the Marshall Space Flight Center in Huntsville, Ala., where 700 will be scratched from the payroll. And reports from recent industrial aerospace meetings indicate the absence of those once ubiquitous recruiting teams.
- NASA officials are now engaged in a series of meetings to review the direction of the space effort and revise spending plans. A spokesman at NASA headquarters says the administrators will be considering new operating plans for every program except Apollo.
- This is traditionally the time of year when work starts on the next budget. Says an official: "We're in a difficult spot; we should be working on the fiscal 1969 budget right now but won't be able to get to it until we can settle on the effect the 1968 appropriation will have."

For the record

Crystal ball. While American manufacturers as a whole anticipate an 8% increase in 1968 sales over this year, electronics manufacturers look to a 6% rise, a McGraw-Hill survey finds. The fall survey of preliminary plans for capital spending reveals that electronics firms plan to hike their capital spending for new plants and equipment 4% in 1968, against a 5% increase by all of American business. The electronics industry anticipates a 4% increase in the prices it will have to pay for new plants and equipment next year—one point less than industry as a whole. But spending for new plants and equipment would be cut back the same 0.4% in the event of a tax

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Reliability
Space saving
Versatility
and ECONOMY

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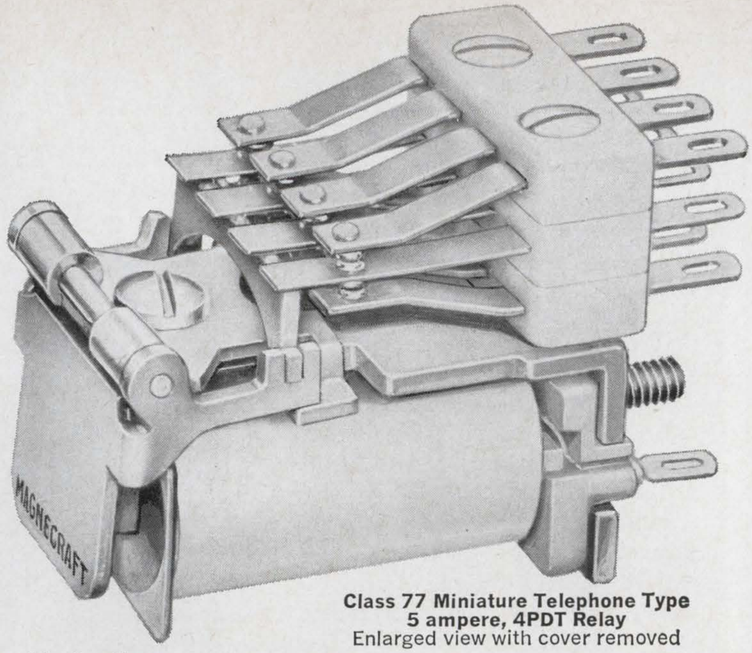
for immediate delivery



Class 77 Miniature Telephone Type 5 ampere, 4PDT Relay
Enlarged view with cover removed

Designed and Manufactured in USA

Direct, Plug-in Terminals give you plug-in relay assembly for the mere extra cost of the socket.

Plug-in Terminals are Pierced and Tinned for solder connections where required.

Telephone Type Relay Design assures unsurpassed adjustment stability through long life.

One-piece Combination Contact Arms and Plug-in Terminals avoid internal wiring.

Oversize Insulating Blocks of Molded Resin rigidly secure the combination contact arm/terminals for mechanical and electrical stability through long life.

The Basic Design provides greatly increased contact pressure without added coil power.

Precision-built, Hinge-pin Armature Bearings assure lowest friction for maximum contact pressure and stabilized adjustment through long life.

The Crackproof See-through Plastic Snap-on Cover protects the relay from dust and stray electrical contacts.

The Application Versatility of Class 77 Relays is illustrated in Figures 1 through 6.

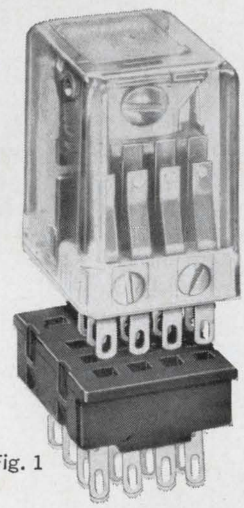


Fig. 1

Standard Class 77 Relay and Socket
(approx. actual size.)
Socket is Optional
The socket can be wired as quickly as the relay; plug-in assembly adds only cost of the socket.

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Standard Class 77, 5 amp. 4PDT with coils for commonly used AC and DC voltages.

Fig. 2
Standard Class 77 Relay in **Socket with solder terminals** (same combination as shown in Fig. 1)

Fig. 3
Standard Class 77 Relay **in Socket with printed circuit terminals.**

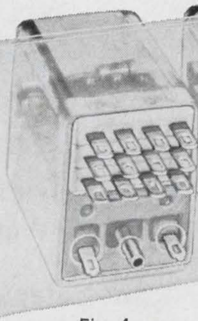

Fig. 4
Standard Class 77 Relay mounted in a panel **for solder connected wiring.**

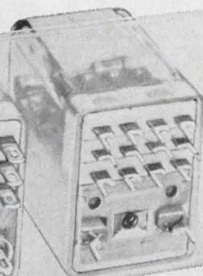

Fig. 5
Special Class 77 Relay **with printed circuit terminals**

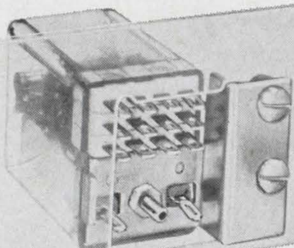

Fig. 6
Standard Class 77 Relay **with special mounting bracket**

Try our new Class 77 Relay. See how it can help complete tough circuits in close space as well as meet tight budgets. Phone the MAGNECRAFT REPRESENTATIVE or contact us direct for literature and samples.

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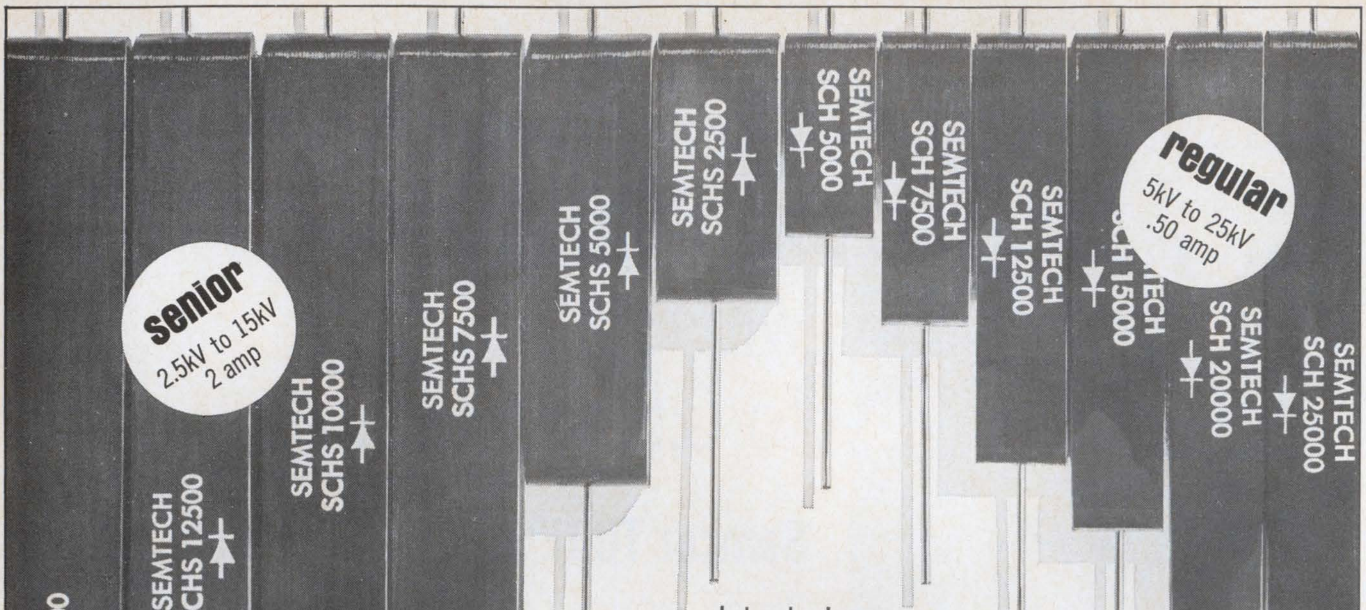

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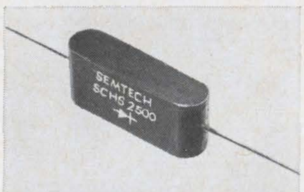
Semtech Corporation is proud to introduce a new "family" of high voltage high current low cost silicon rectifiers . . . "Slimpac." "Slimpac" consists of high density axial lead silicon assemblies, molded into rugged compact rectangular configurations. Internally, the device utilizes the Semtech high performance solid double heat sink junctions welded together for mechanical strength. Now being produced in quantities for off-the-shelf delivery the series is available in three basic current ratings:

"Slimpac" Senior — PIV: 2,500 to 15,000V (Low leakage 10 UA @ PIV, 25°C)
* Average Rectified Current: 2 amps @ 55°C / free air, 1.2 amps @ 100°C / free air
Case Sizes: .687" H, .379" W, 1.5" to 6.5" L

"Slimpac" Regular — PIV: 5.000 to 25,000V (Low leakage 0.1 UA @ PIV, 25°C)
* Average Rectified Current: .5 amps @ 55°C / free air, .33 amps @ 100°C — free air
Case Sizes: .50" H, .25" W, 1.125" to 4.25" L.
Also available: "Slimpac" Fast Recovery (T_{rr} 150 ns max.)

"Slimpac" Junior — PIV: 15,000 to 45,000V (Low leakage 0.1 UA @ PIV, 25°C)
* Average Rectified Current: .050 amp at 55°C / free air, .030 amp @ 100°C / free air
Case Sizes: .25" H, .25" W, 1.5" to 3.5" L.



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The entire "Slimpac Family" has corona free construction and meets the most stringent life and environmental requirements. For use on commercial, industrial and military applications.

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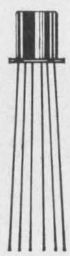

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We have left nothing to chance . . . constant improvement is our hallmark. The relays we produce today are not the same relays we produced one year ago. Our job is not to stand still but to continue to deliver to our customer the most reliable TO-5 relay that today's technology (paced by Teledyne Relays) will permit.

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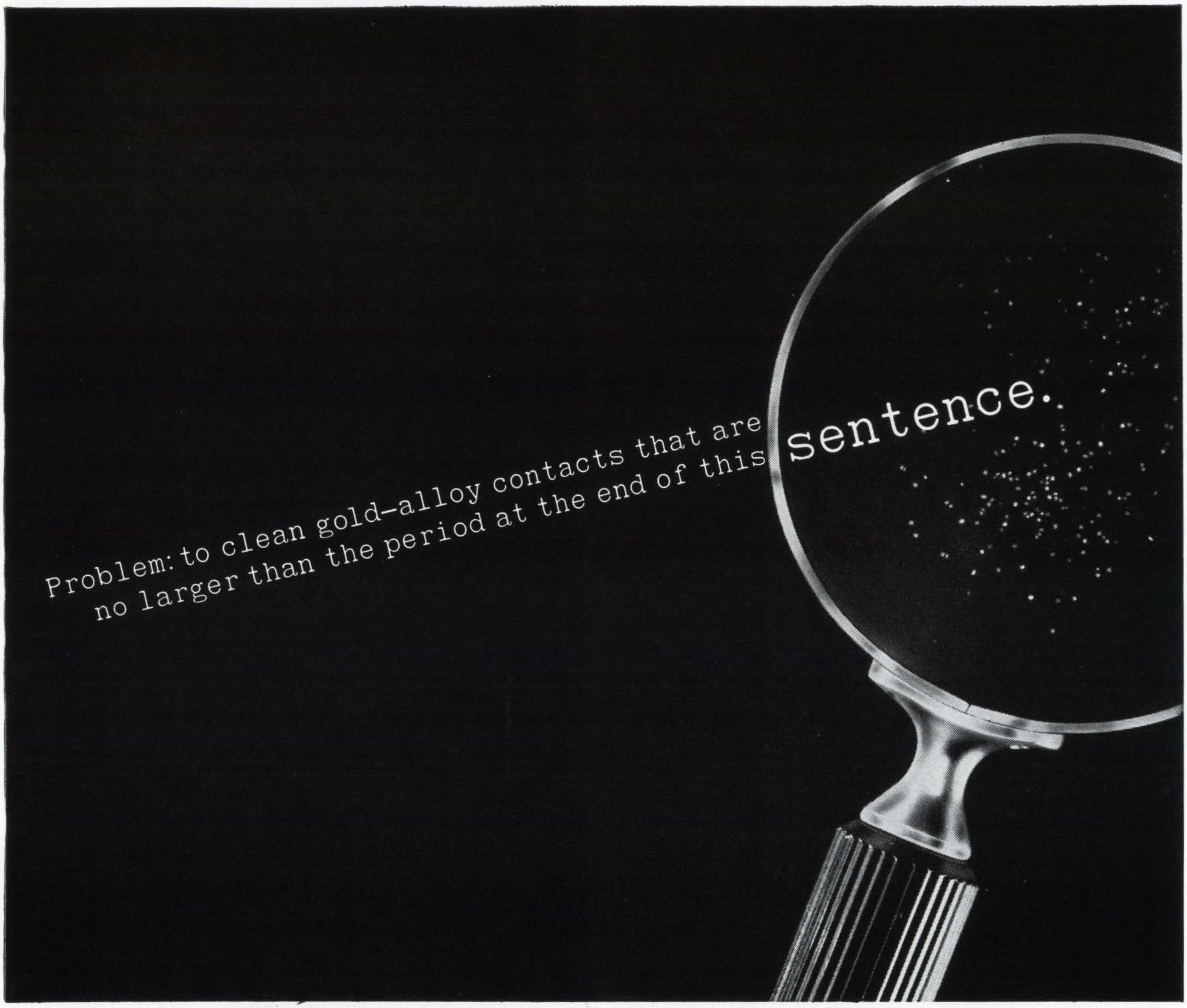
By solving an "unsolvable" cleaning problem, Freon® helped perfect Hamilton's electric watch.



Those specks under the magnifying glass are gold alloys. Each one acts as a contact that transmits power from a tiny battery to the timekeeping mechanism of the Hamilton electric watch ...which now ranks with the best of critical timepieces.

Unless these contacts, located in extremely tight assemblies, are *completely free* of soils and stains, however, the watch will malfunction. Or not function at all. And this was precisely the problem that confronted Hamilton engineers during the watch's development in Lancaster, Pa. They simply could not get the contacts clean *enough*. Even the cleaning agents they used left trouble-making stains.

The problem wasn't solved until FREON*, with its unique properties, was introduced into the cleaning operation. FREON has *low* surface tension, which allows it to penetrate the tightest assembly. At the same time, FREON has *high* density. This permits the quick release of all stains left by trapped cleaners. And because it vaporizes at a little above room temperature, FREON dries rapidly, leaving no stains of its own.

Hamilton uses FREON to clean parts ranging from $\frac{1}{16}$ of an inch (the contacts) up to $\frac{1}{4}$ of an inch... including $\frac{1}{8}$-inch, intricately designed toothed wheels. As many as 3,000 parts are cleaned in an ultrasonic tank simultaneously. So successful was Hamilton's experience with FREON that the company now uses it in its military area. For instance, FREON is used in a degreaser to remove soils from a gravity-triggered release installed in parachute flares.

Do *you* have a tough cleaning problem that FREON can solve? Write Du Pont, Room 5623, Wilmington, Del. 19898. (In Europe, write Du Pont de Nemours International S.A., FREON Products Div., 81 route de l'Aire, CH 1211 Geneva 24, Switzerland.)

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BETTER THINGS FOR BETTER LIVING ...*THROUGH CHEMISTRY* and cost-effectiveness keystones of his policy in budgetary and contracting matters.

It's understood that McNamara would like to resign soon after the new defense budget is completed and submitted to Congress next January. But President Johnson is expected to persuade him to stay on until the critically important November, 1968 election. **A Washington newspaper quoted McNamara directly as saying he does plan to quit "some time" next year.**

Cabinet status for communications?

The White House is putting out feelers on the idea of a Department of Communications. It would include the Department of Transportation, the Federal Communications Commission, and key communications groups within the Department of Defense, the Office of Emergency Planning and the General Services Administration.

Insiders say Transportation Secretary Alan S. Boyd, raised to cabinet level status only this year, wants to expand his domain and cover broader areas, **making his department similar to communications ministries in other nations.**

ARM guidance unit set for production

Mounting aircraft losses due to North Vietnamese antiaircraft fire—both conventional and missile—have moved the Pentagon to put the air-to-ground Standard ARM, a radar-homing missile, on the top-priority list. **A go-ahead has been given IBM for a production run of the target identification and acquisition system (Tias), the ARM's guidance unit.**

The order comes less than a year after General Dynamics received the ARM prime contract and only a month after the completion of flight tests [Electronics, Sept. 4, p. 54]. The ARM will replace the Shrike as the prime Air Force and Navy air-to-ground missile. The Tias, to be carried aboard the aircraft, is built around the IBM 4 pi computer.

Martin unit to build Rada test hardware

Martin-Orlando will get an okay from the Army within the next month to start producing the first test hardware for the Random Access Discrete Address (Rada) system, an automatic dial radio network for tactical communications. Under a new contract covering third-phase development of the secure gear, Martin will build three user-to-user Rada sets for local area calls, plus a retransmission unit for calls within the system but beyond the range of the basic unit.

December date set for total package bids on destroyer

Request for proposals will go out to industry early in December for **the first combat ship to be designed by industry rather than the Navy.** The new class of highly automated destroyers, known as DX for destroyer experimental, will be procured as a total package, an approach that combines design, development, production and maintenance of a ship in one contract. Primary function of the DX will be as an antisubmarine craft, but antiaircraft missiles may be added later. A large number of ships will be built, enough to warrant setting up an automated shipyard for series production.

The Navy doesn't plan to develop any new weapons or electronics systems for the DX, but will incorporate systems under development that will be ready for the fleet by 1974. The contractor will select and integrate all systems and will be named by May, 1969.

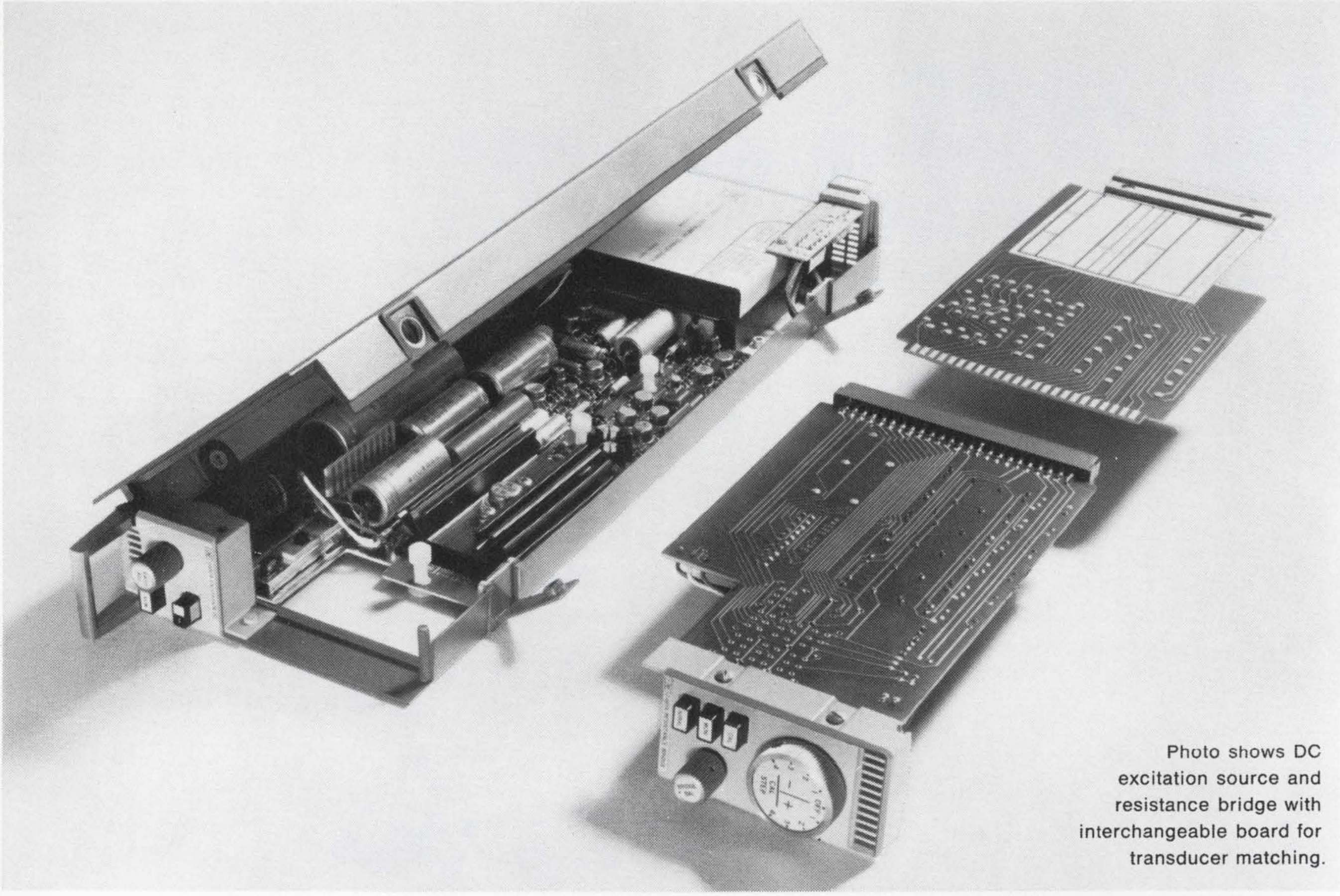
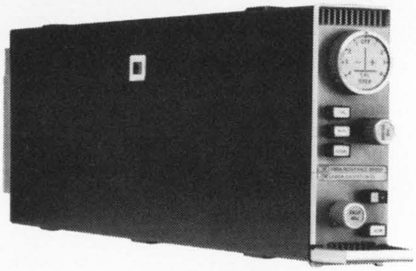


Photo shows DC excitation source and resistance bridge with interchangeable board for transducer matching.

Plug-together Signal Conditioners



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A floated, guarded DC excitation source provides switch-selectable constant-voltage and constant-current operating modes, plus a unique mode for linear output from single active arm bridges. Exceptional environmental stability saves man-hours maintaining large systems in calibration.

Resistance bridge module provides bridge completion, balancing, calibration and normalizing functions. Minimum cost adaptation to transducers is afforded through a detachable board for mounting components for a specific transducer.

The excitation source may be used on a per-channel basis for maximum isolation, or with up to five transducers using inexpensive excitation couplers for each channel . . . or many transducers can be excited from an external power supply, and you can have local regulated level control. Plug-together design allows change from shared to individual channel excitation.

Price for excitation and conditioning: from $160 to $360 per channel (for rack-mounted, cabled system) depending on configuration.

For information on the 2480 Series or compatible data acquisition instrumentation call your local HP field engineer or write Hewlett-Packard, Palo Alto, California 94306; Europe: 54 Route des Acacias, Geneva.

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SIGNAL CONDITIONERS

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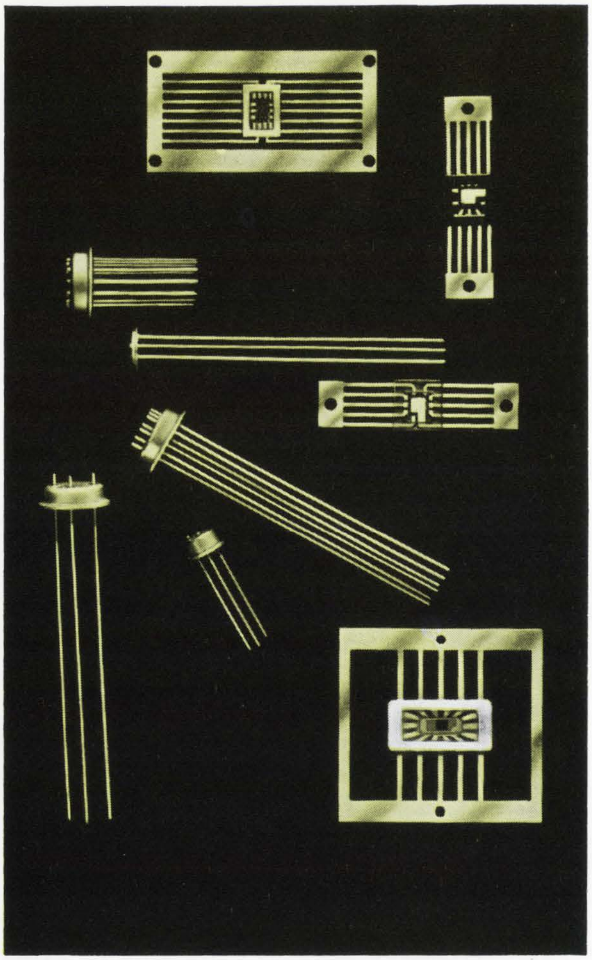

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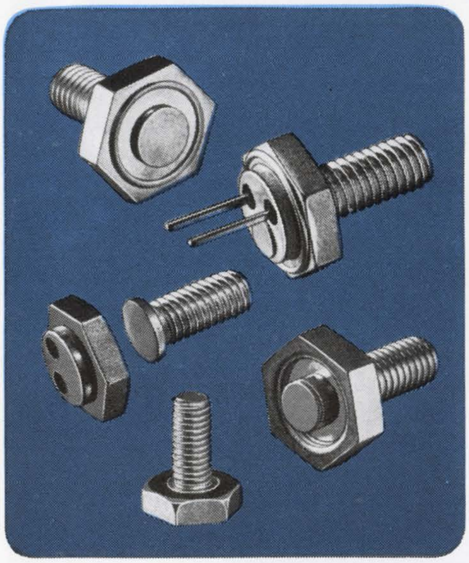

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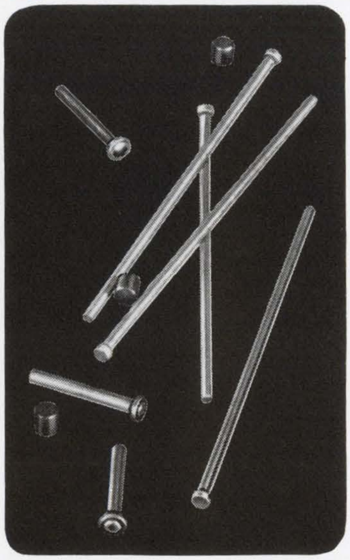

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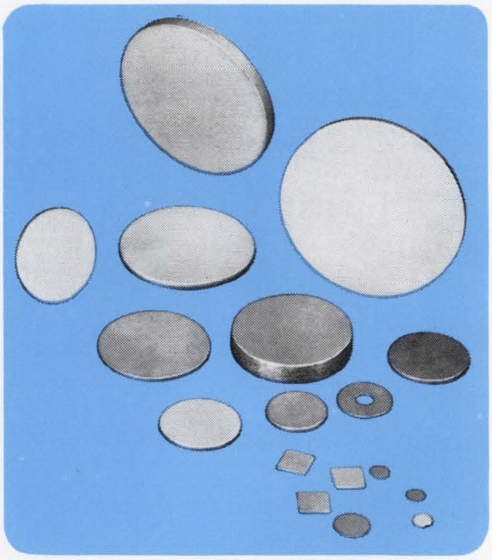

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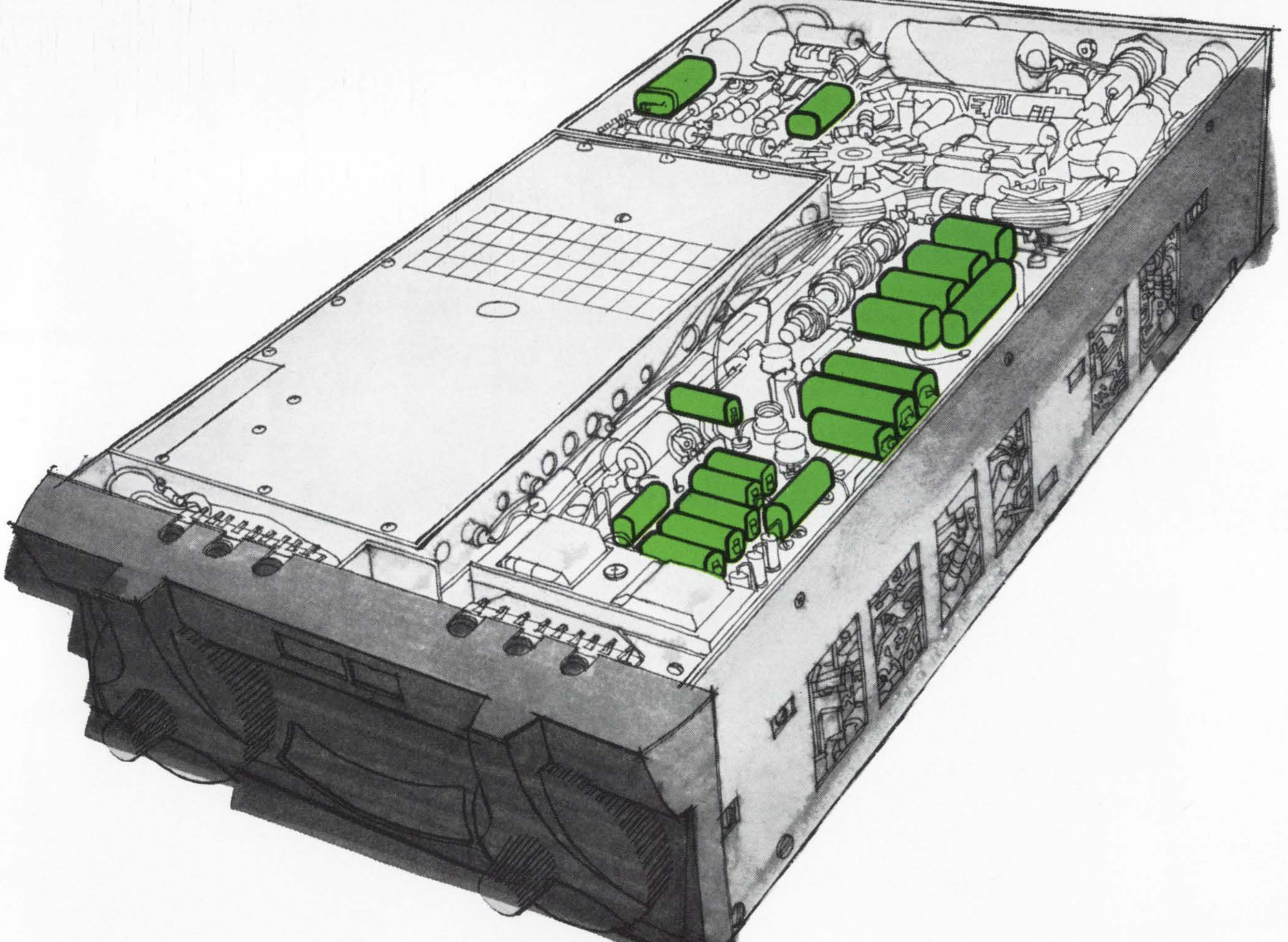
King Radio needed: capacitors that stay reliable even with extreme cold, humidity and vibration.

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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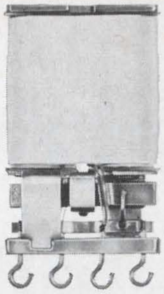
WANT A  **SENSITIVE ANSWER?**

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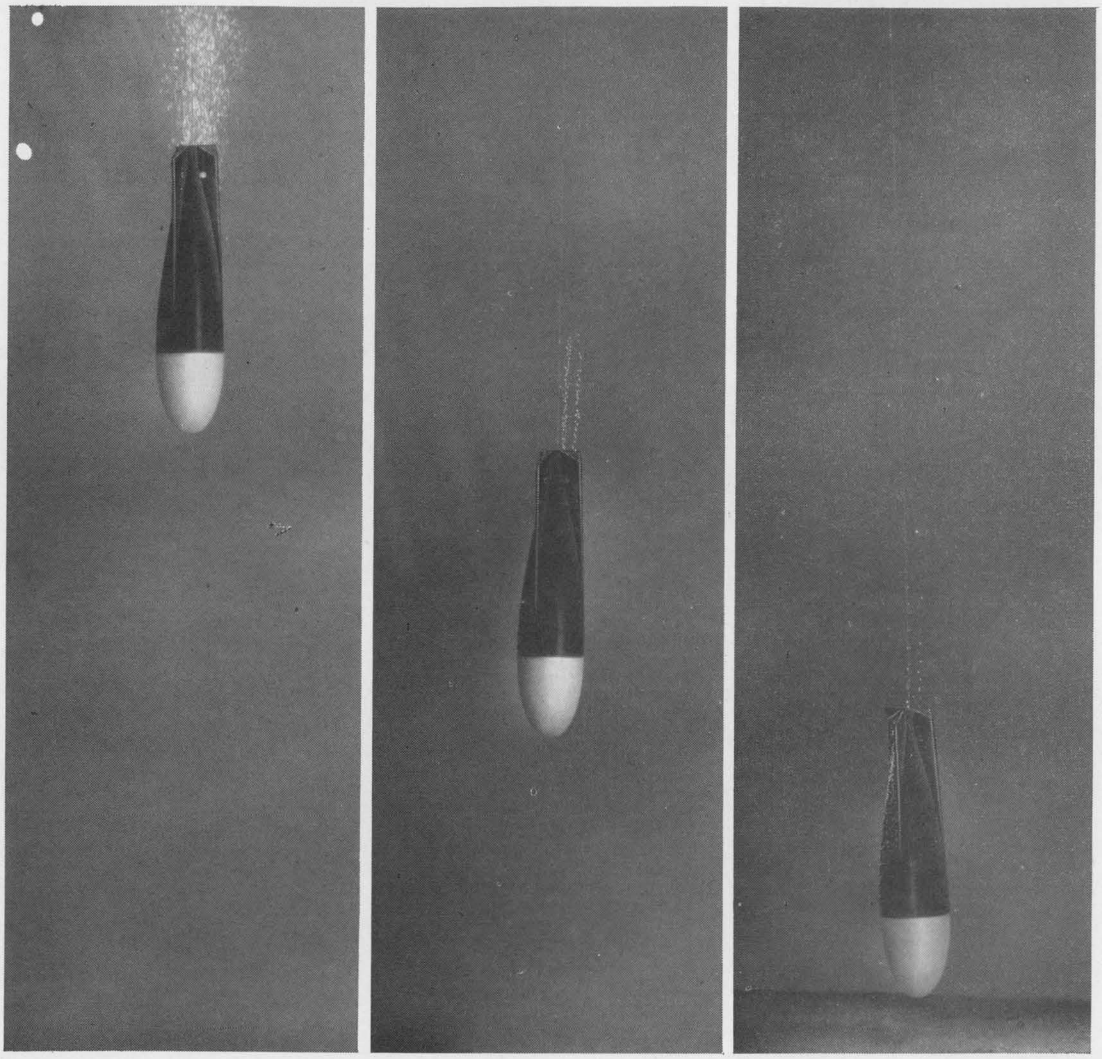

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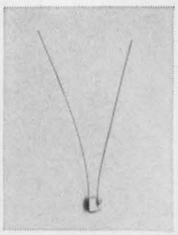

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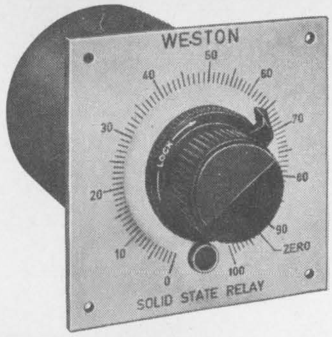
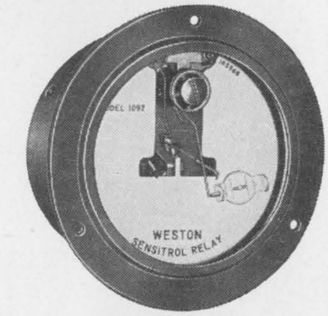
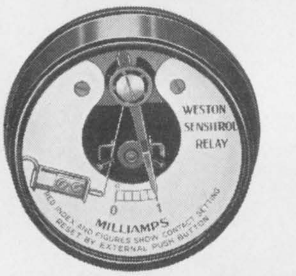


Model 1062 Control Relay—*no moving parts, not even relay contacts; voltage ranges from 0-1 volt, current ranges from 0-100 μa; 200-millisecond response time with 0.5% repeatability typical; zero adjust and trip indicator on 320° scale.*

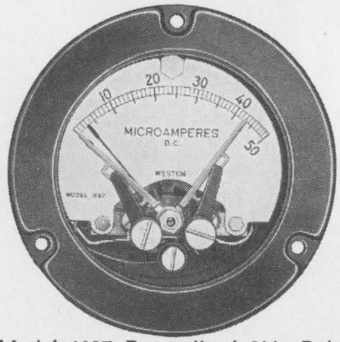


Model 1092 Sensitrol® Relay—*low cost; all purpose; magnetically shielded; wide range adjustability; ideal for use in engineering breadboard circuits.*

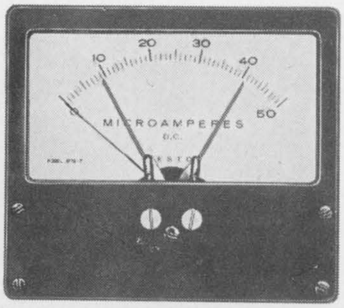


Model 705 Sensitrol® Relay—*highly sensitive; surface or flush mounted; single or double, fixed or adjustable contact; ranges as low as 0.5-0-0.5 μa.*

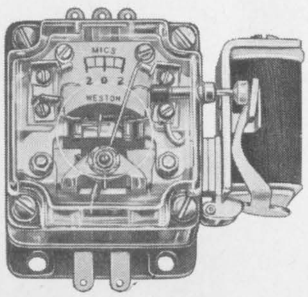
Model 723 Sensitrol® Relay—*sealed; shielded; internal reset; solder terminals; single or double magnetic contact; ranges as low as 1-0-1 μa.*



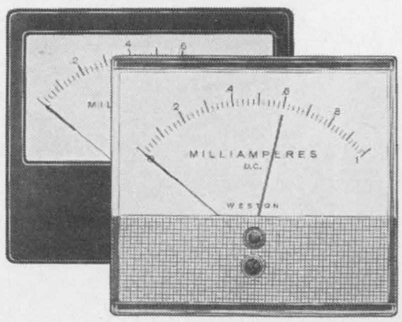
Model 1097 Ruggedized 3½" Relay—*Load Current Contact Aiding type fully meets applicable portions of military ruggedized spec; sealed; long scale; shielded; solder terminals; single or double adjustable contacts.*



Model 1075 Photronic* Relay—*operates without physical contact; single or double adjustable set points; continuous reading beyond set point; taut band frictionless mechanism; solid state switching circuit; ranges from 10 μa.*



Model 813 Miniature Relay—*compact and lightweight; sensitive and Sensitrol (magnetic) contacts; single or double contact; ranges as low as 2-0-2 μa.*



Model 1930/1940 Photronic* Relay—*3½" and 4½" in either bakelite or plastic front; low cost; add-on power supply and solid state switching circuit; shielded; non-physical, adjustable contact.*

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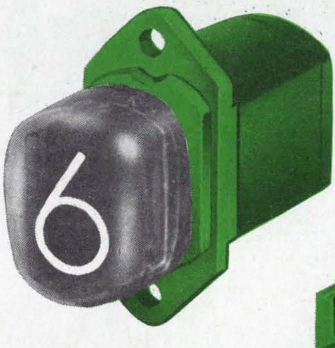

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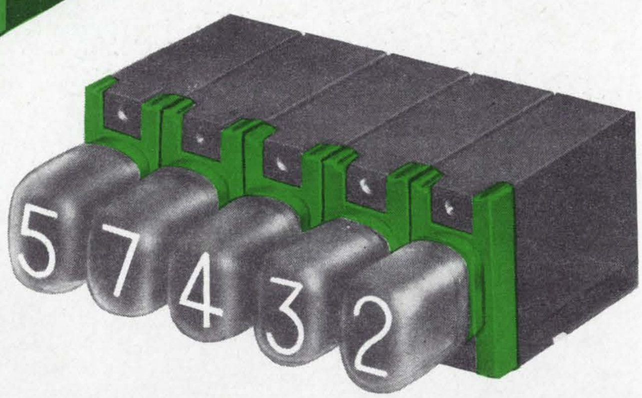

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*Note new shorter overall length.

For additional information contact, Burroughs Corporation P.O. Box 1226, Department D2, Plainfield, N.J.

Burroughs Corporation

Delay line speeds r-f testing

It electrically lengthens one path of a heterodyning test set to produce a difference frequency; the system is basically simple and reduces the time needed to measure transmission characteristics

By Frederick F. Rogers
Western Electric Co., North Andover, Mass.

Measuring transmission characteristics of radio-frequency devices, traditionally a time-consuming task, can be speeded with a broadband, high-loss measurement test set developed by the Western Electric Co.

The unit has the range, accuracy, and sensitivity of a single-frequency heterodyne system, but without that system's complexity. And, unlike conventional swept systems, it doesn't need two signal sources. A delay line creates the difference frequency necessary for heterodyning, and thereby eliminates the need for the complex synchronizing circuits and mechanisms normally employed to keep the difference frequency constant.

Called the Incremental Heterodyne Frequency (IHF) test system, the set is capable of measuring insertion losses, return losses, and voltage standing wave ratio.

Against the tide

As a general rule, increases in the range and accuracy of r-f devices have demanded increases in the complexity of the systems used to test them. The application here of delay-line techniques, long used for making phase measurements, bucks this trend. The resulting instrument is simple and cuts the time needed to test an r-f device with wide dynamic and broad frequency ranges. In one trial, a developmental model of the IHF system operated over bandwidths of 0.5 and 1 gigahertz at test frequencies of 6 and 11 Ghz; the system's dynamic range was 35 decibels.

The set's test signal is derived from a single, swept-frequency source. The signal is split into two paths, one (A) connected to a mixer by a delay line, the other (B) coupled directly to the mixer. The path with the delay line is therefore electrically longer, as in diagram at top of page 95.

An attenuator is used to drop the signal in test path B at least 20 db below the level in the other path. In a heterodyning system, it should be noted, the amplitude of the mixer output is directly proportional to the magnitude of the weaker signal. In this case, test results are carried via path B.

A second attenuator in the same path establishes a reference level on a readout device—usually an oscilloscope. Once the reference level is set, the r-f device to be tested is substituted for the attenuators. The mixer's output, a pulse-modulated signal, contains the test results.

At any instant in time, the swept signal can be regarded as a single frequency. Since the source is a linearly swept frequency generator, it produces, in effect, a series of instantaneous frequencies.

Delays make a difference

If a single set of instantaneous frequencies in the two paths is represented by f_1 and f_2, respectively, and the mixer output frequency by f_3, the values of f_1 and f_2 arriving at the mixer at any time are a function of the sweep rate, r (the rate of change of frequency in hertz/second). If d_1 and d_2 represent the delays in paths A and B, respectively, and $d_1 > d_2$ and $f_1 < f_2$ when r is positive, then $f_2 = r(d_1 - d_2) + f_1$

The desired mixer output (f_3) is the difference frequency $f_2 - f_1$. If the delay and sweep rate are

The author

Frederick Rogers is an engineering associate at the Merrimac Valley Works of the Western Electric Co. He joined the company, the manufacturing arm of the Bell System, in 1957, and has since worked on microwave communications systems.

The competition

There are a variety of conventional circuits that can be used to measure the insertion loss, return loss, and vswr of r-f devices. The simplest, the single-frequency, single-detection measuring circuit, A at right, uses a point-by-point technique in which the frequency of the signal source is manually switched each time a measurement at a new frequency is required. Insertion and return losses are measured with a square-law detector. The configuration A measures insertion losses; the second circuit, B, measures voltage standing wave ratios and return losses.

The simpler circuit has a signal source, a variable r-f attenuator, an r-f detector, and readout device. In the other circuit, a slotted line, a precision termination, and a shorting plate are added.

Combo. Another popular configuration, the modulated single-frequency, single-detection measuring circuit, C at right, also employs point-by-point, square-law-detection techniques. As it combines both of the previous circuits—plus a modulator and a demodulator—it can measure all three characteristics.

The single-frequency heterodyne measuring circuit, diagram D, is useful for extended range measurements. But two signal sources are needed, and they have to be adjusted for every frequency change. The circuit has three sections, of which one—the beat frequency oscillator section—resembles the first circuit discussed here minus the detector and presentation device. The second section—the test signal oscillator—resembles a combination of the first and second circuits, and the third consists of a mixer, an intermediate-frequency preamplifier, an i-f attenuator, an i-f amplifier, a detector, and a presentation device.

The signal strength levels at the mixer of this system must be maintained throughout all measurements, and the difference frequency between the TSO and BFO sections must be kept constant.

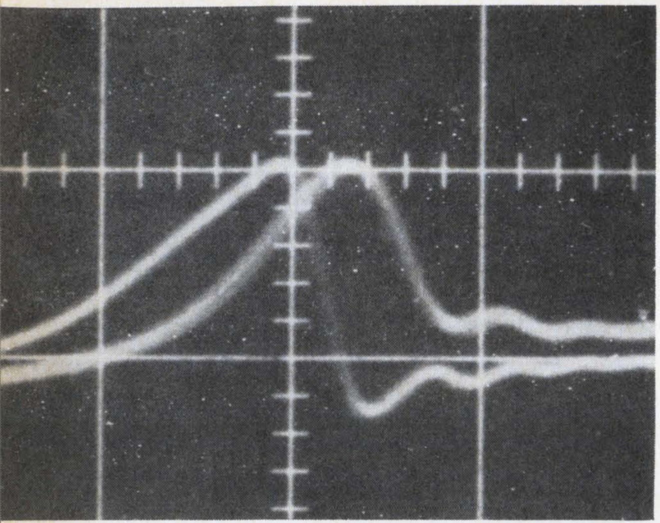
The difference frequency between the TSO and BFO is called the i-f and is usually much lower than either of the oscillator frequencies. Amplification of the i-f increases sensitivity and extends the measurement range.

Modifications. In all of these approaches, the need to switch frequencies wastes time. The signal source can be replaced in any of these circuits with a sweeper—an oscillator whose output frequency is systematically varied many times per second from a start to a stop frequency through a band of frequencies. But severe frequency modulation of the i-f and misalignment of the i-f with respect to the narrow pass band of the i-f amplifiers can occur if the sweepers aren't synchronized.

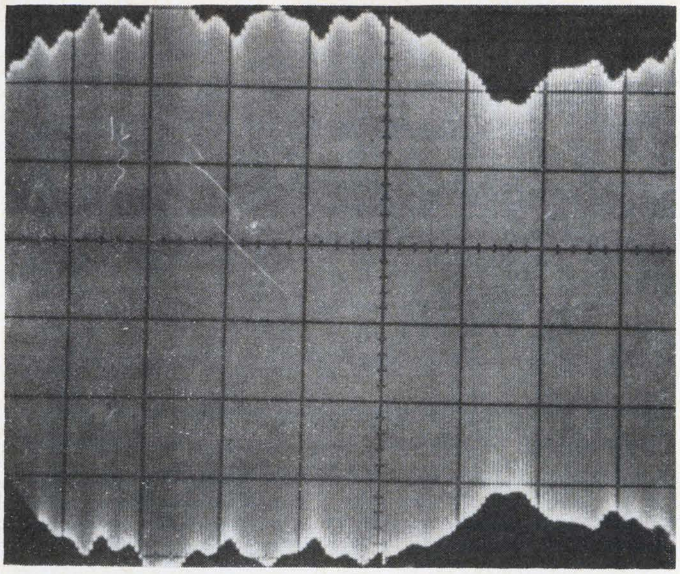
The circuits can be further modified with hybrid junctions to eliminate the slotted line for return loss and VSWR measurements. Adding these junctions boosts the circuits measurement capabilities, but makes for greater complexity.

Technique	Measures			Measurement		Data accumulation		Comments
	IL	RL	vswr	Range (db)	Tolerance (db)	Point-by-point	Continuous (swept source)	
Incremental heterodyne frequency	x	x	x	70	±0.2		x	Needs only one source for heterodyning; simple presentation device such as scope can be used.
Single-frequency, single detection	x	x (a)	x (a)	30	±0.2	x	(b)	Limited range but simplest circuit. Require manual frequency adjustment.
Modulated single-frequency, single-detection	x	x	x	50	±0.2	x	(b)	Amplification of modulating frequency increases system's sensitivity and extends useful range
Single-frequency heterodyning	x	x	x	70	±0.2	x	(c)	Most complex but most versatile of these systems. Two sources and synchronizing are essential.

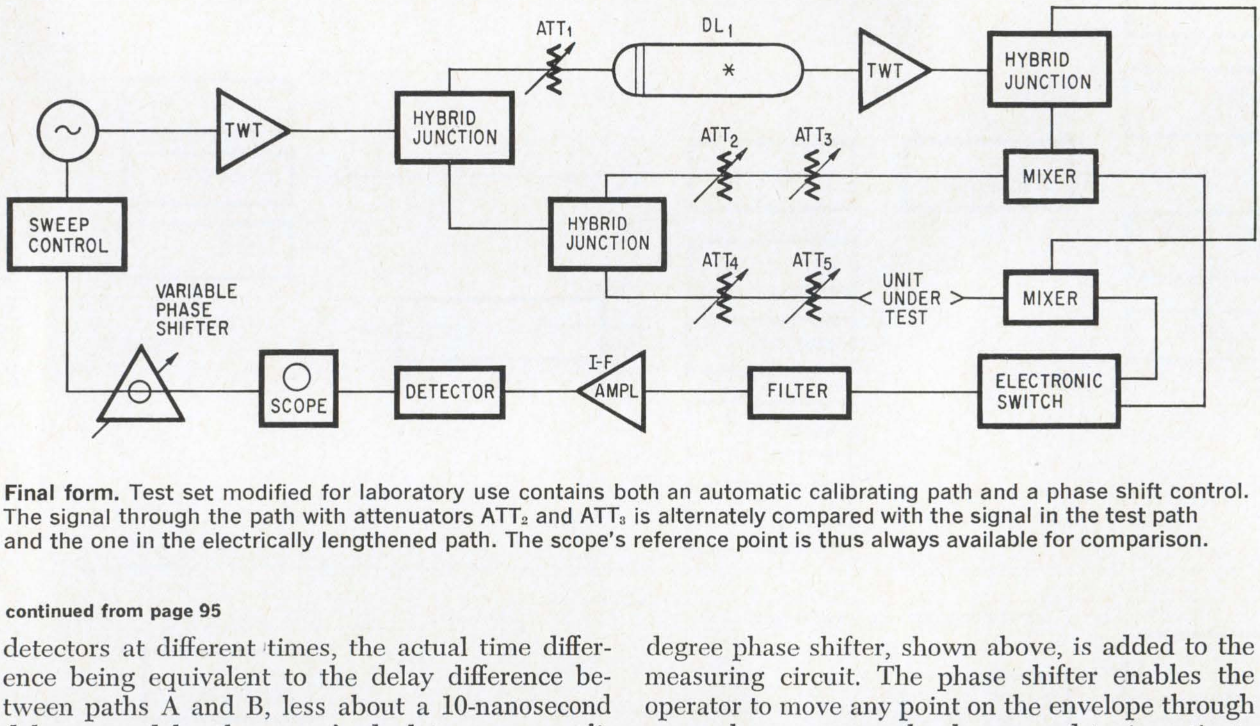
(a) Slotted line must be added to measure vswr and RL
(b) Signal source can be swept to reduce test time and eliminate point-by-point measurements. There are no serious implementation problems.
(c) Sweeping of signal sources provides time-saving benefits, but complex synchronizing circuits and mechanisms are needed to keep frequency difference constant.



Time lag. Pips created by frequency-modulating signal sources and introduced into test system at the start of the two signal paths arrive at the mixer at different times.



Typical output. Test results are confined to the envelope of the oscilloscope display. Shown here is the mixer output signal after the i-f has been filtered and amplified.



Final form. Test set modified for laboratory use contains both an automatic calibrating path and a phase shift control. The signal through the path with attenuators ATT_2 and ATT_3 is alternately compared with the signal in the test path and the one in the electrically lengthened path. The scope's reference point is thus always available for comparison.

continued from page 95

detectors at different times, the actual time difference being equivalent to the delay difference between paths A and B, less about a 10-nanosecond delay caused by the scope's dual trace preamplifiers.

The displacement between two identical frequencies proves that two different frequencies originating at the swept-signal source are present at the detectors at the same time.

The number of points sampled by the test set depends on the mixer output frequency, and the only useful information in the output is contained at the peaks and valleys of the modulated signal's envelope. While this is satisfactory for a production-line instrument, a laboratory system should be able to measure abrupt losses occurring between the sample points.

The IHF system gains this capability when a 360-degree phase shifter, shown above, is added to the measuring circuit. The phase shifter enables the operator to move any point on the envelope through as much as a one-cycle change and to investigate the test results at that discrete sample point.

Measurements made with the new circuit have been correlated to within a tenth of a decibel with a conventional sweeper test set. Losses of more than 50 db have been observed with sensitivities of 1 to 2 db per centimeter on an oscilloscope.

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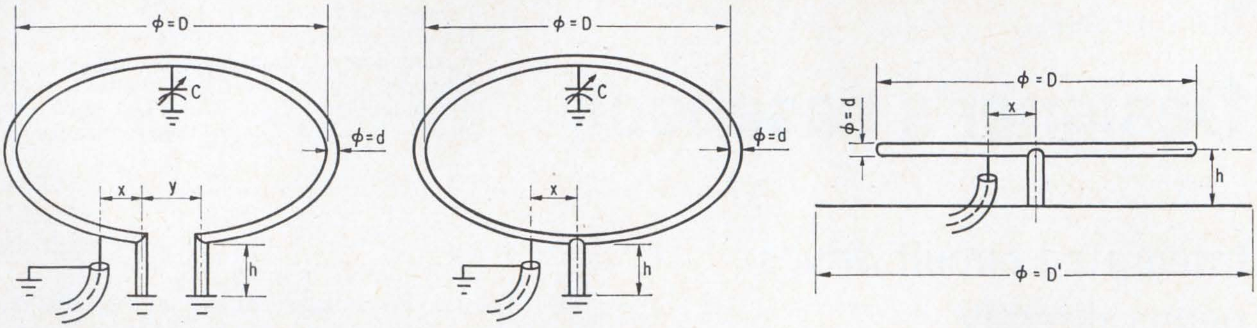


New ring. Efficiency of radiator antenna (left), is improved at very high frequencies by adding capacitor, eliminating the discontinuity gaps (center), and making ground-plane diameter, D', twice loop diameter D (right).

of the capacitor, the loop's diameter is reduced to about 52 electrical degrees. The correct termination is found by moving the feed point through a distance shown as X in the first sketch.

The bandwidth is determined by the diameter, d, and the height above the ground plane of the rod used to form the loop.

Field intensity measurements of such half-wave DDRR's show that they are not only superior to the conventional DDRR, but have 1-decibel better gain than the standard quarter-wave verticle dipole. Radiation directivity was as good as the theoretical omnidirectional pattern given in the 1963 report. A 3-db jump in the directivity pattern is caused by the discontinuity at Y. The length of Y is not critical, and the jump in field intensity can be eliminated by reducing Y to zero, as in the second sketch, closing the loop.

Several half-wave DDRR's have been made for mobile radio applications. The dimensions for the 156 to 17-Mhz band are:

$D = 10$ inches
$d = \frac{13}{32}$ inch
$h = 1\frac{3}{8}$ inch
$X = \frac{13}{32}$ inch, for 50 ohms impedance

This antenna's ground-plane diameter is approximately 2D.

The antenna is well-suited to vhf/f-m use, acting as a sharp bandpass filter centering on the operating frequency. It rejects adjacent-channel interference much better than conventional dipoles. Receiver signal-to-noise ratio is also better when the loop is grounded through the vehicle frame, to drain off static charges.

The low profile of the antenna, when mounted on an automobile roof, makes for low wind resistance and therefore less signal flutter, and inconspicuous appearance.

Relay actuator produces one-hour pulses

By David L. Pippen

National Aeronautics and Space Administration,
White Sands Test Facility, N.M.

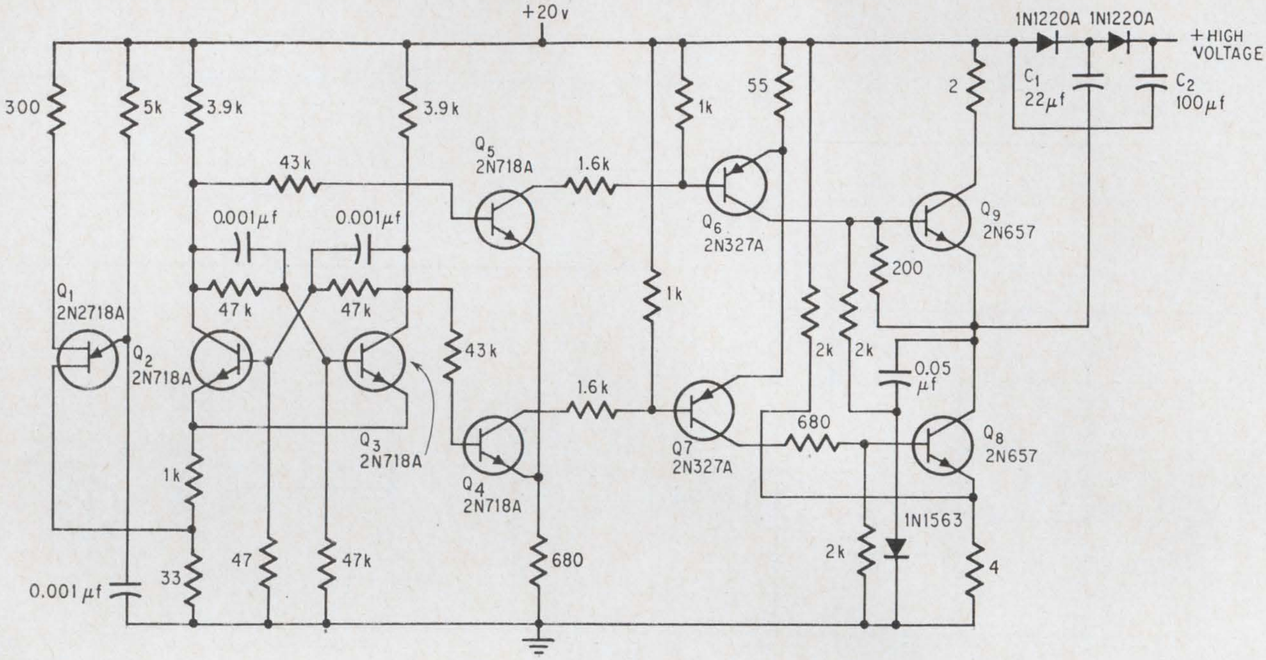
Long pulses at slow repetition rates for timing applications are generated by a free-running pulser consisting of solid state components and a relay. Pulse widths and rates from 20 milliseconds to several minutes can be obtained by changing the values of the resistors and capacitors that govern time constants.

The component values allow pulse width to be adjusted from approximately 50 to 150 msec, at a nominal repetition rate of one pulse per second. Stability of the repetition rate is within 2% over normal operating temperatures.

When a direct current is applied to the circuit, capacitor C_1 charges through resistors R_3 and R_4 until the firing point of the unijunction transistor, Q_1, is reached. This time delay, adjustable with R_3, establishes the repetition rate.

After Q_1 is triggered, the silicon controlled rectifier, SCR_1, fires and energizes relay K_1, closing the normally open contact K_{1B}. Now, power is applied through R_2 and R_5, charging C_2; this time delays the pulse width and is adjusted with R_2. The charging of C_2 fires the second unijunction transistor, Q_2, and SCR_2.

The low impedance of SCR_2 in its on state shunts SCR_1 so it returns to its off state. At the same time, K_1 returns to its de-energized position. The pulse-width-determining circuit is now fully recovered and waits for the next triggering signal from Q_1. Several low-priced, high-sensitivity SCR's tried in this circuit did not function adequately, since they sustained conduction with less than 5 microamperes anode current. The on-state resistance in the SCR_2 must be low enough to assure SCR_1's turning



Autotransformer. In actual circuit, the switching is controlled by a unijunction transistor, Q_1, and transistors Q_8 and Q_9 replace the switch contacts.

by Q_4 and Q_7 and Q_5 and Q_6.

The two remaining transistors, Q_8 and Q_9 take the place of the switches S_C and S_D in the explanatory circuit. They are turned on alternately so that C_1 repeatedly charges and then discharges into C_2, producing the high-voltage output.

The circuit shown was assembled to test the concept. With a 20-volt input, the output was 35.5 volts at 80 milliamperes and the efficiency was 60%. The output can be efficiently regulated by providing feedback from the output to control the amplifiers in either the charge or discharge circuit.

Transistor replaces supply in CRT amplifier

By Phil Salomon

Pasadena City College, Pasadena, Calif.

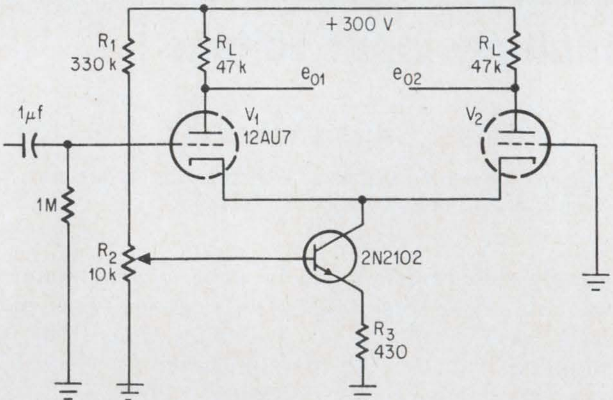
Adding a transistor to a conventional paraphase amplifier eliminates the need for a negative power supply and improves the balance of the output-signal amplitudes.

Paraphase amplifiers are widely used as balanced deflection devices for electrostatic cathode-ray tubes. They provide outputs of opposite polarity and equal gain when signal currents of equal magnitude flow in the two tubes, V_1 and V_2, shown in the conventional circuit. Quiescent current for each tube is supplied from the cathode resistor, R_K.

Ideally, R_K acts as a current source—it holds the quiescent current steady when operating conditions vary. Therefore, R_K is returned to a negative power supply, $-E_{cc}$, so that the potentials of the tubes' cathodes are held near ground. An analysis of the equivalent circuit shows that R_K must be large, since

$$R_k = \frac{100}{P}\left[\frac{r_p + R_L}{\mu + 1}\right]$$

where P is the percent of unbalance between the



Hybrid amplifier. Transistor and bias resistor network prevent voltage variations from affecting current balance.

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The speed and accuracy of GAF radiography has actually helped improve welding techniques, making for greater construction efficiency. This has enabled Sun to launch its precedent-making ship in record time. Designed for long-term charter to MSTS, the vessel's combination of high speed (in excess of 25 knots) and large deck area, could well set a trend for use of gas-turbine power.

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Gallium arsenide begins to keep some promises

Always just around the corner, this versatile compound semiconductor is finally challenging silicon and germanium in a host of uses, and is tackling some special applications all its own

By Stephen E. Scrupski
Senior associate editor

As multifaceted in application as it is in its crystal structure, gallium arsenide is on the verge of challenging germanium and silicon for the over-all championship of the semiconductor field. But the challenger has been brought along slowly, and rather than immediately risking a direct confrontation with its rivals in the transistor field, it may begin by outflanking them in light-emitting and bulk-effect applications.

New developments in the use of germanium and silicon as semiconducting materials are trailing off; it would not be an oversimplification to say that most of the work with these materials is now directed toward finding new ways to arrange devices, deposit insulation, and form photomasks. But materials research in the field of gallium arsenide is on the upswing. The conferences covering basic materials—electrochemical and metallurgical society meetings, for instance—are being inundated with papers on compound semiconductors.

Of these compound semiconductors, gallium arsenide is receiving the lion's share of attention. In terms of processing refinements, it's far ahead of the others. In the same terms, it's still far behind silicon, but silicon can't do all that GaAs does.

GaAs is today the most versatile of all semiconducting materials; the articles following will emphasize this. Varactors, transistors, microwave diodes, light-emitting diodes, injection lasers, bulk microwave power sources, negative resistance, amplifiers, and bulk-effect integrated circuits—all are possible with gallium arsenide.

Of these, only varactors, Schottky-barrier microwave diodes, light-emitting diodes, and injection lasers are being made in quantities that even approach conventional "production" levels. But advanced gallium-arsenide devices are waiting in the wings—in fact, they're being demonstrated in laboratory models.

Lifting the lid

And when the bulk-effect devices finally hit the market, a new world will open up, one in which functional integrated circuits are designed by shaping the material and by chemical processing. With such circuits, now being built at Bell Telephone Laboratories by Masazuku Shoji and at Standard Telecommunication Laboratories, Harlow, England, by C. P. Sandbank, we can forget about such individual components as transistors.

The key factor in gallium arsenide's success up to now is a single property—a higher electron mobility than either silicon or germanium. Gallium arsenide also has a wider band gap, a feature suggesting high-temperature uses. But Arthur Uhlir of Microwave Associates, author of the section on varactors in this report, sums up the present situation: "High-temperature characteristics, though they were once given as the main reason for research in gallium arsenide, have not been a very significant factor in the application of any gallium-arsenide device."

In fact, as Uhlir notes in his article, the one GaAs application that has anything to do with temperature involves cryogenic freezing just a few degrees above absolute zero. This is the cooled parametric amplifier, which uses a gallium-arsenide varactor in a low-noise receiver.

The main obstacle to fuller exploitation of GaAs is its relative impurity compared with germanium and silicon. These elemental semiconductor mate-

Some special features make the difference

By David Richman

RCA Laboratories, Princeton, N.J.

The similarities between gallium arsenide and the elemental semiconductors, germanium and silicon, are important but hardly surprising—all three have the same basic crystal structure, zinc-blende and diamond, that accounts for their semiconducting properties. But gallium arsenide's place as potentially one of the most important semiconductor materials rests on the differences.

A gallium-arsenide p-n junction, for example, is an efficient light emitter; germanium and silicon diodes are not.

For germanium and silicon, the conduction-band minimum occurs at a momentum different from that of the maximum of the valence band. But in GaAs, the minimum and the maximum occur at the same momentum—a feature that's the basis for the injection laser and the light-emitting diode.

Gallium arsenide thus is a direct-gap material; an electron can make the transition directly from the conduction band to the valence band without changing momentum and can give up its energy in the form of a quantum of light.

In germanium and silicon, indirect-gap materials; electrons cannot move from one band to the other with the same momentum and they must give up most of their energy to the lattice in the form of lattice vibrations, or phonons.

Mobility

Two other significant differences—gallium arsenide's greater energy-band gap and the greater mobility of electrons in its conduction band minima—give the material its higher temperature and higher frequency capabilities.

Electron concentration and mobility are often used to judge the purity of a sample of GaAs. Pure material has about 1×10^{15} electrons/cm^3 and a mobility greater than 8,000 cm^2/volt-sec. Less pure material has higher electron concentration and mobilities in the 5,000 cm^2/volt-sec. range. In pure material, the mobility increases as temperature decreases; mobilities of over 100,000 cm^2/volt-sec have been measured at temperatures of about 77°K.

GaAs is the basic material of Gunn-effect devices because there are two valleys in its conduction band, one of which is at a slightly higher energy level—about 0.36 electron-volt—than the other. Electrons in the lower-energy valley have much greater mobility than those in the other valley, though the energy difference between the two levels is so small that strong electric fields give the electrons enough energy to move from one minimum to the other. When the upper—higher energy—valley is more densely populated than the lower, the material exhibits a differential negative resistance; as the voltage is increased, more electrons move up to the lower-mobility band and the current decreases, causing bulk instabilities such as the Gunn effect.

Impurity

The maximum purity attainable with present GaAs crystal-growing methods is about 10^{15} impurity atoms per cubic centimeter. Since GaAs has about 4.4×10^{22} atoms/cm^3, this limit corre-

Energy-band properties

Property	Ge	Si	GaAs
Band gap (ev)	.67	1.106	1.40
Type of band gap	Indirect	Indirect	Direct
Calculated maximum electron mobility at 15° C (cm^2/v-sec)	3,950	1,900	11,000
Calculated maximum hole Mobility at 25° C (cm^2/v-sec)	1,900	425	450
Electron effective mass	.55	1.1	.043–.071
Intrinsic electrons at 25° C (cm^{-3})	2.4×10^{13}	1.5×10^{10}	1.4×10^{6}
Intrinsic resistivity at 25° C (ohm-cm)	46	2.3×10^{5}	3.7×10^{8}

Matchups

Property	Germanium	Silicon	Gallium arsenide
Melting point (°C)	936	1,420	1,238
Solid density (gr/cm³)	5.328	2.329	5.316
Lattice constant (Å)	5.658	5.430	5.654
Distance between nearest neighbors (Å)	2.45	2.35	2.45
Atoms per cm³	4.42×10^{22}	5.0×10^{22}	4.43×10^{22}
Vapor pressure at melting point (atm)	10^{-9}	10^{-7}	1
Specific heat (cal/gm)	.074	0.167	.086
Dielectric constant	15.7	12	11.1
Thermal coefficient of expansion ($°C^{-1}$)	6.1×10^{-6}	2.33×10^{-6}	5.93×10^{-6}

type lattice. Each gallium atom is surrounded by four arsenic atoms at the corners of a tetrahedron, and each arsenic atom is surrounded in the same way by four gallium atoms. Germanium and silicon crystalize in a diamond lattice with all sites occupied by the same type—germanium or silicon—atoms.

With germanium or silicon, all 111 faces of the crystal have the same chemical reactivity, since the atoms are the same when viewed from any direction. But in the zinc-blende structure, all 111 faces present alternating layers of gallium and arsenic atoms, and opposite planes have different surface atoms—gallium in one direction and arsenic in the other. As might be expected, the two surfaces react differently to chemical treatment.

The near equality of the lattice constants—the spacing of the unit cells in the crystal—and the thermal coefficients of expansion are the features that permit the epitaxial growth of germanium on gallium arsenide, a useful method in forming heterojunction transistors.

Materials II

Crystal holds key to the future

By J.M. Woodall

International Business Machines Corp., Yorktown Heights, N.Y.

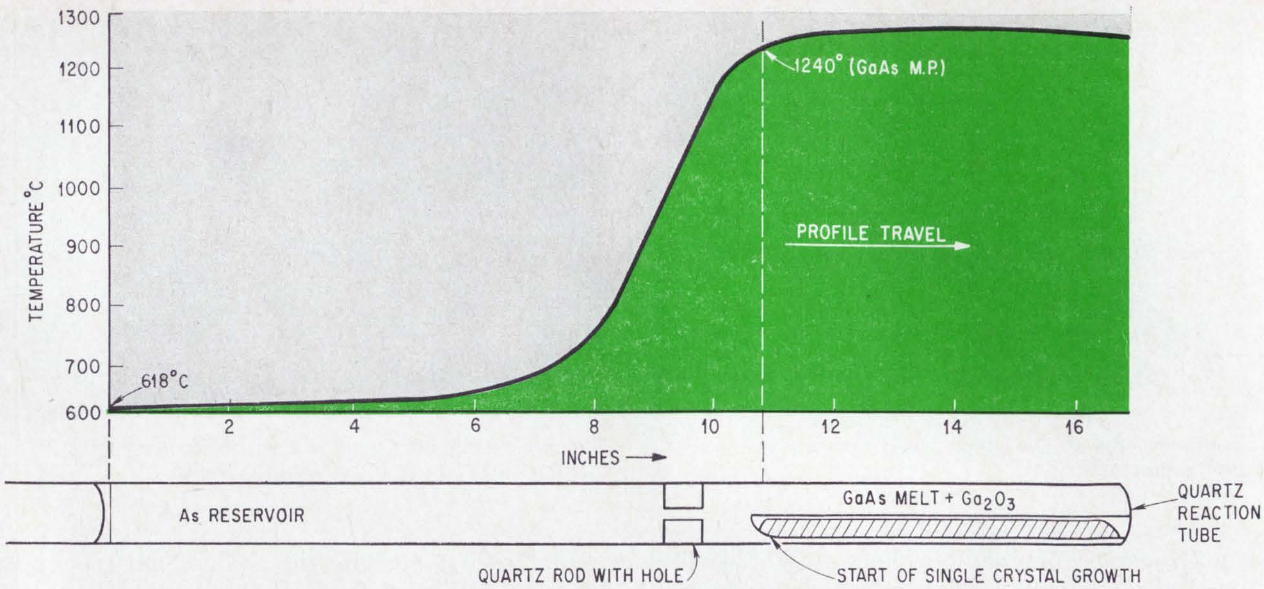
"To achieve better, more uniform results, it is clear that better materials are needed." This comment, found all too often at the conclusion of an article about gallium-arsenide devices, emphasizes the increasing importance of crystal growth techniques.

Epitaxy—the atom-by-atom growth of a layer of GaAs on bulk crystal—has proved a success, but the attainment of more reliable, more uniform, and longer-lived devices requires improved methods of bulk crystal growing. The future of epitaxial devices depends on the quality of the bulk-grown substrates.

Device-quality GaAs is grown by freezing the molten material at 1,242°C into a single crystal structure free of chemical contamination and structural defects. Besides producing high temperatures and promoting single-crystal growth, the apparatus used must prevent the melt from dissociating. The arsenic in the melt has a dissociation pressure of one atmosphere, and without this external vapor pressure it would leave the melt, thereby chemically unbalancing the crystal structure. Either this pressure must be provided, or as in a newer method, the melt can be encapsulated, and an inert gas used to block the escape of the arsenic.

Two paths to growth

Two methods of crystal growth are now popular, the Czochralski and the horizontal Bridgman (the vertical Bridgman method is not as convenient for use with semiconductor materials). In the first method, a seed crystal is inserted in the melt and then slowly withdrawn so that the melt forms a meniscus and solidifies as it's raised above the molten surface, repeating the same single-crystal structure as the seed. Typical high-purity results of



Passing through. In the horizontal Bridgman method, the GaAs melt is passed through a temperature gradient and single-crystal material forms on the cooler end.

special seals and feedthroughs. Because the motor-driven apparatus working through magnetic coupling or special seals may have small speed variations, the crystal cannot be grown at a microscopically uniform rate and the dopants tend to collect, often in periodic striations. In the Bridgman method, the motor-driven apparatus runs at a more uniform speed because it's simpler and operates at room temperature.

In the other version of the Czochralski method, the need for arsenic vapor is eliminated altogether by ensapsulating the melt in a viscous nonreactive material such as boric oxide, B_2O_3. Little arsenic escapes from the melt when an inert gas such as argon is applied outside with a pressure of one atmosphere.

The crystal is grown by dipping the seed through the B_2O_3 and then withdrawing it at a uniform rate. As the grown crystal passes through the seal into the inert atmosphere, it picks up a thin layer of B_2O_3. This method thus allows the use of more stable seed-lifting mechanisms and should result in the growth of more perfect crystals.

Boatloads

The horizontal Bridgman method generally produces higher-purity material and a more uniform crystal. As with the Czochralski, the system is sealed and contains one atmosphere of arsenic vapor. A boatload of molten GaAs traveling through a temperature gradient forms a single crystal in the shape of the boat.

Neither the melt nor the solid crystal should adhere to or be constrained by the boat. This puts some restrictions on the choice of boat material—a factor of no importance in the Czochralski method.

One advantage of the Czochralski method is that it affords a wide choice of crucible materials; the major concern is the chemical reactivity, not, as in the Bridgman method, whether the melt wets the crucible. Aluminum-nitride, boron-nitride, and aluminum-oxide crucibles have all been successfully employed in growing high-purity GaAs.

Also, a special graphite crucible for Czochralski growth offering a desirable temperature gradient and good r-f coupling for heating has recently been used to grow dislocation-free GaAs—the substrate required for epitaxial growth of dislocation-free material.

With a recent development, the horizontal Bridgman method is also capable of producing dislocation-free material. This material, seeded crystals grown near the 310 direction in sand-blasted quartz boats and doped with 2×10^{18} tin atoms/cm^3, has yielded the best room-temperature laser devices made so far, even though GaAs crystals grown in quartz are generally contaminated with silicon from the quartz at a concentration of 1 part per million or 10^{17} atoms per cm^3—a high impurity level by semiconductor standards.

Although 1 part in 10^6 silicon content doesn't affect laser devices, most other applications couldn't tolerate that level of impurity. But with modifications in the growth apparatus and additions of Ga_2O_2 to the melt—to suppress the reaction of silicon with the melt—this contamination can be reduced to about 1 part in 10^8.

Crystals grown this way are generally semi-insulating—having resistivities near 10^8 ohm-cm —but heat treatment produces high-mobility GaAs with resistivities between 1 and 1,000 ohm-cm depending on the temperature and length of heat treatment.

For more on . . .

Crystal growth: L.G. Bailey, Transactions of Metallurgical Society of AIME, March 1967, p. 310.

p^+-n^+ junctions, several hundred injection lasers emitting visible light at room temperature have been fabricated, the only such devices yet reported. One laser operating at 4.2°K is the brightest electro-luminescent source ever prepared. Others emitting visible light in a continuous-wave mode at 77°K have also been built.

Multilayer

A major problem with GaAs and $GaAs_{1-x}P_x$ light-emitting diodes is that much of the light given off is reabsorbed by the diode itself. To minimize this, a phosphorous-rich layer is placed above the p-n junction to act as a window for the light to pass through. This multilayer structure would be difficult to build with ordinary fabrication procedures, but is easily prepared with vapor-phase technology. Such a diode has provided a brightness of 135 foot-lamberts at a current density of 10 amps/cm^2.

For a Gunn diode, n^+-n^--n^+ layers are vapor-grown in one continuous process with the n^- region as thin as 1 micron. This again demonstrates the absence of autodoping effects. Using such a structure with a 2.5-micron-thick n^- region, a Gunn oscillator has operated in the transit-time mode at 40 Ghz, the highest frequency reported for this kind of operation.

The same type structure with an n^--layer 100 microns thick has provided 143 watts of pulsed power at 2.2 Ghz.

For more on . . .

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Materials IV

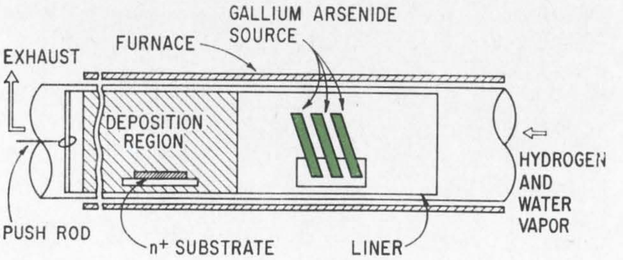
Film-making: a delicate job performed under pressure

By Kenneth L. Lawley

Bell Telephone Laboratories, Murray Hill, N.J.

The growth of a single-crystal material on a substrate of a similar material is the key step in fabricating many semiconductor devices. The epitaxial process produces material not attainable with bulk crystal or diffusion processes. Because of the low temperature of these processes, pure crystals can be grown, allowing the full realization of the high electron mobility possible with gallium arsenide.

Gallium-arsenide films are harder to grow than elemental semiconductors because there are no suitable gallium compounds that are gaseous at room temperature and atmospheric pressure. Both the arsenic and gallium gaseous compounds must therefore be supplied to the reactant system under closely controlled conditions.



Water carrier. In the water-vapor epitaxial method, bulk gallium arsenide is used as the source.

The three deposition methods generally applied use:

- bulk GaAs as a source and water vapor or a chloride as a transport medium;
- pure gallium as a source for the gaseous gallium compound and arsine or arsenic trichloride for the arsenic;
- condensed GaAs in liquid gallium.

Pure and simple

The simplest of these methods is the first. The bulk material is exposed to an oxidizing gas, and the products of this reaction serve as the gaseous source from which gallium arsenide is deposited. Water vapor, hydrogen chloride, or chlorine diluted in hydrogen are usually used as the oxidizing gas, though other halides have been tried.

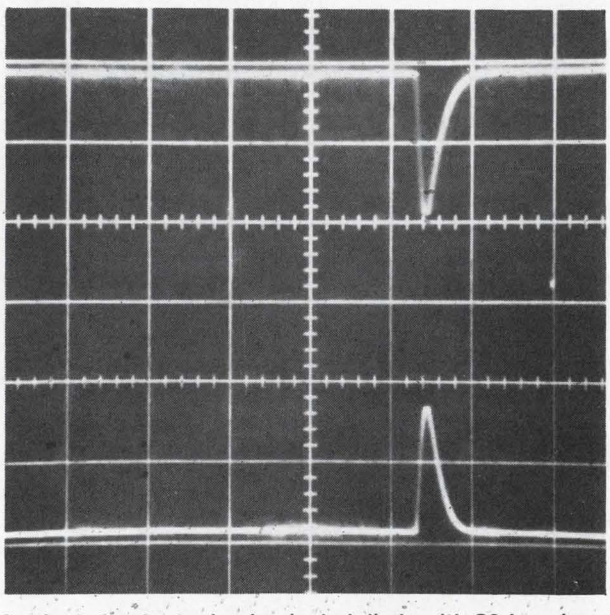
Getting dopants on the beam is a long-term project

By Kenneth E. Manchester
Sprague Electric Corp., North Adams, Mass.

The technique of implanting dopants in crystals of gallium arsenide with a high-energy beam of ions is still at an early stage of development. Holding out the promise of alternative methods for building devices requiring limited processing temperatures and a precisely shaped doping profile, ion implantation can eventually complement existing diffusion method for doping semiconductors.

In the field of light-emitting gallium-arsenide devices, the technique would make it relatively easy to build the junctions close to the surface; this would enhance light-emitting properties by reducing absorption before the light leaves the surface. Diodes made with implanted dopants in the laboratory have emitted about the same levels of light as diffused diodes.

There are two major obstacles to practical ion-implanted GaAs devices: our ignorance of the details of the implantation process and impurities in the GaAs substrates. However, the considerable efforts being made to understand ion implantation in silicon should carry over into the area of gallium arsenide.



Implanted outputs. Ion-implanted diode with 80 kev zinc ions delivers sharp pulse (lower trace) in response to input (upper trace).

Experimental diodes

At the Sprague Electric Corp., zinc has been implanted in n-type GaAs, and tellurium in p-type GaAs; ions have been accelerated to 40 and 80 kiloelectron-volts, a relatively low energy level, to produce shallow junctions.

Two types of diodes were formed by this process, each doped with 80-kev zinc ions. One was annealed in an argon atmosphere for 20 to 30 minutes at 650°C, the temperature above which arsenic tends to leave the GaAs surface—a thermal etching effect. The other was annealed for 10 to 15 hours at the same temperature in argon. The diode surfaces were protected with a layer of silicon dioxide to further prevent thermal etching.

The first diode had an essentially abrupt junction and a sharp reverse breakdown. A good thermally diffused diode with a similar background carrier concentration would have a similar junction but a more gradual reverse breakdown.

The second diode had a graded junction, a higher reverse breakdown voltage, and a relatively high forward resistance. The rate at which the impurity concentration decreased away from the junction was about $10^{20}/cm^3$ per centimeter—about 1/100th the grading coefficient of a typical diffused graded-junction device.

The low grading coefficient indicates a long tail on the implanted distribution due to deeply penerating ions. This tail may be the result of either a channeling phenomenon occurring during implantation—where ions travel down open channels in the GaAs lattice—or a diffusion process during the long annealing period.

Comparisons

Both diodes emitted light at 9.2 microns when forward biased, but the abrupt-junction diode ently produced. This resistivity stems from the high density of traps, and from the fact that mobilities are normally much lower than those in the semiconducting n-type crystals. Typical electron-mobility values for the semi-insulating material lie between 200 and 2,000 cm^2/volt-sec. Because the electrons are more mobile than the holes, they account for most of the small current flow.

Lab results

Semi-insulating GaAs has been deposited epitaxially by Haisty and P.L. Hoyt of TI, who obtained resistivities of up to 10^5 ohm-cm by doping with iron. And J. Franks and P.R. Selway of Standard Telecommunication Laboratory have made p-i-n diodes in which the intrinsic region was formed by the diffusion of chromium into n-type slices having an initial carrier concentration of more than 10^{16} per cm^3. Resistivities at the surface of the intrinsic layer were measured at 10^8 ohm-cm.

These results demonstrate the feasibility of integrated circuits in which the semi-insulating properties of the substrate are brought to the surface by a local diffusion of chromium to produce isolating channels in the semiconducting layer.

Peak mobilities of 100,000 cm^2/volt-sec have been achieved at the Standard Telecommunication Laboratory with semiconducting n-type GaAs vapor-deposited on semi-insulating GaAs by the arsenic trichloride-gallium process. Researchers at STL also report mobilities of 8,000 at room temperature (56,000 at 78°K) with n-type layers deposited from the liquid phase on semi-insulating substrates. The fact that n-type layers of GaAs can be grown on semi-insulating substrates simplifies the evaluation of the epitaxial process.

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Devices I

Off to a good start

By Arthur Uhlir Jr.

Microwave Associates Inc., Burlington, Mass.

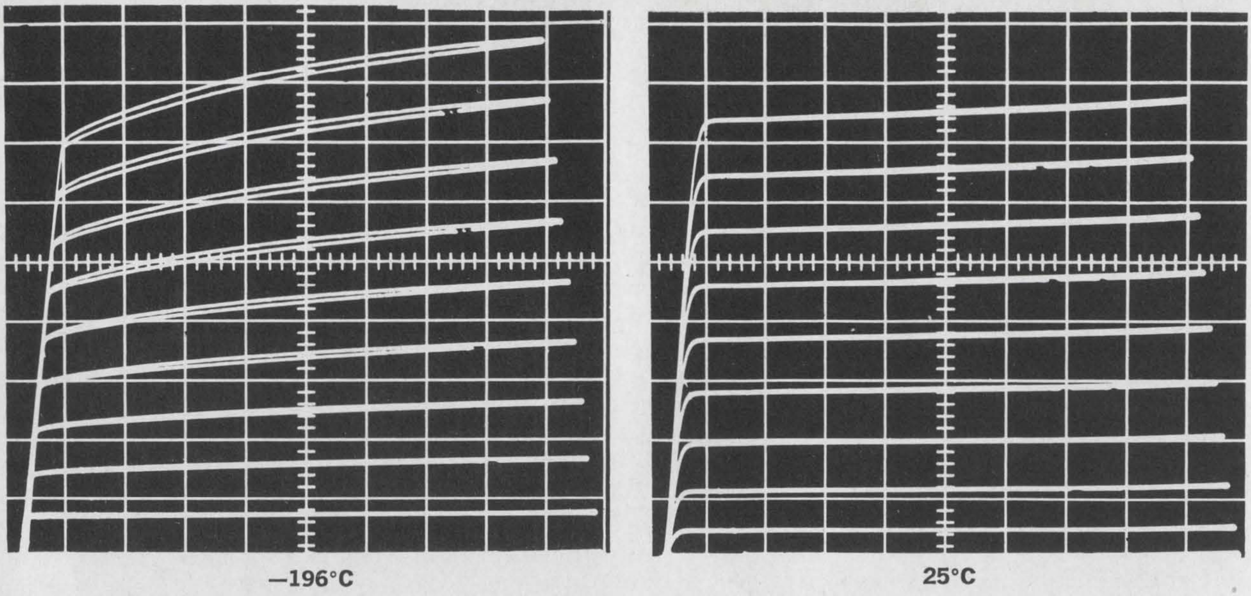
For its first use in a practical device—the varactor diode—gallium arsenide was in the right place at the right time. In the late 1950's, makers of microwave systems needed low-noise parametric amplifiers and frequency multipliers that couldn't be built with other semiconductor materials.

The use of gallium arsenide for varactors in microwave systems is a reflection principally of quantitative features such as high electron mobility and retention of conductivity at 4.2°K liquid helium temperatures—a must for cooled, low-noise parametric amplifiers. In this respect, the varactor differs from more recent GaAs devices such as light-emitting diodes, lasers, and piezoelectric transducers, where the emphasis is on properties that are qualitatively different from those of silicon and germanium.

GaAs varactors have scored their biggest success in low-noise parametric amplifiers. Here they compete with silicon devices in uncooled applications and have the cooled field to themselves.

At room temperature, the higher electron mobility of GaAs yields a series resistance lower than that of silicon, and cutoff frequencies three or four times higher. This, however, doesn't result in a comparable drop in amplifier noise. For one thing, losses stemming from the relatively low mobility of holes in the p-type regions of the GaAs diode and from the finite conductivity of the cartridge metal reduce the cutoff-frequency advantage to a factor of about two—600 gigahertz against silicon's 300 Ghz. For another, high pumping frequencies are needed at room temperature to take full advantage of varactors with high cutoff frequencies.

When cost is no object, however, refrigeration will make parametric-amplifier noise negligible in comparison with noise from antenna feeds. It's far easier to design such an amplifier with a GaAs varactor than with silicon or germanium because



Temperature effects. Common-emitter characteristics of GaAs bipolar transistor at −196°C, left, and at room temperature, right. Vertical calibration is 1 milliampere/division, horizontal is 1 volt/division; base current increases 0.1 milliamp with each step.

emitter to collector, and thus limits emitter efficiency and base spreading resistance.

In addition, it's difficult to measure the other material properties bearing on transistor operation, and difficult, with present processing methods, to do anything about changing them.

Although they have only partly fulfilled expectations, GaAs transistors have been a major factor in the development of other GaAs devices. Because of their dependency on material quality and fabrication processes, GaAs bipolar transistors are sensitive tools for the study of GaAs material and device technology.

Performance forecast

About 10 years ago, it was commonly predicted that GaAs transistors would bypass silicon and germanium devices in temperature and frequency performance because of gallium arsenide's wider band gap and higher electron mobility. Based on a maximum operating temperature of 100°C for germanium, engineers projected silicon transistors operating at up to 250°C and GaAs transistors at up to 450°C.

The highest operating frequency is related to the product of electron and hole mobility in the case of bipolar transistors, and to the majority carrier mobility with unipolar (field effect) transistors. Bipolar GaAs and germanium transistors lead silicon devices in this mobility factor; the two are equals at higher frequencies because the higher electron mobility of GaAs is offset by germanium's higher hole mobility and somewhat higher dielectric constant.

GaAs unipolar transistors should operate at frequencies roughly twice as high as the top levels for germanium unipolar transistors, which, in turn, should surpass those of silicon devices by about the same factor.

The first GaAs transistors were fabricated from Czochralski-grown material. Reproducibility was very poor and current gains were low. Boat-growing led to better devices, but high current gain could only be achieved consistently after the introduction of vapor-phase epitaxial methods.

But the problems of relating material properties to device performance still remain; it isn't yet possible to define "good" transistor material, or even to influence critical parameters by changing growth conditions. The conveniently measurable properties of the material, such as dislocation density, mobility, and doping level, don't relate to transistor performance, although they are useful for basic material.

However, the recently applied cathodoluminescence technique may provide a means of selecting suitable GaAs material for device fabrication. In this technique. GaAs is bombarded with electrons that penetrate deep. From deep inside, the GaAs emits light related to such parameters as diffusion length and lifetime.

The influence of particular dopant elements on device performance is small compared with the effect of the starting material. Almost all transistors have been of the npn type because of the wide ratio of electron to hole mobilities—about 20:1 in GaAs.

The general difficulty in making GaAs transistors is that only two to three orders of magnitude concentration difference can be achieved between emitter and collector; with silicon transistors, the concentration difference runs to four or five orders of magnitude. In GaAs, the collector concentration is typically about $10^{16}/cm^3$. At lower concentrations, thermal conversion of n-type to p-type material occurs, sometimes caused by fast diffusing acceptors such as copper. The solubility of electrically active donors in GaAs (the maximum for deep oil wells and in gear for space probes near the sun.

Stability

Before GaAs can be considered for high-temperature circuits though, serious stability problems must be solved. All GaAs transistors suffer from instability when operated over long periods of time, even at room temperature. At temperatures of 400°C to 500°C, the possibility of a rediffusion of emitter and base regions must be considered. Although individual transistors have been operated over periods of several thousand hours in a 300°C ambient environment with little degradation, these results are not reproducible with all transistors.

Studies of the stability of GaAs have produced a better understanding of the degradation of transistors, light-emitting diodes, and microwave devices. But failure-mechanism studies of GaAs devices have just scratched the surface of the problem.

For more on. . .

Comparisons with Ge, Si: D.A. Jenny, Proceedings of the IRE, June, 1958, p. 959.

Cathodoluminescence studies: D.B. Wittry, D.F. Kyser, Journal of Applied Physics, 1967, p. 375.

Iron doped transistors: H. Strack, Gallium arsenide—Institute of Physics and Physical Society Conference Series No. 3, p. 206.

Devices III

Fast-moving FETs can outpace rivals

By Hans Becke

RCA Electronic Components and Devices Division, Somerville, N.J.

Gallium-arsenide bipolar transistors may have a hard time trying to replace their silicon counterparts, but the story may be different in the case of field effect transistors. Gallium arsenide enters the race with at least one big plus—a far higher electron mobility than silicon's. This feature can mean more gain at higher frequencies to go along with gallium arsenide's higher temperature performance.

The frequency response of a field effect transistor is primarily determined by the mobility of the majority carriers—electrons in an n-channel device—and GaAs has a 5:1 edge over silicon on this score. Two recent developments, a very-high-frequency device using silicon nitride as a gate insulator, and a microwave device using a Schottky barrier as the gate, demonstrate the potential of GaAs FETS. Since both depend on channel carrier mobility for high-frequency performance, they have the same frequency response limits.

Both are made in planar form and can be easily incorporated into integrated circuits. Such transistors, working with other new gallium-arsenide devices, could herald a new era in IC's.

The silicon-nitride, insulated-gate FET, developed at the Radio Corp. of America, has provided 22 decibels gain at 200 megahertz though it wasn't designed with a high-frequency geometry. Silicon devices with the same geometry give only 16 db gain at the same frequency [Electronics, June 12, 1967, p. 82].

The device channel was made with the hydride vapor technique of J. J. Tietjen and J. A. Amick of RCA Laboratories [details on p. 115]. A thin layer of lightly doped n-type GaAs was epitaxially grown over a p-type substrate and covered with a layer of silicon nitride. After the Si_3N_4 was masked and the source and drain sites were etched, tin was diffused into the source and drain sites to provide heavily doped n-type material for use with the contacts, which were then applied over the gate channel region and also over the source and drain sites.

Fewer surface states

Silicon nitride has a big advantage over silicon dioxide here in that it allows the electric field produced by the gate to penetrate deeper into the GaAs because it produces fewer surface states to terminate the gate field near the surface. This affords greater control of the channel current and a higher transconductance—typically, about 10 to 25 millimhos against silicon's 8 to 10 millimhos. The transthese high impedances over large bandwidths is a formidable task, and most designers resort to biasing the diode to reduce its impedance, or to padding the unit; both measures decrease sensitivity.

For high video impedances, the capacitance of the diode junction must be very small—less than 0.2 picofarad for S-band detectors and less than 0.05 pf for X-band.

The Schottky diode detector then must have as small a junction capacitance as possible; a large video impedance; low series resistance; and a Q between 10 and 20 at the operating frequency.

Therefore, the material chosen should have high electron mobility and small dielectric constant, and the diode should be made with a thin, high-resistivity epitaxial layer designed so the space charge of the junction can punch through into the substrate at or near the operating bias.

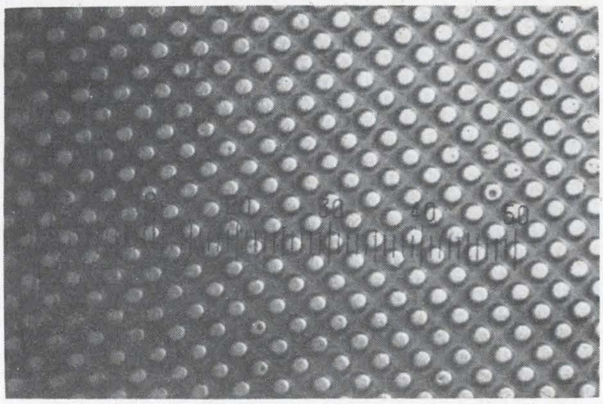
Epitaxial GaAs is thus an excellent choice. It offers a higher mobility of n-type material than does silicon, and is grown at lower temperatures, an incidental factor that can enhance control of doping in the epitaxial layer and reduce grading of the substrate-epitaxial interface. Too much grading gives a narrower-than-optimum diode space charge and boosts junction capacitance.

Generally, the larger the junction, the better the burnout resistance, but GaAs has less than a quarter of the thermal conductivity of silicon, and these factors tend to offset each other.

Gallium-arsenide Schottky detector diodes are made by depositing one of many possible metals on a clean epitaxial wafer. Nickel and gold are easily deposited, but nickel has a higher eutectic temperature with GaAs (500°C) and therefore a greater resistance to burnout.

The knee of the forward conductance curve depends on the work function of the metal used and on the crystal orientation of the gallium arsenide. The table gives a list of various metals and their barrier heights on planes 111 and 100 in GaAs and silicon; the height doesn't appear to affect sensitivity. All GaAs Schottky detector diodes require bias because the variable conductance doesn't occur near zero bias.

For a typical X-band diode, an n-type epitaxial GaAs layer 0.5 to 1 micron thick with doping of less than 10^{16} electrons/cm^3 is first coated with a layer of aluminum borosilicate glass 2 to 5 microns thick. This glass has a dielectric constant of 3.8 and also matches the thermal expansion of the GaAs well.



Pinheads. Array of Schottky-barrier metal contacts on batch-fabricated GaAs slice.

Barrier heights of metals

Elemental metal	n-type, GaAs Orientation (111)	n-type, GaAs Orientation (100)	n-type Silicon Orientation (111)
Nickel	0.83	0.70	0.58
Gold	0.99	0.90	0.79
Silver	0.94	0.85	0.62
Tungsten	—	0.73	0.67
Aluminum	0.80	0.71	0.63
Tin	0.70	0.68	0.60
Copper	0.80	0.73	0.58

Note: All heights measured to ±0.02v

After the dielectric layer has been deposited, ohmic contacts are applied to the substrate; sintered gold-tin contacts give low ohmic resistance.

The Schottky diodes are formed by photoetching holes through the dielectric layer to expose the GaAs. The metal is deposited either by vacuum evaporation through a mask or by electrodeposition from a proper solution; there appears to be no difference between diodes made with either process. After the metal-semiconductor junction has been formed, the hole is filled with metal.

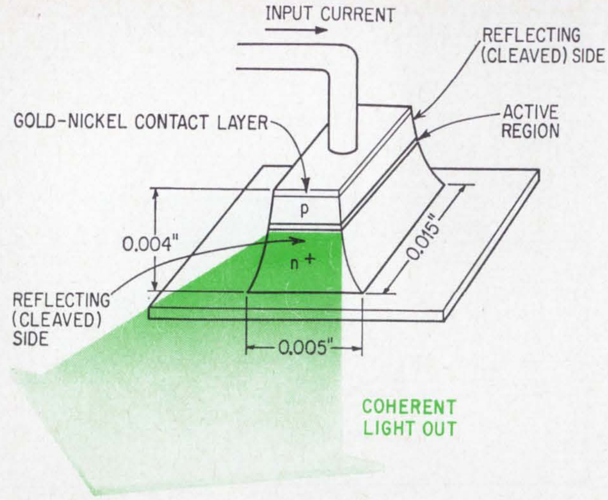
Because it's difficult to make the necessary low parasitic capacitance contacts—which should be less than 0.02 pf—a small plated whisker is bonded to the junction. But a junction only 1 micron thick is difficult to contact, so many small junctions are formed and contact is made to one randomly.

Microwave mixers

The ideal microwave mixer is a multiport device with large-signal and small-signal parameters determined by the variable conductance set up by the local oscillator and the terminations of each port.

The mixer diode's important electrical characteristics are conversion loss, the noise ratio at the intermediate frequency, and the impedances at each of the four ports. The conversion loss depends not only on the impedances presented at each port but on the termination presented to the harmonics of both the signal and local oscillator. However, if the mixer circuit is taken to be ideal, the image is resistively terminated, no signal power is lost in the higher-order harmonics, and the diode's conversion loss depends on signal match and resistive losses.

An ideal mixer diode presents to the signal a time-varying conductance whose average value can fall within a wide range without hurting performance (in contrast to the detector situation). In a typical Schottky diode, the corresponding impedances will be 100 to 300 ohms, depending on the local oscillator drive. The capacitance of the junction tends to shunt this variable conductance. Because its barrier impedance is far lower than a detector's, the mixer

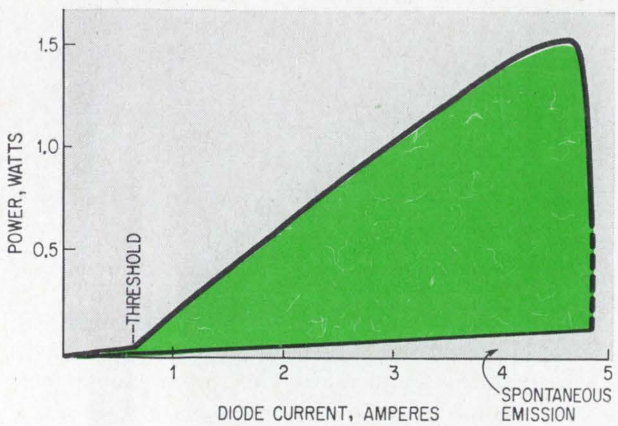


Flat beam. Gallium-arsenide injection laser produces coherent light in plane of junction.

fully realized the laser must be operated at the environment's temperature. Today's goal is high pulsed power and continuous operation at 300°K, or at least at temperatures above 100°K, where simple cooling equipment can be used. Limitations on the duty cycle and ambient temperature primarily stem from heating effects within the laser.

Researchers reported, back in 1962, that when a GaAs diode is forward biased, electrons are injected from the n side into the p side, and that—in a region about 1 micron wide—the conduction-band electrons recombine with holes in the valence band and give up their energy as radiated light. The emitted photons have an energy close to the energy separation of the conduction and valence bands—the so-called band gap, which is about 1.4 electron-volts for GaAs at 77°K.

The recombination can occur spontaneously, where individual events are completely uncorrelated, or by a mechanism first proposed by Einstein in 1918—an emission induced by another photon. It's this process of induced emission that leads to the phenomenon of lasing.



Laser power. Stimulated emission region (in color) shows high-power output above threshold.

Getting in the mode

In a Fabry-Perot structure, a resonant cavity with two parallel reflecting surfaces, the photons that propagate perpendicular to the reflecting sides multiply fastest. When a certain threshold current is reached, they outnumber the photons propagating in other directions. The gain then becomes equal to the losses from absorption inside the cavity and at the partially reflecting end faces, and the diode enters a lasing mode of operation.

During operation, the junction temperature rises because of ohmic power losses within the diode and because much of the stimulated radiation is internally absorbed. The rise in junction temperature increases the threshold current density needed for laser action and thus cuts power output. When this temperature hits a level that boosts the threshold current above the applied diode current, lasing stops.

Much effort is being made to reduce threshold current density—normally about 100,000 amperes per square centimeter—and to make it as independent of temperature as possible. Geometric configurations that reduce ohmic losses and allow effective heat transfer from the junction to the heat sink are being sought.

Progress is reported toward both major goals. By forming the p-n junction with either a double-diffusion process or liquid-phase epitaxial process, the threshold can be lowered by a factor of 4 or 5 at 300°K. Values as low as 26,000 amp/cm^2 have been observed in diodes with a cavity length of 0.38 millimeter.

Despite the progress in high-power technology, continuous operation hasn't been extended much beyond liquid-nitrogen temperatures; typical values are about 3 watts continuous power at 77°K. When pulse operated at room temperature, improved diodes have delivered about 10 watts.

Declining powers

Laser diodes tend to degrade during operation. There appears to be an irreversible decrease in power output if a certain current density is exceeded, a situation frequently accompanied by a physical chipping of the reflecting surface along the junction line. The cause isn't fully understood.

It was determined early in the laser's history that near-perfect substrates are needed as a starting material. Periodic fluctuations in the doping level due to unstable growth conditions increase threshold current and decrease power output because the losses tend to become larger. Local inhomogeneities due to clusters of defects have a similar effect and are probably responsible for the oft-observed filamentary lasing mode, where only narrow "stripes" in the junction are lasing.

For more on . . .

Injection lasers: G. Burns, M.I. Nathan, Proceedings of the IEEE, July 1964, p. 770.

antimony alloy.

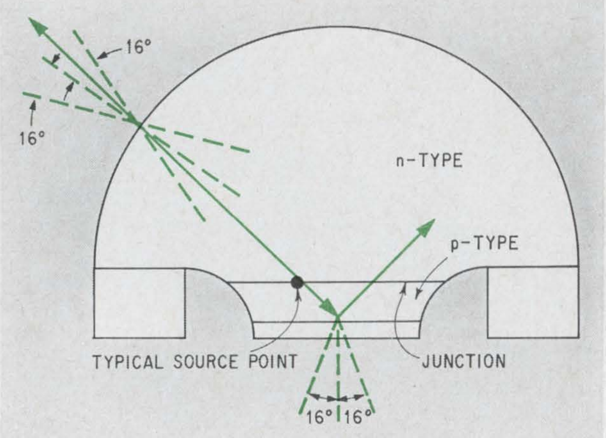
Recently, light emitters with improved efficiency and stability have been made by vapor-phase or solution epitaxy on bulk-grown substrates. The vapor-phase epitaxial technique [see p. 113] has been used to achieve a controlled degree of compensation and to approximate a graded diffused junction.

Light emitters built of bulk or vapor-phase epitaxial GaAs are processed in an arsenic-rich environment. Different properties are created when the material is grown in a gallium-rich environment by solution epitaxy; more stable and efficient light emitters have been produced in the laboratory with this technique.

A reactor used to fabricate high-purity and heavily doped solution-grown GaAs is on page 129 above. A substrate slice is inserted into a gallium melt saturated at around 900°C with doped or undoped GaAs, depending on the electrical properties desired. Upon cooling, a deposit is formed on the substrate. When group II elements are used for doping the melt, p-type deposits result; n-type deposits are obtained with group VI impurities. Group IV impurities are amphoteric; they lead to either n- or p-type deposits depending on the growth temperature.

The loss mechanisms of spontaneous emitters are different from those of lasers. Laser light exits in the junction plane through surfaces perpendicular to the junction, and light loss occurs because of free carrier absorption, cavity leakage, and transmission through the exit surface. Spontaneous light emission is isotropic and most of the light exits through planes parallel to the junction; losses are caused by bulk absorption, total reflection, and transmission.

Since the optical absorption losses in the bulk are about 10 times greater than the effective losses in the cavity, and since most of the emitted light is reflected back into the material, spontaneous emitter structures are generally less effective than lasers.



Light dome. Hemispherical shape of emitter assures that light falls within angle of transmission.

To offset total reflection losses, spontaneous light emitters have been built with a light-emitting junction embedded into a GaAs hemisphere. If the ratio of the sphere diameter to the junction diameter is equal to the dielectric constant of GaAs—about 12—no total reflection losses occur. Although absorption losses increase because of the longer light path in the crystal, the dome structure improves efficiency by about an order of magnitude.

Another way to improve external efficiency is to reduce the absorption losses. Because n-type GaAs doesn't absorb light originating at the p-side of the junction as much as p-type GaAs does, the n-type material is used for the dome structure. Solution-grown junctions doped amphoterically with silicon emit light at 1.33 ev, about 0.1 ev below the band-gap energy. In this energy range, the absorption is considerably reduced.

The average efficiency of a planar light emitter in bulk-grown GaAs is about 0.2% at room temperature. The efficiency of a dome-structure device of the same material would be about 2% and that of the best solution-grown diode with a hemispherical exit surface is 20%.

The light emitter's efficiency can also be increased by an antireflection coating with a dielectric such as silicon monoxide to increase the transmissivity of the GaAs-air interface. If the losses due to total reflection bulk absorption are cut, the external efficiencies of lasers and spontaneous emitters should be about comparable. Laser differential quantum efficiencies of up to 40% have been reported for pulse operation.

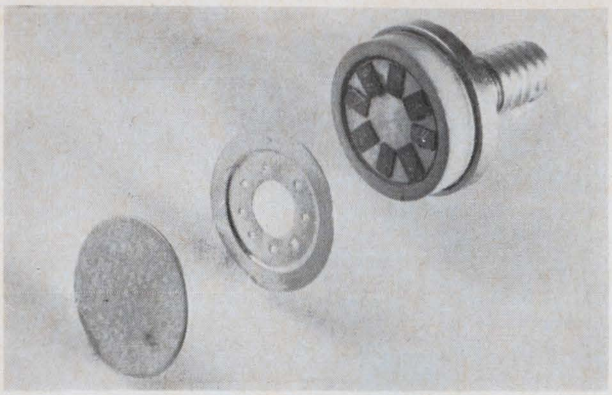
The fact that efficiency generally increases at lower temperatures has never been completely explained, but contributing factors are reduced absorption, increased injection efficiency, and decreased radiative lifetime. Efficiencies of 45% at 77°C have been reported for dome structures in bulk-grown GaAs.

Laser efficiency isn't linked to temperature to any pronounced degree. Differential laser efficiencies of 50% at 77°K have been measured. The threshold current for lasing, however, depends to a large extent on temperature. Typical values are 10,000 amp/cm^2 at 25°C, 1,000 amp/cm^2 at 77°K, and 100 amp/cm^2 at 4°K.

Applications

Spontaneous emitters will probably be the first volume-produced GaAs devices. The two areas where these light sources are most likely to have an impact are data processing and, with GaAs-GaP alloys, indicator lamps. In both fields, solid state light emitters are superior to conventional units in both efficiency and reliability.

Miniature card-reader light sources have delivered 30 milliwatts per ampere total output in a 20° solid angle, and about 15 microwatts of radiant power into a 2.5° solid angle for a diode current of 50 milliamperes. To focus the light, the dome-shaped GaAs emitter is placed in a reflector package. The dimensions of the package, 120 mils diam-



High power. Parallel assembly of Gunn-effect diodes boosts power output.

panies are claiming powers up to 200 mw.

In pulsed research, experiments at Varian have produced 615 watts at 1,100 Mhz. However, the oscillator was restricted to a very low duty cycle because it used crystals grown from the melt by the horizontal Bridgman, or boat-grown, process. Although this technique produces good crystals, they have too much carrier compensation for practical applications.

The highest pulsed powers using epitaxial material are those reported by Radio Corp. of America—143 watts peak at 2,200 Mhz. Also reported by RCA was a device showing 24% efficiency at 112 watts, 1,900 Mhz. This high efficiency was attributed to a controlled doping profile. The RCA investigators also reported stability of both power and frequency against wide temperature excursions.

Commercial devices, however, are still rare. Although several companies are actively developing experimental Gunn diodes, the only ones being offered for sale are by Mullard (5 mw at X band) and Texas Instruments (10 mw at X band).

No compensation

The desired doping level for Gunn effect is about 10^{15} atoms/cm^3. This is less than one part in 10^7, and cannot be achieved in boat-grown material. Thus, the needed high-resistivity n-type GaAs (anything lower than about 5 x 10^{15}/cm^3 in doping density) must be made by compensating the shallow donors, close to the conduction band with acceptors, and allowing the deep donor levels to provide the active electrons. But—because the deep donors are not fully ionized at room temperature—the semiconductor carrier density is sensitive to temperature and can be effectively used only in research applications.

A practical device must be able to operate over a wide ambient temperature range; this alone would rule out compensated material. Even more critical is the fact that compensated material, whose conductivity increases as temperatures increase, will cause thermal runaway and device destruction under modest thermal stress. For example, the impressive data on pulsed LSA devices of boat-grown material applies only to pulse lengths of 100 nanoseconds. Microsecond pulses would probably tell a different story—thermal runaway and a short-circuiting conductive channel.

Keeping pure

More success has been achieved with epitaxial GaAs where the crystal grows in a pure environment at temperatures from 650° to 850°C and the required purity can be held. Purity cannot be held at the melting temperature of GaAs (1,242°C) needed in the boat-growing procedure.

Vapor epitaxy, in which the gallium and arsenic are transported independently to a GaAs substrate, has been used with success for thin layers for several years, but the process is being worked at its limits to achieve the needed purity for Gunn diodes. More recently, there has been renewed interest in growth from a liquid (usually gallium) solution which may offer better control of purity.

A typical Gunn-effect oscillator designed to deliver 20 mw at X band requires a layer of GaAs, grown epitaxially on a highly doped substrate, which is about 10 microns thick, homogeneous in doping level to perhaps 20%, and with an average doping level between 0.5 and 2 times 10^{15} carriers/cm^3.

Many wafers of material with these specifications have been fabricated in a large number of laboratories, yet the yield and controlling process variables are but slightly understood. The saving factor is that the active device is only 0.1 mm across, and it is conceivable that one square centimeter of good material could make 10,000 useful 20-mw oscillators.

The homogeneity problem is even worse with pulsed devices. Pulsed devices require larger areas of gallium arsenide than c-w devices to withstand the higher voltages. For example, an oscillator to deliver 1,000 watts peak at 1,000 Mhz would ideally use about 0.2 cm^2 of material homogeneously doped to 2 x 10^{14} donors/cm^3. It may take another two years to refine the processes enough to do this.

Making contact

Most good ohmic contacts to GaAs fall into two general classes—alloy and epitaxy. Much of the early work with Gunn effect was done with alloyed tin contacts. These seem to give good performance, but are not suitable for operation at elevated temperature, and under some conditions they show fairly rapid degradation. More recently, alloy combinations such as gold-tin, gold-germanium, silver-indium-germanium, tin-nickel, and many others have been reported.

The liquid epitaxy process for growing contacts consists of saturating a pool of liquid tin with GaAs, allowing the mixture to envelop the GaAs wafer and cool a few degrees before removing it. The result is that a thin layer of GaAs, heavily doped with tin, grows on the surface of the wafer. This heavily n-type surface layer may then be easily contacted by almost any metal.

Bulk-effect boosting

By Hartwig W. Thim

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Solid-state amplifiers have been catapulted into the millimeter-wave range by gallium arsenide's negative resistance properties. Studies on these new bulk-effect amplifiers are too recent to say with certainty how practical and widely used they may become. But the signs are good; bulk-effect amplifiers, like bulk-effect oscillators, offer the promise of simple, low-cost devices, competitive with transistor amplifiers which have had tough going at microwave frequencies. Tunnel diodes, the only other solid-state microwave amplifier, could be easily outclassed since they can produce only about a hundredth of a percent of the power available from bulk-effect amplifiers.

Bulk-effect amplifiers can be considered as three basic types:

- The stable amplifier, which has been operated up to 50 gigahertz.
- The traveling-domain amplifier, which has delivered 100 milliwatts at 6 Ghz.
- The unilateral traveling-wave amplifier, which has been operated at 0.1 mw at 1 Ghz.

Stable amplifier

Developed in 1965 at Bell Telephone Laboratories, the stable amplifier—also called a subcritically doped amplifier—uses a GaAs wafer whose product of doping and length, n_oL, is less than $10^{12}cm^{-2}$. This restriction is necessary to prevent Gunn-type oscillations, since the crystal is too short and too lightly doped for the domains to form.

A bias field of several thousand volts per centimeter is applied across the short wafer with only about 20 volts needed to set up this high field. The result is that electrons injected from the cathode are decelerated on their way toward the anode because of the differential negative mobility. A nonuniform field—low at the cathode and increasing across the device toward the anode—builds up and becomes stable after one transit time. The differential d-c resistance is positive, but an applied a-c signal will see a negative resistance at frequencies corresponding to the integral multiples of the transit time. For the 50-micron wafer, the transit time is 0.5 nsec, and the frequencies for negative resistance are 2 gigahertz, 4 Ghz and so forth, up to the millimeter-wave region.

For a three-terminal amplifier circuit, the wafer is mounted in a conventional reflection-type circuit that has a broadband circulator. The incident signal enters port 1 of the circulator, exits at port 2 to the GaAs wafer, is amplified and then reflected back to the circulator and into the load resistance connected at port 3.

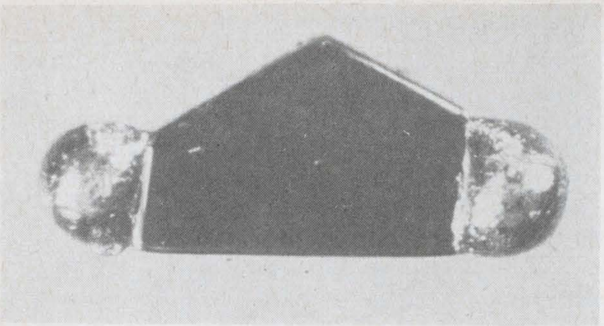
For a typical wafer, about 50 microns thick, the gain peaks at 10 decibels at 4 Ghz, the second harmonic of the fundamental transit-time frequency. Gain can be increased by adjusting the characteristic impedance of the transmission line to a value close to the negative resistance of the diode. However, the maximum output power per unit cross section is restricted by the limitation on the n_oL product. These subcritically doped amplifiers have achieved saturation levels in the order of 1 milliwatt and efficiencies of about 0.1%.

Traveling domain

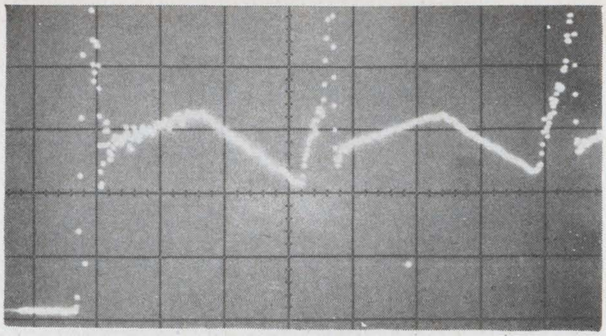
The traveling-domain amplifier uses the negative resistance property of traveling high-field domains in Gunn oscillators. Such domains exist only in wafers with n_oL products greater than $10^{12}cm^{-2}$. Because of the cyclic formation and disappearance of the domains at the contacts, this amplifier, in contrast to the stable amplifier, oscillates at the transit-time frequency while amplifying at some other frequency.

The only difference between the circuits of the stable amplifier and the traveling-domain amplifier is that in the latter a resonant cavity is connected to the coaxial line close to the GaAs wafer to act as a short circuit for the Gunn oscillations. The length of the cavity is thus an integral number of wave-lengths at the transit-time frequency of the Gunn oscillations, and the signal circuit is decoupled from the oscillator circuit, reducing parametric effects.

The traveling-domain amplifier is linear until the output power approaches the power available from the same device when operated as a Gunn oscillator. The maximum output power obtained from a traveling-domain amplifier was 0.1 watt, the efficiency 1%. The upper frequency limit was 11 Ghz, slightly higher than the transit-time fre-



Current generator. Peaked shape of gallium-arsenide sample is reproduced in the output current waveform.



Current wave. Pulses, shown on sampling scope, were produced by a GaAs bulk generator of the type at left.

thick, and ground carefully to desired shapes. The pieces then were cleaned, etched, and alloyed with pure indium contacts.

Another basic type of bulk-effect pulse generator employs contacts placed along the path of the domain to produce extra pulses at any point in the cycle. The contact is separated from the bulk material by a layer of high-resistivity material, an oxide formed by exposing the surface to air for several days. The oxide allows extra current to flow around the domain as the domain passes under it, and this shunt current appears in the output at a point corresponding to the position of the contact. When the domain reaches the anode, it delivers its normal current pulse to the output circuit.

Controlled pulses

The extra current pulse in the high-resistivity region can be switched in and out of the cycle with a switch connecting the contact to ground. The current can then be shunted to ground and won't appear in the output.

Samples operating in this way were made of n-type GaAs with concentrations of 4 to 7 x $10^{14}/cm^3$. A typical size was 40 mils long, 20 mils wide, and 20 mils thick. Pure indium contacts were alloyed to the ends, and the samples were exposed to air for from two to 60 days to oxidize the surface. Silver paint contacts then were applied to the surface to form the control electrodes.

Many applications are possible. For one, a multicontact device could perform logic, and, if the switches on the external current paths were replaced with photoconductive material, could be used as an image scanner.

For more on . . .

Waveform generators: M. Shoji, Proceedings of the IEEE, May 1967, p. 720.

Current pulse generators: M. Shoji, Proceedings of the IEEE, May 1967, p. 710.

Advanced technology V

Over the horizon: gallium arsenide IC's

By Edward M. Mehal

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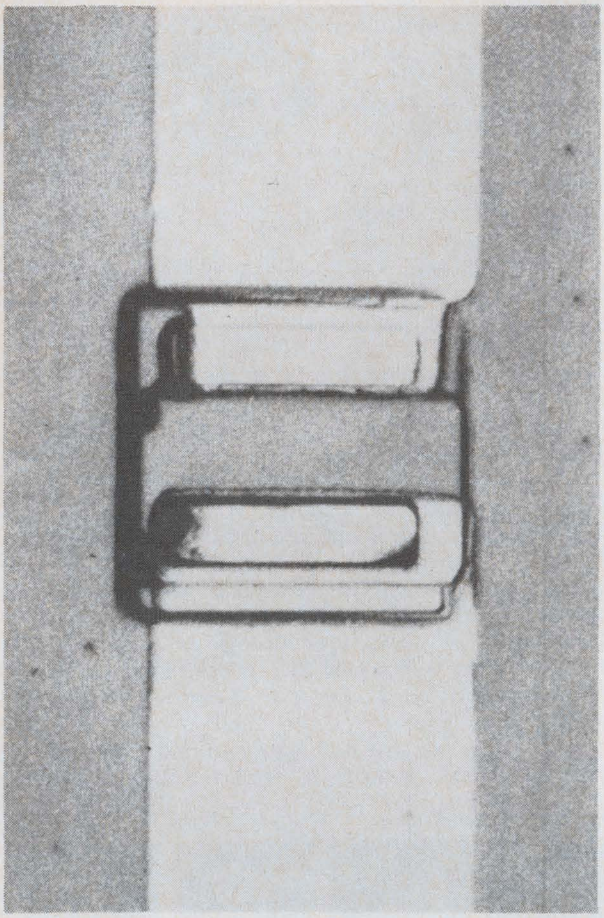
Indicative of today's fast-paced technology is the fact that gallium-arsenide integrated circuits are being developed right along with the discrete devices. Although the additional fact that these IC's cost more than their silicon counterparts and are harder to fabricate will generally limit them to a few special jobs, they do have a clear field in two areas—the microwave and the optoelectronic. The microwave GaAs IC may be with us soon; the optoelectronic IC is farther off.

The key to monolithic gallium-arsenide circuits is the semi-insulating form of GaAs. This material



Gunn oscillator. Planar device designed for use in 94 Ghz microwave-receiver integrated circuit.

provides a single-crystal matrix for the epitaxial growth of GaAs devices and affords excellent electrical isolation between components.

The basic building process sounds simple: pockets are etched in a wafer of semi-insulating GaAs to accommodate active devices, semiconducting GaAs is epitaxially grown in these pockets, and a layer of metalization is added to interconnect the devices with microstrip transmission lines. Of course, there are practical problems—how to get the semi-insulating GaAs, etch clean-cut holes, and grow pure epitaxial layers.

Fabrication

The first step in the process is to orient the GaAs semi-insulating substrate to a 111 surface and then to chemically polish the surface to remove any defects. As a mask, a silicon dioxide film about 0.3 microns thick is applied externally by sputtering or chemical deposition methods; the best method found at Texas Instruments is the thermal oxidation of tetraethylorthosilicate (TEOS).

Next, the pockets delineated by the SiO_2 mask are etched out. Most of the common etching techniques produce holes with irregularly shaped bottoms, due to greater etching around the periphery of the hole. But this effect has been eliminated with a hydrogen peroxide-sodium hydroxide solution that's reaction-rate limited rather than diffusion-rate limited and yields an etched hole with a planar bottom.

Care must be taken when semiconducting GaAs is deposited in the pockets; if these depositions project above the surface, masking will be upset. Pockets of different dimensions must therefore be filled separately to minimize overgrowth in the smaller ones. Regions with overgrowth of less than 1 micron have been achieved on 111-oriented substrates. The semiconducting GaAs used has a fairly low impurity content—around $1 \times 10^{15}/cm^3$—and can be controllably doped with sulfur or tin to produce the required n-type carrier concentration for the devices.

Possible components

Planar bipolar transistors that could possibly be used in integrated circuits have been fabricated by Wilhelm von Muench of the International Business Machines Corp. lab in Boeblingen, Germany. He used one selective deposition of n-type GaAs into semi-insulating GaAs, and formed base and emitter regions by planar diffusions. Field effect transistors also have been fabricated on semi-insulating GaAs substrates, and these too might find employment in integrated circuits.

Microwave circuitry has been the principal area of application. Gunn oscillators and Schottky-barrier diodes made in planar form with selective deposition techniques are now being combined into microwave IC's.

The planar Gunn oscillators, which have operated at up to 28 Ghz, require three selective depositions of GaAs—two n^+ regions for contacts, and an n^- area as the active region.

An IC for the front end of a 94-gigahertz microwave receiver is being built at TI under a contract from the Air Force Avionics Laboratory, Wright-Patterson Air Force Base, Dayton, Ohio. It consists of a Gunn oscillator in a resonant circuit operating at about 31 Ghz; a tripler circuit that converts the 31-Ghz Gunn oscillator signal to 94 Ghz to serve as the local oscillator source; and a balanced mixer using two Schottky-barrier mixer diodes.

For more on. . .

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Schottky-barrier diodes: T.H. Oxley, J.G. Summers, Gallium arsenide—Institute of Physics and Physical Society Conference Series No. 3, 1967, p. 138.

Suitcase-size memory for longer space trips

Employment of pulse techniques and MOS transistors results in a portable computer storage that dissipates only 3.5 watts, reducing power requirements and stretching mission times

By Dewey E. Brewer
Wright-Patterson Air Force Base, Dayton, Ohio

and Samuel Nissim and George V. Podraza
Bunker-Ramo Corp., Canoga Park, Calif.

Just as a businessman steps off a plane with attaché case in hand, so may an astronaut someday step out of a spaceship, onto the moon or Mars, carrying a computer. The idea isn't far-fetched. A portable memory dissipating only 3.5 watts and designed to fit into a 21-inch suitcase is now being evaluated by the Air Force for various classified applications.

The memory is the first of what is expected to be a whole family of complex digital equipment, each unit of which will dissipate only a small amount of power—provided perhaps by a self-contained battery—and will be portable.

Development of integrated-circuit technology from gate to function to system levels has reduced the cost of such assemblies, and the amount of power they require. A production run of memory systems based on the prototype design would perhaps cost as little as 10 cents per bit in 1972, and might dissipate even less power if individual transistor tolerances were tightened. The 10-cents-a-bit level is about the price of present conventional magnetic memories.

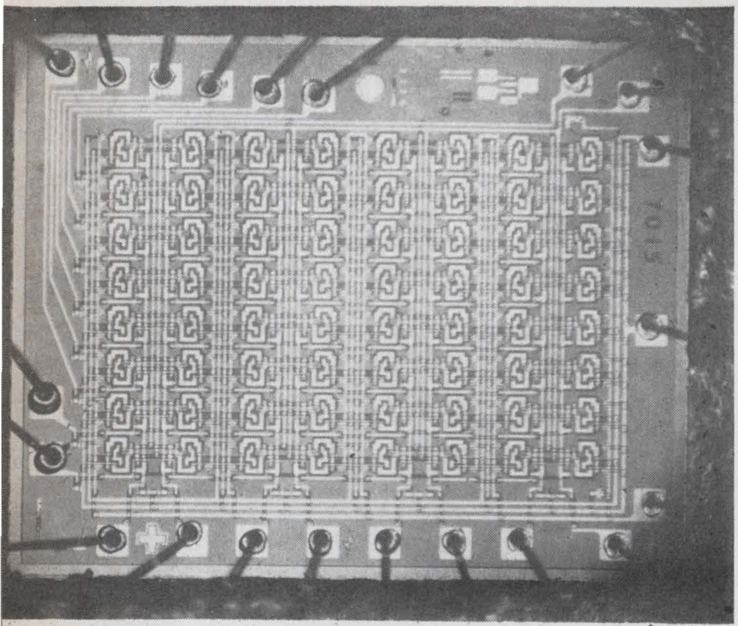
At such costs, semiconductor memories would be competitive with conventional types made of ferrite cores or thin films, particularly in such sophisticated applications as associative memories, scratchpads, input-output buffers, and index registers. And low power dissipation would give semiconductor circuits the edge in aerospace applications, where the weight of power sources is always a problem. Ferrite cores need high driving power, and the thin films' small output signals demand complex sense amplifiers that also require high power.

Cutting power

Power reduction was at least as important a consideration as size in the development of the memory. Designers concentrated on the memory rather than on an entire computer, because the memory subsystem dissipates 40% to 60% of the total power in present aerospace computers. Paring memory power requirements could, therefore, significantly reduce over-all power requirements and the weight of power supplies, thereby extending mission times. Low power dissipation was emphasized at the expense, where necessary, of other parameters such as size and weight; a little extra weight devoted to power conservation, it was reasoned, can save many times more weight in power supplies.

The prototype model in the suitcase is a random-access memory suitable for production at reasonable cost. It has 1,024 words of 30 bits each, built with metal oxide semiconductor transistor arrays for storage, and bipolar transistors for the peripheral accessing circuits. It provides nondestructive readout with an access time of 0.7 microsecond, and a full read or write cycle of 1 microsecond.

The designers chose these integrated circuits because pulsing permits MOS flip-flops to be operated at a very low power level, and because MOS is well suited to low-cost large-scale integration. The bipolar devices used in address decoders,



Memory chip. The 64 individual cells are easily discernible in this microphotograph.

x-address line is common to all the cells in a single row of a chip, and one y-address line is common to all the cells in a column. Therefore, one x-address and one y-address pulse select a single cell on the chip. The y-address opens the gate of Q_7, applying the negative level of the x-address to the gates of Q_5 and Q_6 and turning both transistors on.

To read data from the cell, both digit lines are kept at or near ground. Assume that Q_1 is conducting and Q_2 is off. When Q_5 and Q_6 turn on, current from Q_1 flows into the corresponding digit line through Q_5; no current flows through Q_6 because the drain of Q_2 is already at ground. A differential amplifier of them is receiving the current, and thereby connected to the digit lines senses which senses the state of the addressed cell.

To write data in the cell, a positive-going pulse is applied to one of the two digit lines while the other remains at ground and while Q_5 and Q_6 are on. If, for example, this positive pulse appears at the source of Q_6, it is transmitted to the drain of Q_2 and thence to the gate of Q_1, which, if previously conducting, turns off. The drain of Q_1 discharges to ground through Q_5 and the other digit line, and this ground level then turns on Q_2, reversing the states of the bistable elements.

The monolithic chip shown in the microphotograph at left measures 80 by 100 mils and contains 64 memory cells. These cells contain one bit in each of 64 different words. Thus 30 of the chips can store 64 full 30-bit words, and 16 sets of 30—480 chips altogether—give the 1,024-word capacity of the memory. Each chip is mounted in an individual 22-lead flatpack.

Pro and con

The addressing method employed is similar to the coincident-current technique common in magnetic memories except that the MOS array uses coincident voltages. The MOS memory has a number of advantages over magnetic memories; for one, it requires simpler peripheral circuitry because its inherently non-destructive readout makes it unnecessary to regenerate stored data after reading it out. The relatively high-amplitude read-out signals from the array and high signal-to-noise ratio of the output also simplify the peripheral circuits. Nevertheless, the memory's power dissipation is mostly in the peripheral circuits, not in the storage elements, as in magnetic memories.

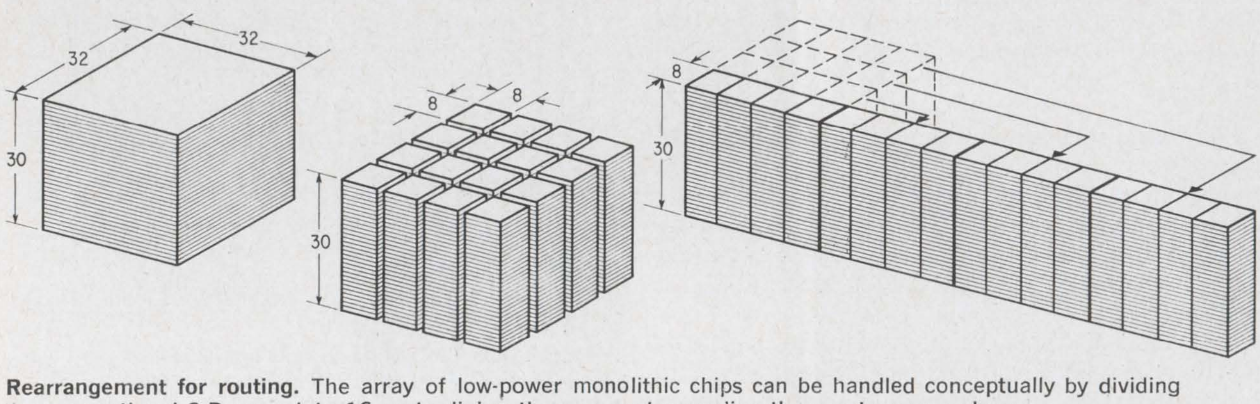
Volatility is the principal disadvantage of the MOS memory, as compared with magnetic memories. Even momentary loss of power invariably causes loss of data. This difficulty is somewhat offset by the low power consumption, which makes an auxiliary battery source practicable to prevent data loss.

Also, the MOS memory cannot be used at temperatures over 60°C., nor unshielded in the presence of nuclear radiation.

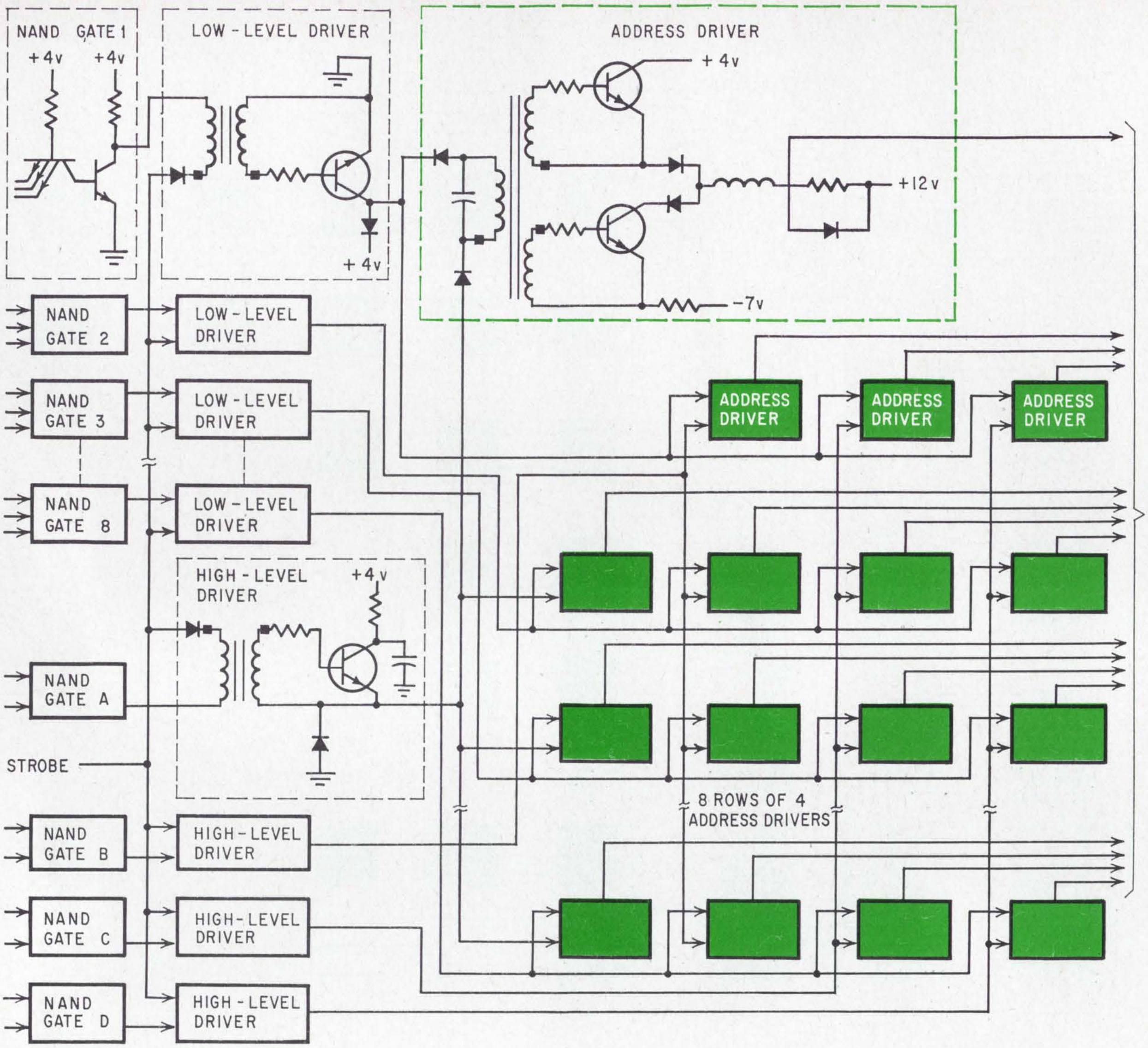
Mad but methodical

The 1,024 words in the memory are addressed by 32 x-address lines and 32 y-address lines; one of each can locate any single word. However, each bit of the word is on a separate chip, so that each address line must be connected to 30 different chips. This leads to a rather complicated routing of the address lines.

The easiest way to visualize the routing is by analogy with a conventional three-dimensional memory. Such an organization contains 30 planes, stacked vertically, with 1,024 bits—one bit of each



Rearrangement for routing. The array of low-power monolithic chips can be handled conceptually by dividing the conventional 3-D array into 16 parts, lining them up and spreading them out on one plane.



Address decoder. A matrix arrangement translates five bits from the memory exerciser into 32 address lines that locate a specific word in the memory. A new inductive line driver circuit reduces the power dissipation [see detailed schematic diagram on page 145].

drivers, sense amplifiers, and timing circuits. The feasibility model also contains a memory exerciser (in the same suitcase!), which supplies write data and checks read data for errors.

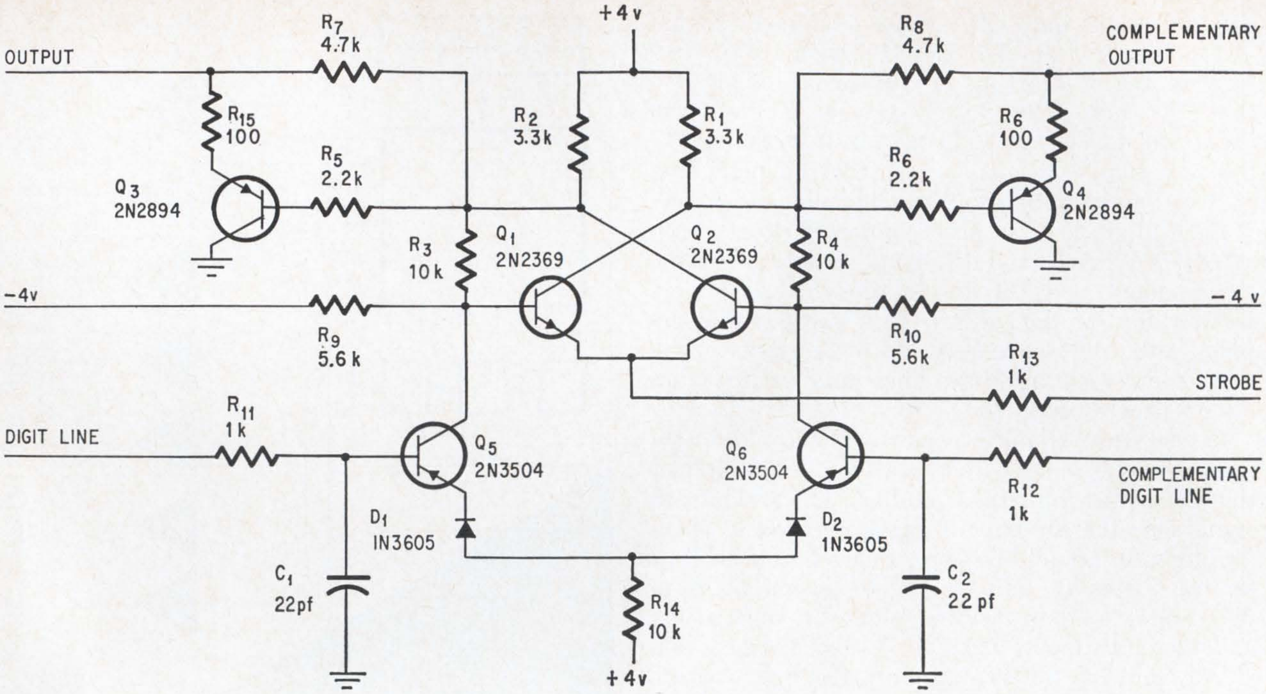
The 1,024-word capacity requires a 10-bit address, which is divided into two five-bit parts, one for x and one for y. A common pair of digit lines connects all 1,024 memory cells corresponding to a specific bit in each word. One or the other digit line is pulsed by the write driver when data is being written, and current on one or the other digit line is picked up by the sense amplifier during a read operation. Write and read strobe signals activate the corresponding circuits during the respective operations, so that data being written does not pass through into the sense amplifiers.

On the periphery

Two identical address decoders generate the x and y signals for addressing the memory. The memory exerciser transmits 10 bits and their complements to the decoders—five bits to each decoder. In the decoder, eight NAND gates—standard commercially available integrated circuits—decode three of the five bits, and four other NAND gates decode the other two. A given address actuates one high-level and one low-level matrix driver, which together select a single address driver out of a 4-by-8 matrix of address drivers; the low-level driver is actually only a ground return for the high-level driver. The address driver generates a signal on one of the 32 address lines.

The memory exerciser transmits the data to be written into the memory, each bit with its complement, on 60 lines to the write drivers, and the write command signal activates those drivers that have binary 1 inputs, placing the signal on the corresponding digit lines.

In the driver's quiescent state, transistor Q_4 is conducting, as in the schematic opposite, ground-



Sense amplifier. In the absence of a strobe pulse, this circuit is completely "off." A current differential on the two digit lines biases the flip-flop in the center, and the strobe sets the flip-flop in one of its two stable states, establishing the two complementary outputs.

occur if a restore pulse were applied simultaneously to the entire memory, the memory is divided into eight sections that receive a pulse one at a time in rotation. A self-contained restore clock, asynchronous to the rest of the system, steps a three-stage counter and, following each count, delivers a pulse to one of the eight drivers in an order determined by a decoder. The restore pulse driver circuits are quite similar to the address drivers.

Timing control is done entirely by integrated monostable multivibrators.

Pack it in

The MOS storage elements are packaged on both sides of two multilayer printed-circuit boards, each 12 by 14½ inches; a third board carries the x-address decoder and the restore generator, and a fourth carries the y-address decoder and control circuits. All these boards are mounted in one end of the bottom of a Samsonite suitcase; the power supply is in the other end of the bottom. The memory exerciser is mounted at the top and connected to the memory by two connectors. An external computer could also operate the memory through these connectors.

The total measured power of the assembly is 3.4 watts, when the ratio of write to read operations is 3:10, the clock rate is 1 megahertz, and temperature is between 0° and 60° C. Continuous writing of data that repeatedly changes the state of every storage element in a word requires considerably more power than continuous reading, of course. Such continuous writing involves the active driving of many circuits rather than merely the detection of their various states.

The memory array itself dissipates slightly less than 1 watt, thanks to the restore-pulse technique. The exact figure is 930 milliwatts, or 30.3 microwatts per cell. Another 0.7 watt is dissipated in the 64 address driver circuits, of which only two are in operation at any one time; the smallness of this amount reflects, to a large extent, the special switching circuits.

The technique for cutting the dissipation can best be understood by comparing it with the straightforward driving technique. The address, digit, and restore lines in the memory array present relatively large capacitive loadings to their respective driving circuits. The energy, W, stored in this distributed capacitance is

$$W = \frac{1}{2}CV^2$$

where C is the total capacitance in farads and V is the voltage across the capacitance.

The energy stored in charging the capacitance is, of course, returned when the capacitance discharges, because the capacitance itself ideally dissipates no energy. However, energy equal to that stored is dissipated in the resistance through which the capacitance is charged (to demonstrate, square the exponential expression for the current in an RC circuit, multiply by R, and integrate), and this amount of energy is dissipated in both the charging and discharging processes. Therefore, the total amount of energy dissipated in a single charge-discharge cycle is

$$W = CV^2$$

Power is the average rate of energy dissipation and V_1 must therefore be of greater magnitude than V_2 to compensate.

The address driver, shown at the bottom of page 145, embodies the design principles illustrated in the idealized example. The line capacitance is initially charged to +12 through resistor R_4. The primary of the transformer is shunted by a capacitor that balances the stray capacitance of the network when the high-level driver is actuated and the low-level driver is not. When the high-level driver turns on, therefore, the voltage appears across the transformer, turning on transistor Q_2.

The saturated transistor connects the line capacitance through inductance L_1 to the —7-volt supply, and the resonant circuit begins to oscillate. But after only half a cycle, diode D_4 becomes reverse biased, thus effectively disconnecting Q_2 from the output.

When the high-level driver turns off, the transformer input voltage drops quickly, turning on transistor Q_1. (Observe the polarity marks on the transformer windings.) The line capacitance charges up to its initial level through Q_1.

When circuit losses and semiconductor voltage drops are considered, the parameter values shown provide a 26-volt negative pulse on the address lines. The angular frequency given by a 2.7-microhenry inductance and 1,500-picofarad capacitance is 15.8×10^6 radians per second, corresponding to address-pulse rise and fall times of about 0.2 microsecond each.

The same technique is also used in the restore drivers, but not in the write drivers. The high digit line capacitance would have made additional power supply voltages necessary for an inductor-and-switch circuit. But the write drivers normally contribute very little to total system power because of their low duty cycle.

The sense amplifiers dissipate very little power because they are essentially shut off in the absence of any input signal or strobe.

Up the road

Advanced as this memory system is, further improvements are in sight. The list includes:

- Complexity. About four times the number of bits could be built on a single chip with today's technology if a tenth the speed of the present low-power memory, or less, is permissible. With such a design, the same flatpack could also contain peripheral and restore-pulse circuits.
- Speed. When metal-over-metal crossovers are developed to the point where they can replace the present junction crossovers, they will afford either double the speed or double the density of the present chip, and could permit a substantially reduced restore-pulse duty cycle. Complementary MOS devices could boost the present model's speed by a factor of 10 or more.
- Power. A lower-frequency restore pulse would reduce power dissipation even further, and by a significant amount.
- Cost. Volume production is bound to bring it down. Duplicating the present model would cost something over $2 per bit. A production run of 1,000 systems would cost perhaps 50 cents per bit.
- Size. Larger memories following the present design could be easily made by adding flatpacks. The limiting factors would be reduced readout signal-to-noise ratio because of crosstalk, and the additional capacitance on the digit lines, with the resultant loading on the driver circuits. The size of the present memory could probably be double or quadrupled with only minor modifications—new shielding, new inter-connection boards, an 11-bit decoder, and perhaps a bigger suitcase. Memories larger than 4,096 words are practical, but would require multiplexed driving and sensing circuits, and would therefore dissipate somewhat more power per bit.

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The authors

Dewey Brewer joined the Air Force Avionics Laboratory in 1962 and has since worked mostly on memory devices and systems. Previously he worked for the Martin Co. in Orlando, Fla., designing ground-support equipment for the Pershing missile system.

Sam Nissim is the manager of advanced computer development in Bunker-Ramo's information technology laboratory. Before 1964, he worked in the computer division of Thompson Ramo Wooldridge Inc., Bunker-Ramo's corporate predecessor.

George Podraza is a staff consultant specializing in circuit and hardware design. He has been with Bunker-Ramo since 1963, coming from the Martin Co. in Baltimore.

Circle 147 on reader service card→

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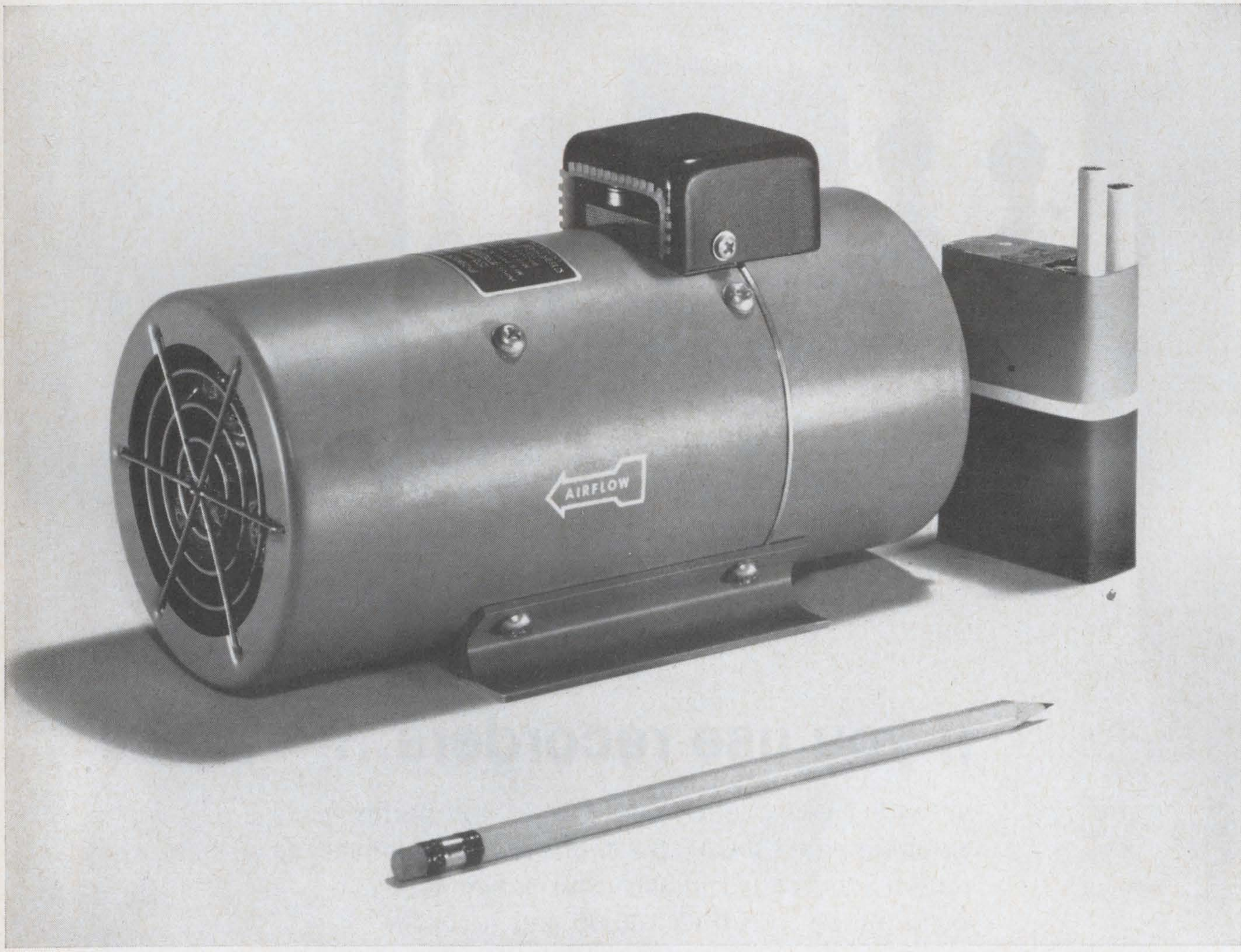

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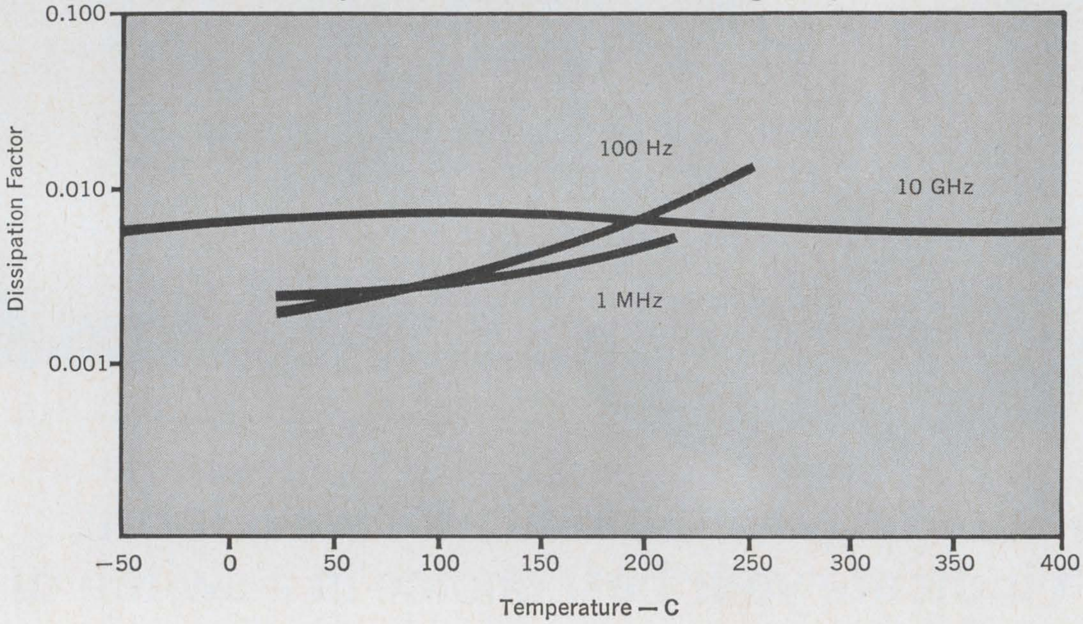
Dissipation factor of silicone molding compound



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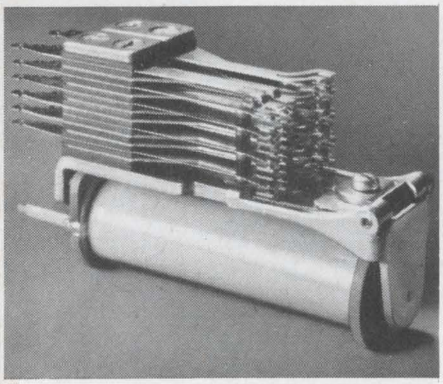

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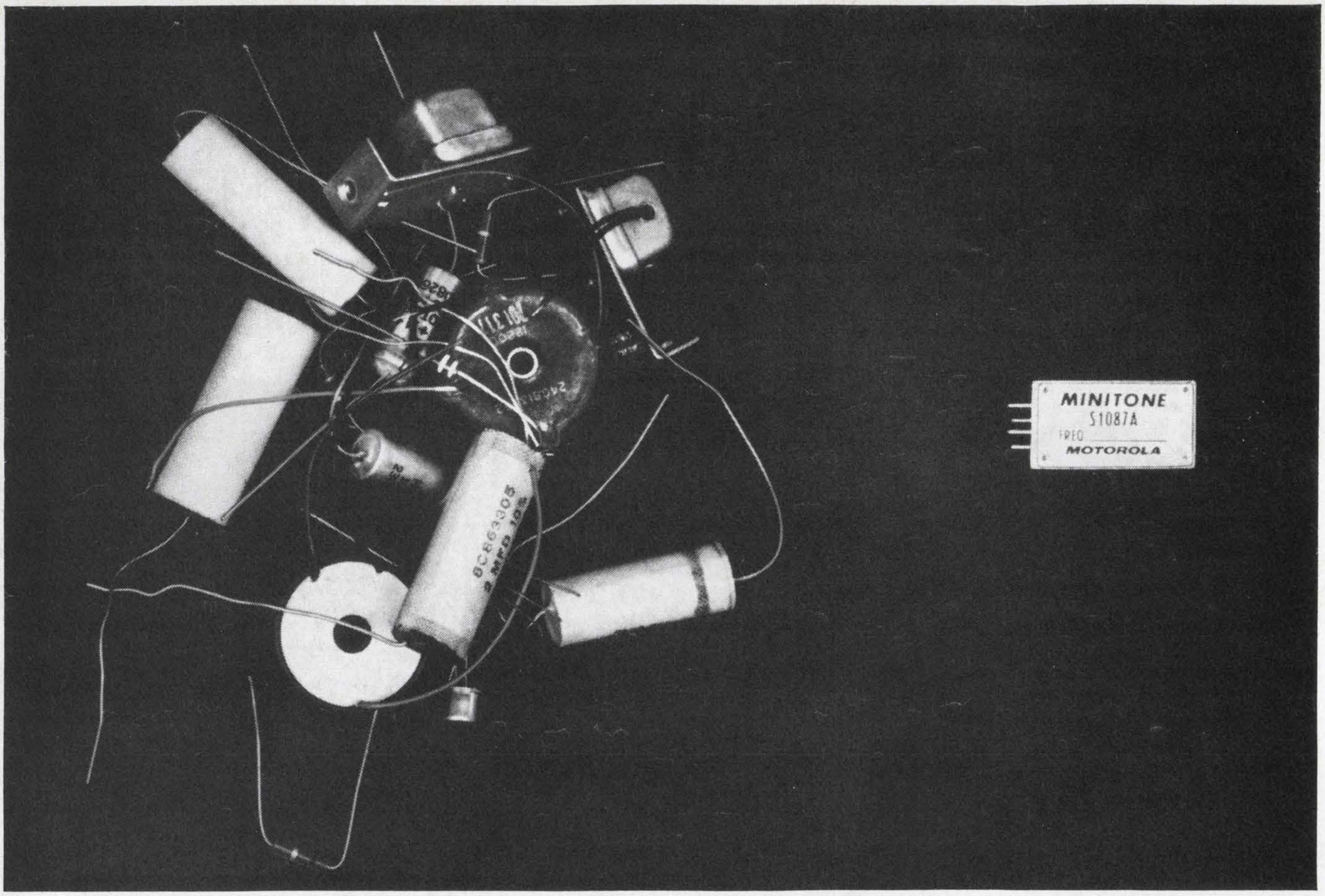

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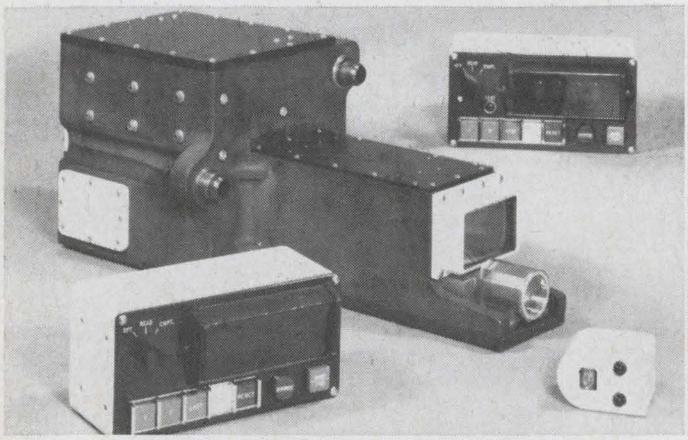

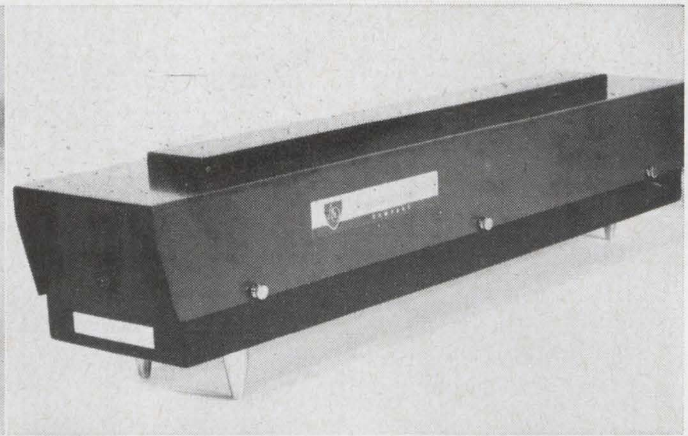

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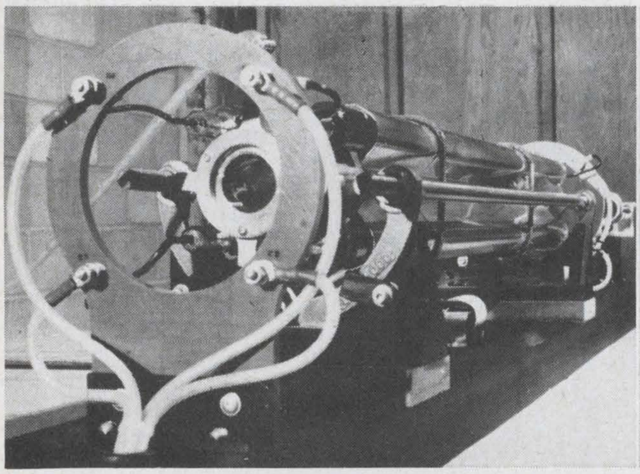

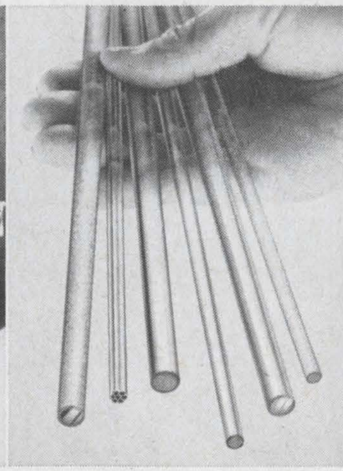

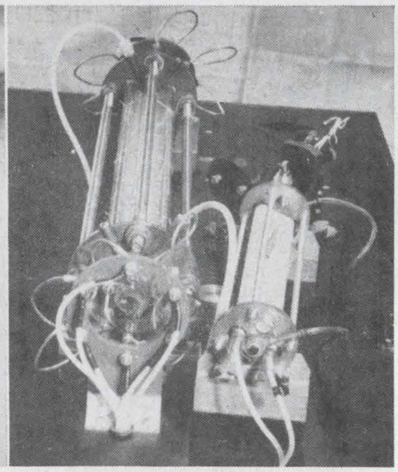

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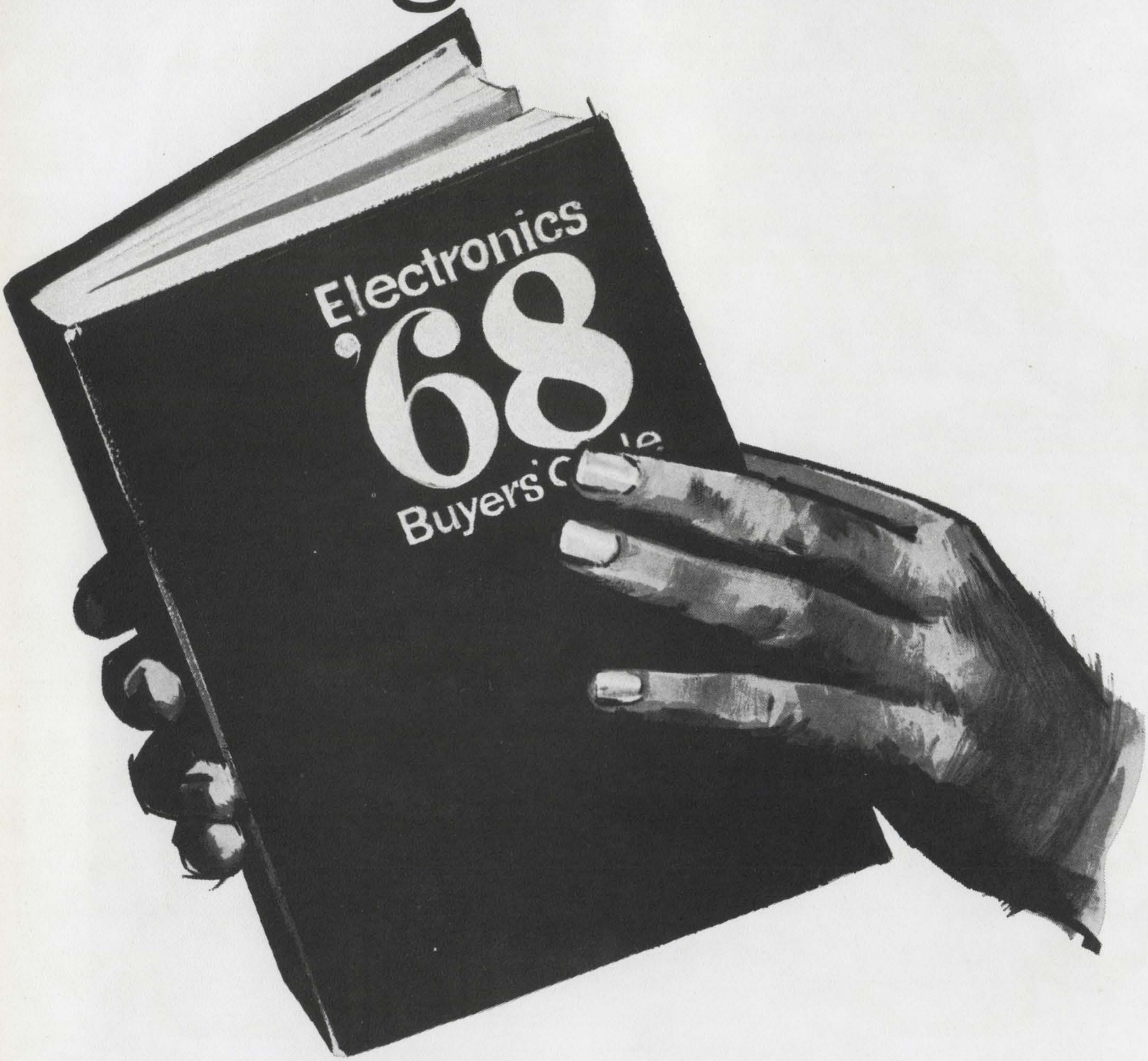

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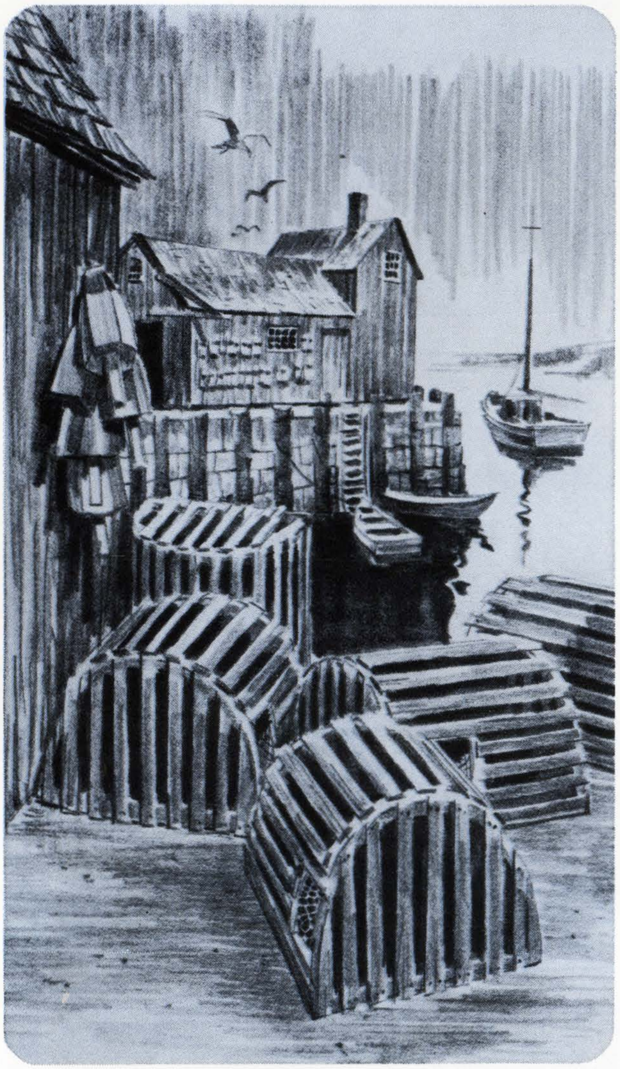
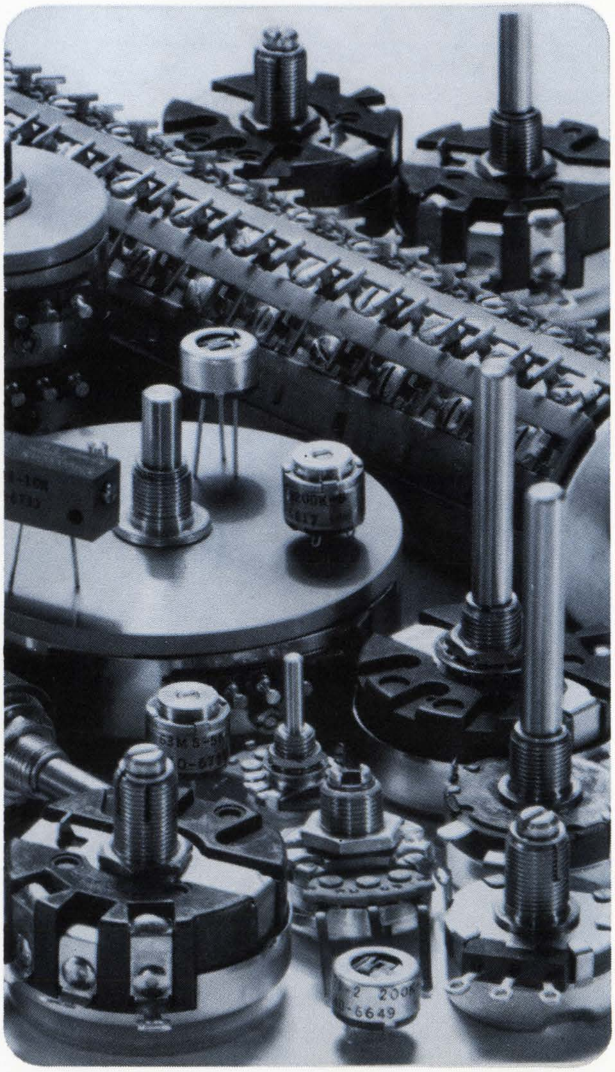
Pots ....a New England Tradition





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EFFECTIVE OCTOBER 1, 1967

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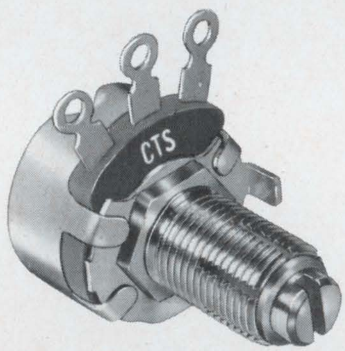

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3KΩ to 1.35 meg.	−100 to +250	±100
1.36 meg. to 5 meg.	±250	±150
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. . . Motorola emitter-coupled logic is used in the digital ranging gear . . .

ground link sub-system gear.

Motorola's SGLS contract specifies that the firm will provide Philco-Ford with a ground receiver and analog ranging equipment, essentially a monopulse tracking system, according to Kemmeries; digital ranging equipment; a digital range rate extractor; a demodulator; a doppler frequency converter; a baseband separation unit; and a 1.7 megahertz biphase subcarrier demodulator. Motorola expects to finish its share of the SGLS work before the first site—Hawaii—goes operational.

I. Versatile receiver

The SGLS antennas are slaved to the receiver. Motorola built a receiver for TRW for the developmental ground stations but the current model has been redesigned. A wideband autotracking mode, incorporating a frequency synthesizer for continuous tunability over the SGLS spacecraft transmitter range of 2,200 to 2,300 Mhz, has been added as has fault-isolation circuitry and indicators that permit tracing of malfunctions to any of the 50 individual subassemblies. The fault isolation feature gives a 15-minute mean time to repair, says Kemmeries. The wideband autotrack mode is required because the receiver is a monopulse unit, and has recently been given the job of pointing the 60-ft. antenna for the ASGLS carrier. The unit already had the antenna pointing job for the SGLS carriers.

The SGLS has two down-link carrier waves. The first—carrier 1—provides return ranging and various low-data-rate subcarriers up to 1.7 megahertz. The second—carrier 2—provides telemetry data at rates up to 1 million bits per second.

Pickup. When SGLS carrier 1, the basic S-band carrier, is operating, the receiver provides two error outputs—one each for azimuth and elevation. The 60-ft. antennas have four feedhorns picking up signals from the spacecraft. The receiver processes the outputs from the horns, summing and differencing them to provide an error signal. These are S-band signals, which the receiver converts to two analog d-c voltages—one each for azimuth and elevation.

The error is zero when the spacecraft "is dead center on the antenna," says Kemmeries. A plus error or minus error is generated if the spacecraft is off center, and the error is fed to the antenna servo system to position the antenna properly in azimuth and elevation. Kemmeries says this antenna signal error detection function is performed in either a phase-locked or wideband mode; the 60-ft. antenna is monopulsed while the 14-ft. unit is conically scanned.

In addition to detecting antenna signal errors, the Motorola receiver also does data-demodulating for the principal carrier for range, range rate, and telemetry signals. The digital ranging equipment is connected to the receiver and the ground station transmitter. This apparatus provides a digital code word, which the transmitter sends to the spacecraft's transponder. The word is a pseudo-random noise signal with a length of more than 5 million bits and a duration of 5 seconds, giving the ranging equipment the ability to track spacecraft at lunar distances—even though the Air Force requires only a synchronous orbit ranging capability.

II. Odd jobs

The retransmitted signal sent back by the spacecraft transponder is demodulated by the receiver and fed to the digital ranging equipment; the system's accuracy is approximately 100 yards. All active circuitry in the digital ranging equipment uses Motorola emitter-coupled logic supplied by the company's Semiconductor Products division. Kemmeries says there are 31 cards in the ranging equipment, with about 500 MECL packages per system.

Range rate—the spacecraft's speed—is determined this way: analog doppler outputs from the receiver are fed to the doppler frequency converter, which processes them together with a subcarrier 1 and carrier 2.

Receiver refinements. A threshold improvement demodulator in the receiver demodulates carrier 3's f-m data, using a wideband modulation tracking phase-locked loop that yields a 4-decibel threshold improvement. "This means that you can have 4 db less signal before you reach the deterioration point where the f-m signal is lost in noise," Kemmeries explains. He says that this is equivalent to extending antenna diameter from 60 ft. to about 95 ft.

The most significant features in the SGLS receiver, say Motorola officials, are the 4-db threshold improvement, the wideband autocorrelation capability with spectrums up to 35-Mhz of bandwidth, and tunability across the band using a frequency synthesizer in the phase-locked mode. These are all state-of-the-art developments, Kemmeries says. For wideband autocorrelation, the receiver compares the signal on a sum channel with signals on two angle channels, and puts out a d-c signal proportional to the antenna-pointing error.

Motorola has a line of standard radio-frequency components in the receiver called E, for extruded, and P, for potted, modules. The E module is a standard plug-in aluminum housing for all r-f packaging; the P modules fit inside. Motorola has 19 standard modules, including phase detectors, mixers, wideband amplifiers (100 to 200 Mhz with relatively flat response), variable gain amplifiers, power amplifiers, video amplifiers, and phase shifters. These units are epoxy potted and plated with tin for r-f shielding.

Two for one. A typical SGLS ground station will have one of each of the ground station subsystems plus a backup. "This redundancy, in effect, gives you two stations at each site," Kemmeries says.

III. Advanced link

A typical advanced space-ground link subsystem terminal will have three wideband receivers, each with an f-m demodulator. There will be three pcm demodulators and two pcm bit synchronizers. All of these units are connected in-line. In addition, there will be two pieces of automatic checkout

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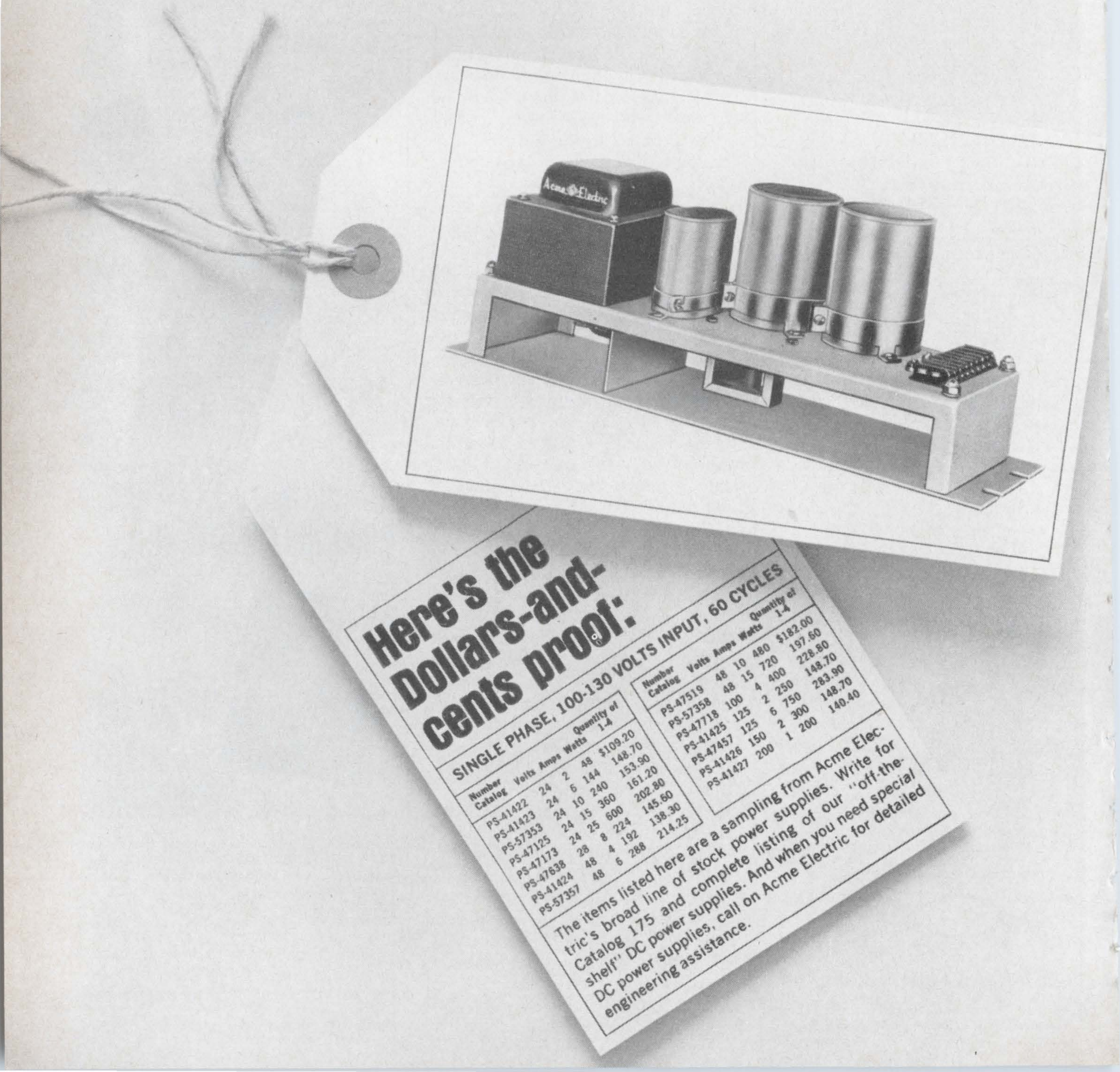


... uhf broadcasting is ill-served by those who minimize its problems...

equipment was a couple of years behind vhf progress. Rather than risk criticism for further delays, the commission gave vhf a go-ahead in 1948.

By 1949 so many stations operating in the same channels were interfering with each other that a three-year freeze on allocations was necessary. While the commission was studying the situation, uhf boosters watched in dismay as millions of tv sets equipped to receive only vhf signals rolled off production lines.

In 1952 the FCC rescinded its ban and opened up the uhf band. But there was little incentive for broadcasters to build stations because the chances of set owners spending extra money for uhf equipment were nil.

Eventually, the vhf band became so crowded that Congress—at the behest of the FCC—passed the all-channel law in 1962 in an effort to stimulate investment in uhf stations. Statistically, the legislation has proved a big success: an estimated 50% of the sets now in use around the country are equipped to receive uhf. And as of October the number of on-the-air uhf stations totaled 204, as against 573 vhf installations.

Mournful numbers. For all their optimistic projections, uhf operators and FCC officials are well aware that sets with uhf receivers are one thing and sets with uhf antennas quite another. Good reception of uhf tv signals depends as much upon the quality of the antenna used as it does upon the effective radiated power level of the transmitter. Although no definitive data have been compiled, there is a significant discrepancy between the total of all-channel receivers in use and the number that can get a good uhf signal without being tied into a community antenna television operator's system.

A source in the FCC's broadcast bureau is philosophical about the disparity. He says: "It's up to the set owner. If he wants good uhf reception, he should invest in a quality yagi antenna." However, the commission is apparently content to permit this position to popularize itself among consumers.

II. Bad press

Controversy over the quality of uhf television signals has also proved something of a drag on the field's growth. Network spokesmen in particular insist that uhf transmission is inherently inferior to vhf. However, the evidence suggests that any disparity is the result of economic, rather than technical, factors.

Test case. In 1961 the FCC got $2 million from Congress to check the quality of uhf signals in New York City. A 50-kilowatt transmitter and an antenna mounted atop the Empire State Building were used. The experiment, conducted in a metropolitan area with every conceivable type of interference, proved that uhf signals are virtually indistinguishable from vhf. And, concluded the final report, under ideal conditions, the picture, in both black and white and color, is clearer. In addition, engineers say that because there is less man-made noise in this band, a light signal—assuming power is adequate—is inherently better than vhf.

The FCC has established 5 megawatts as the maximum permissible effective radiated power level for uhf stations. While one broadcaster is known to have boosted his signal into the 4-megawatt range with 110-kilowatt transmitter and a 1,000-foot-high tower antenna, the majority of new uhf stations simply cannot afford the kind of investment involved in such facilities.

III. Prose and Cons

Nor is uhf's cause particularly helped by efforts to minimize its difficulties. For example, William Walker, director of broadcast management for the National Association of Broadcasters, frequently speaks of the industry's rosy prospects at the trade group's regional get-togethers. The only factors that could retard the growth of uhf, says Walker, are direct broadcast satellites and CATV.

Actually, satellites are well

Playing the field

Cable tv operators are moving nimbly to exploit the opportunities available to their medium. Among the newest: a service that will use CATV facilities to pretest the impact of television commercials in consumers' homes. A joint venture of the H&B American Corp., a large cable system operator, and Audits & Surveys Inc., a marketing research firm, the new company, Television Testing, will go after advertising agency trade.

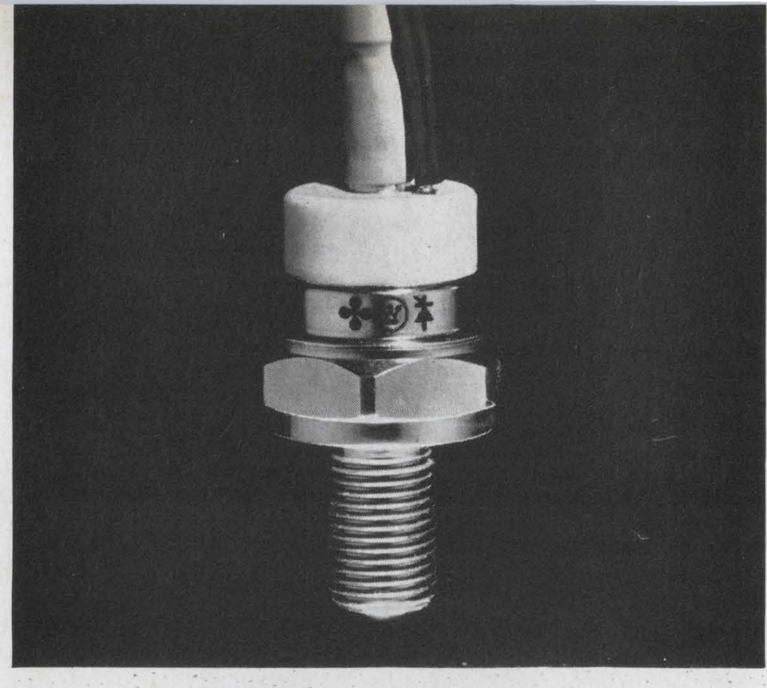
The demographic and brand preference characteristics of four medium-sized markets—Ventnor, N. J.; Lompoc, Calif.; Dubuque, Ia., and Walla Walla, Wash.—are being profiled for storage in computers. These data banks can be sampled to get the reactions of specific audience groups.

Viewers selected by the computer will be advised to watch a certain program when tests are scheduled. A monitoring device will determine how many sets were tuned in for how long. Phone calls will be made to test consumers' recall and the results verified later by market surveys of the test area. The service will start in January.

it will be up to the FCC to reevaluate its position concerning the industry's right to import signals."

Another difficulty for uhf operators centers about network affiliation. A spokesman at one of the big three puts it this way: "The networks prefer not to spill programing into uhf; they do so only when there are no other outlets in an area." This source cites two reasons for this policy: "There is at best a 50% penetration of uhf receivers in the television market, and even with a maximum effective radiated power the quality of a uhf picture is not as good as vhf."

Niche. Since uhf's future will be determined to a large extent by the fate of the vibrant CATV industry, many observers believe the whole broadcast field must reorient its goals to accommodate the upstart. Siegel, as well as several FCC commissioners, suggests that uhf operators should seek to provide viewers with programing unobtainable elsewhere. Shows keyed to self-improvement including cultural, educational, and community-interest formats are among the possibilities.



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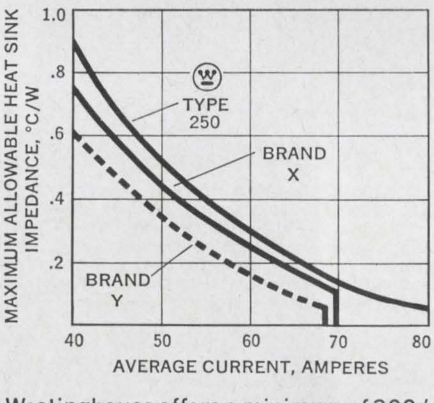

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COMPARISON OF PERFORMANCE CHARACTERISTICS — 70-80 AMP DEVICES

	Ⓦ250	BRAND X	BRAND Y
Current (I_{RMS}/I_{AVE})	125/80	110/70	110/70
Applied Current (θ_{SA}=.125°C/W, T_A=40°C)	71.5	64.4	70.0
Voltage (V_{FB}/V_{FT})	1500/ 1800	1300/ 1550	1300/ 1560
dv/dt (Exponential to full V_{FB})	300	200	200
I_{gt} (T_J = 25°C)	100	150	150

COMPARISON OF PERFORMANCE CHARACTERISTICS — 35-40 AMP DEVICES

	Ⓦ251	BRAND X	BRAND Y
Current (I_{RMS}/I_{AVE})	63/40	55/35	55/35
Applied Current (θ_{SA}=.44°C/W, T_A=40°C)	40	35	35
Voltage (V_{FB}/V_{FT})	1500/ 1800	1300/ 1550	1300/ 1560
dv/dt (Exponential to full V_{FB})	300	200	200
I_{gt} (T_J = 25°C)	100	100	150

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SC 2092

... Comsat's sweeping proposals for Intelsat were artfully timed ...

will be done outside the U.S.

Some of the more important members of the consortium would like an even bigger share of the contracts, however. Japan, a number of European nations, and Australia would like the 1969 agreement to stipulate that every third satellite be built outside the U.S. Such a provision is probably unrealistic, this official says, because most nations trail the U.S. in such key fields as reaction controls and apogee motors.

Play for time. But there may still be some international foot-dragging on Intelsat 4 in the hope of a better deal after the 1969 renegotiation. Intelsat has to get the interim committee's approval for the launch, scheduled for 1970. If a go-ahead could be put off, some reason, many countries could catch up technologically.

The U.S. executive believes the less developed nations won't put obstacles in the way of Intelsat 4 since they badly need the communications services it could provide. He also holds that Comsat should continue to oversee international operations, but that management of regional and domestic systems be delegated to area associations and individual countries.

III. Skillful ploy

Comsat's sweeping proposals for Intelsat's future were artfully timed. Most interested parties have had insufficient time to develop hard positions, and the company expects no substantive reaction before a mid-January meeting of the interim group. In the meantime, Comsat will have had the benefit of being able to gauge the potential response to its bombshell.

One thing is already clear: the formula linking votes to usage should bring some offbeat supporters into the American camp, where Japanese and British authorities profess to be already. Italy, for example, takes greater advantage of Intelsat-financed facilities than do either France or West Germany. The same may soon be true of Spain, which activates a ground station this month and expects an increase in its traffic with South America.

Such a prospect cannot help but vex France and Germany, which are planning to put a regional communications satellite system, called Symphonie, into service by 1971. Comsat opposes such efforts on the grounds that they will "drain the global organization."

However, neither France nor Germany appears particularly discomfited by Comsat's stance; the French for their part have urged that communications satellite activities be autonomous in each of four geographical sectors of the globe, and that Intelsat's authority be reduced to coordinating overlapping efforts.

Home front. Domestic satellite systems also threaten international communications amity. Canada, for one, is determined to get an operational network—with or without U.S. cooperation—by the early 1970's [Electronics, Sept. 4, p. 131]. In proposing that domestic satellite programs without Intelsat blessing be proscribed, Comsat can fall back on the technological muscle of the U.S. Renegade nations would presumably get short shrift from the National Aeronautics and Space Administration should they seek launching facilities, boosters, and the like. However, the European Space Vehicle Launcher Development Organization may eventually offer an alternative to U.S. aid—albeit an expensive one—and Russia appears willing to support selective efforts. The Soviets have agreed to put up a French research satellite, and the two countries already exchange tv broadcasts over Russia's Molnya.

Ironically, Comsat's stringent proposals in this area are at odds with a recommendation it made last April for a pilot project. At this moment, the company is in the incongruous position of resisting domestic programs outside the Intelsat orbit while trying to get an independent project off the ground for the U.S.

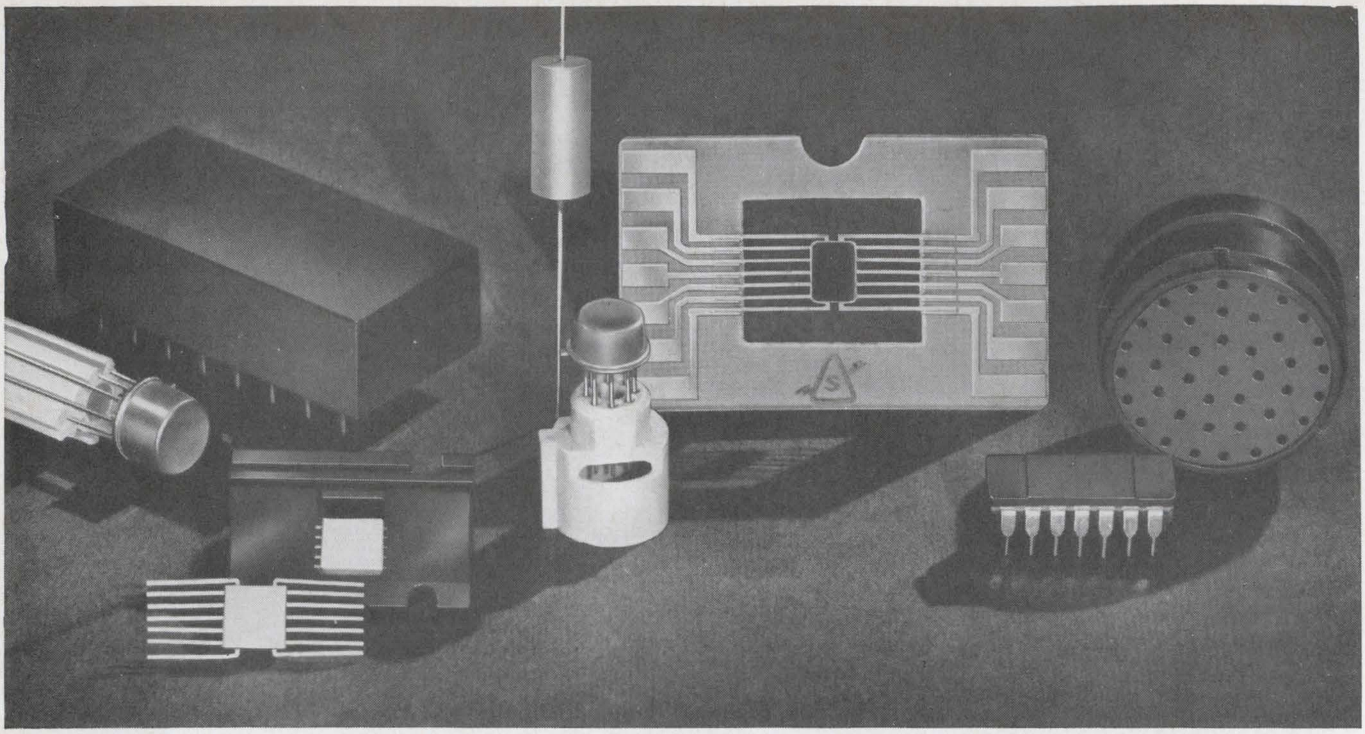
Comsat officials point out that domestic satellites will be a necessity for certain countries. In Chile, for example, the Andes mountains constitute a communications barrier between north and south. And Brazil could use a satellite system for communications between its populous east coast and primitive interior regions.

IV. The big picture

James McCormack, Comsat's chairman, lists navigational aids for air traffic control, shipping assistance, rescue work, disaster warning, and earth-resources management as potential jobs for Intelsat. Although the company anticipated little opposition to such grandiose schemes, a division of opinion is already shaping up. German officials feel that the density of air traffic in Europe is not great enough to demand Intelsat control, so they plan no push for such services. France is also unenthusiastic about expanding applications within Intelsat's framework, but might go its own way, possibly with Russian help, to establish an independent system for areas it considers important—West Africa, Europe, and Canada. On the other hand, Italian sources back Comsat. "It's not the service but the means," says one.

Room at the top. Another problem, one of a technical nature, is sure to affect the outcome of the Intelsat renegotiations. The equatorial belt, the only space location that can accommodate communications satellites in synchronous orbit, has a finite capacity; just how finite has been the subject of feverish investigation. Last month, Comsat reported that two spacecraft can operate within less than 2^0 of each other in a 23,000-mile-high orbit without interference (at this altitude, 2^0 equals about 1,000 miles). Before the latest experiment, estimates of the necessary separation ranged from 2^0 to 6^0.

However, though there is more parking space up there than most observers had dared hope for, some locations are more attractive than others. For example, the optimum spot for a communications satellite linking London and Tokyo is 26.5^0 east longitude. Spacecraft more than 1^0 off either way would lose one of the cities. As a result, the number of satellites linking London and Tokyo will have to be held to two or three at the most.



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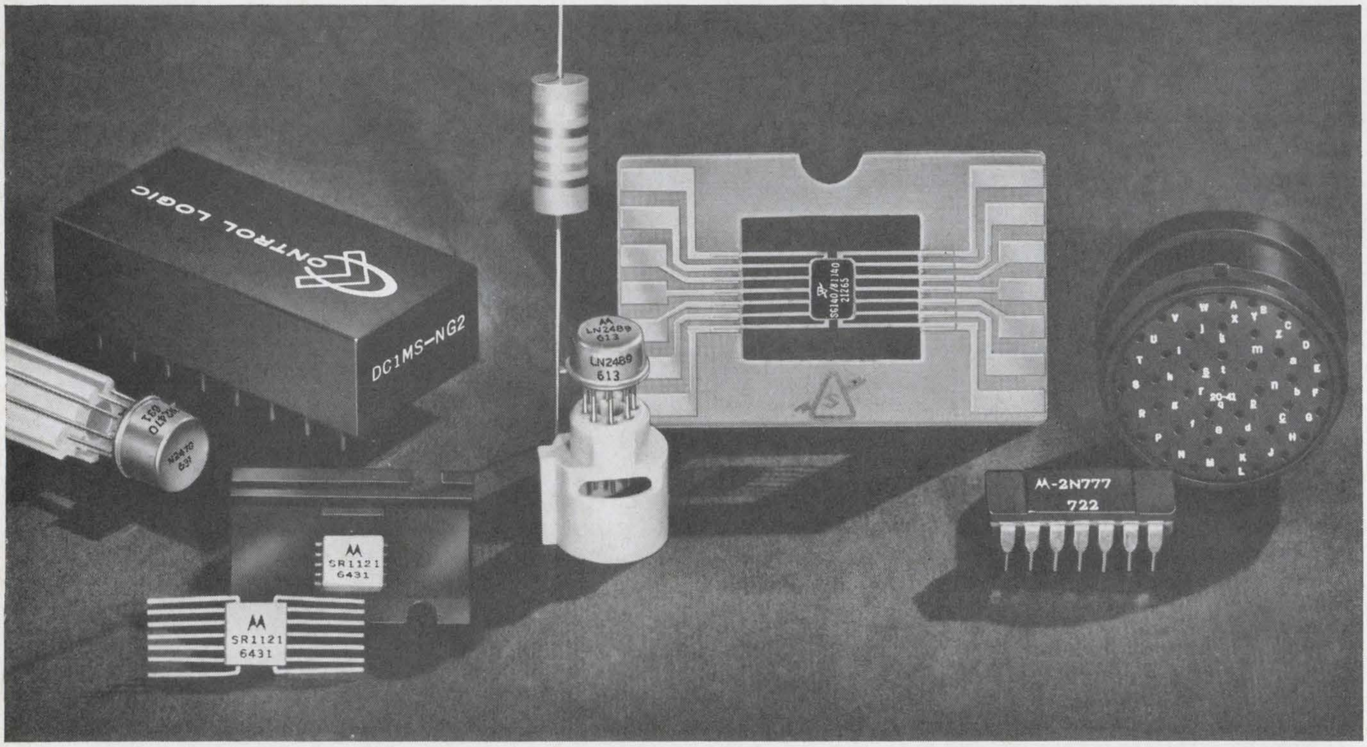

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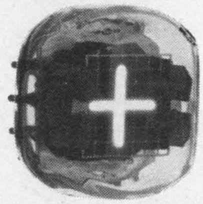
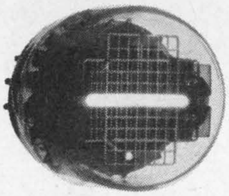
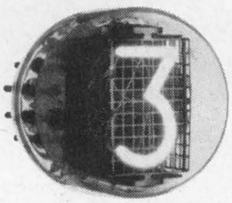


CK1903—Interchangeable with B5992 and NL5992.



CK1901—Interchangeable with B5016 and NL5016; CK1902—Interchangeable with B5032, NL5032, B50911 and NL50911.



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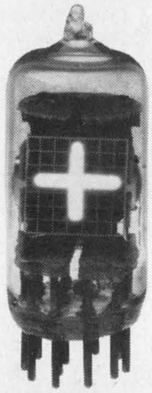

CK1900 (used with CK8650, CK1905, CK1906); CK1907 (used with 8754)—Interchangeable with NL843.

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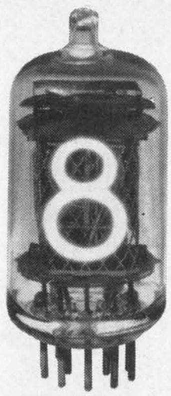
CK1905; CK1906 (right-hand decimal point).



CK8650

These indicator tubes—just a few of Raytheon's wide selection—offer you advantages in design, economy and performance. For example:

You don't need to revise designs. Raytheon's Datavue round and rectangular end-view tubes conform to EIA ratings—interchange with other brands. And Raytheon also offers you a selection of side-view types—and "specials" with up to 12 characters, ± signs, symbols, etc., to your specifications.

You can buy them at low cost. All Datavue Indicator Tubes are priced competitively—or lower. Most side-view types, for example, cost less than $5 each in lots of 500 or more.

Reliably trouble-free readouts. All Datavue characters are fully formed—not segmented. The fully formed characters are brightly displayed and easy to read—at distances up to 30 feet.

They last for years. They're made better because of Raytheon's experience—40 years of producing more than 100,000,000 cold cathode gas-filled tubes with carefully controlled electrical performance. Ultra-long-life types, for example, have dynamic life expectances of 200,000 hours or more.

They're readily available—in sample and production quantities. For samples, prices, or technical information, call your Raytheon regional sales office or distributor. Or write: *Raytheon Company, Industrial Components Operation, Quincy, Mass. 02169.*

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RAYTHEON

Industrial Components Operation—A single source for Circuit Modules/Control Knobs/Display Devices/Filters/Hybrid Thick-Film Circuits/Industrial Tubes/Optoelectronic Devices/Panel Hardware.

Circle 187 on reader service card→

If it's so great, how come it's so cheap?

It's only $5,000 because you said that's what it ought to cost. Our market research boys told us there was a tremendous need for an IC tester specifically designed for QC, QA, reliability testing, and everyday engineering evaluation. They also told us we could sell four times as many at $5,000 as we could at $7,500.

So we gave our design department a list of functions, a $5,000 pricetag, and locked the door. Here's what came out: A $5,000 IC tester that:

- Performs both pulse and dc parameter tests as well as functional tests without external equipment.
- Has a measurement accuracy of 1% (0.1% with an optional digital readout DMM.)
- Can be operated by a bright girl with half-a-day's training.
- Programs with thumbwheels in less than 60 seconds for most IC's.
- Has power supply accuracy of 0.1% ±1mv. (All supplies have adjustable current or voltage limiting and will both source or sink current.)
- Has Kelvin connections to the device under test.
- Has self powered, line-isolated modules.
- Has a complete line of device adaptors available.

How were we able to deliver so much machine per dollar? It was a snap. All we did was make every damn penny do a dime's work. We did it by committing to an annual agreement wherever there was a price advantage.

We did it by cutting out the fat. If a function was non-essential, it went. (This is one ungilded lily.)

We did it with painstaking project engineering. For example, the loads module: We could have made 1% capacitive loads. But it would have cost three times as much, and no one knows what to do with capacitive accuracy of better than 5% anyhow. Another example: the thumb-wheel switches. We found a great one, but discovered the price included $2 each for a pair of stainless-steel screws. We bought them knocked-down, assembled them ourselves and used 6¢ screws instead.

Or the pulse generator. Ours is equivalent to two single-channel output units like the ones that Datapulse sells for $775. They're great, but by sacrificing separate control and adjustment (which isn't necessary in our tester anyway) and the fancy case cut the price in half.

We found a terrific $15 digital switch. But we didn't use it. We built one without superfluous extras for a buck and a half apiece.

We're handling the AC-switching with 32 controlled planar devices. This saves 192 reed relays, that is to say, greenbacks.

One thing we did was hardest of all. We cut the profit margin. We're honest-to-gosh taking only ¾ the typical profit.

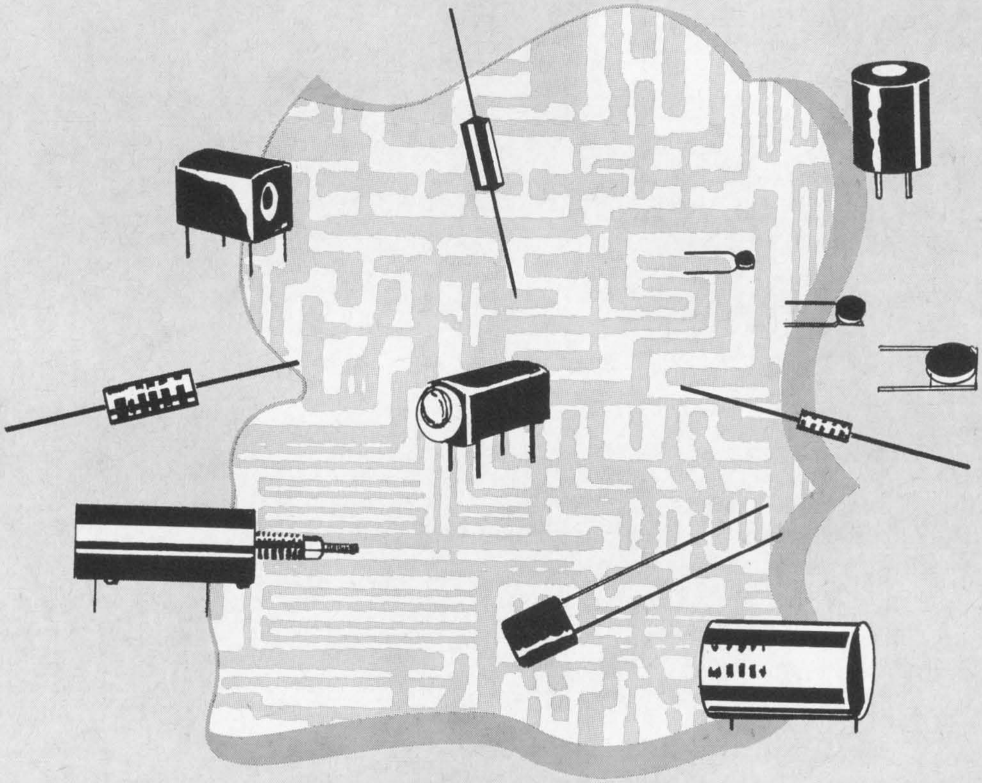
One more thing. The 990 turns out to cost $4,950 instead of $5,000. Use the extra $50 to take the little woman out to a show and dinner.

Write for complete technical data, or if you're in a hurry, call us collect.

Redcor's 990 IC tester

Redcor Corporation/7800 Deering Avenue/Canoga Park, California/(213) 348-5892/TWX 910-494-1228

Keep ahead of your competition.



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Delevan is the most experienced coil and transformer manufacturer in the world. We got that way . . . by innovating . . . by packing high values into the smallest configurations known today.

Combine engineering talent with large volume production experience and you have a company you can depend on. Try us!

Delevan Electronics Corporation / Division

AMERICAN PRECISION INDUSTRIES INC.

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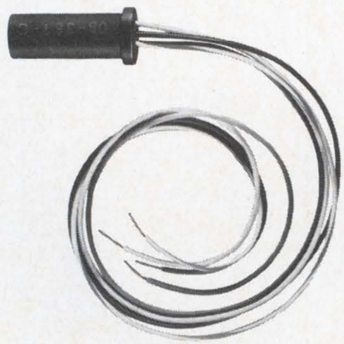
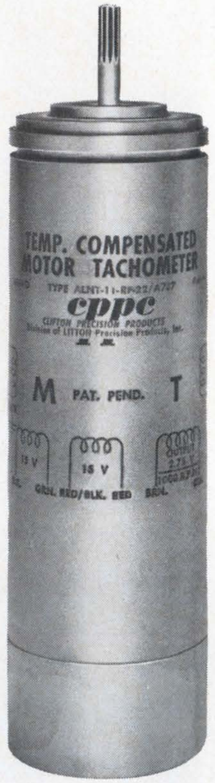
Circle 191 on reader service card→

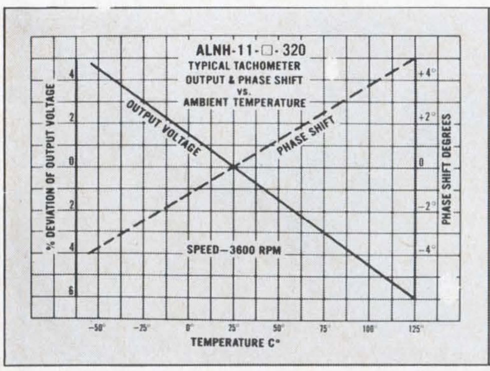
This Keystone Thermistor assembly

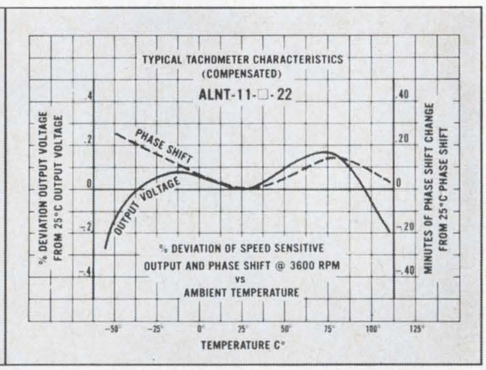


in this CLIFTON integrating tachometer



Makes all this difference in temperature performance





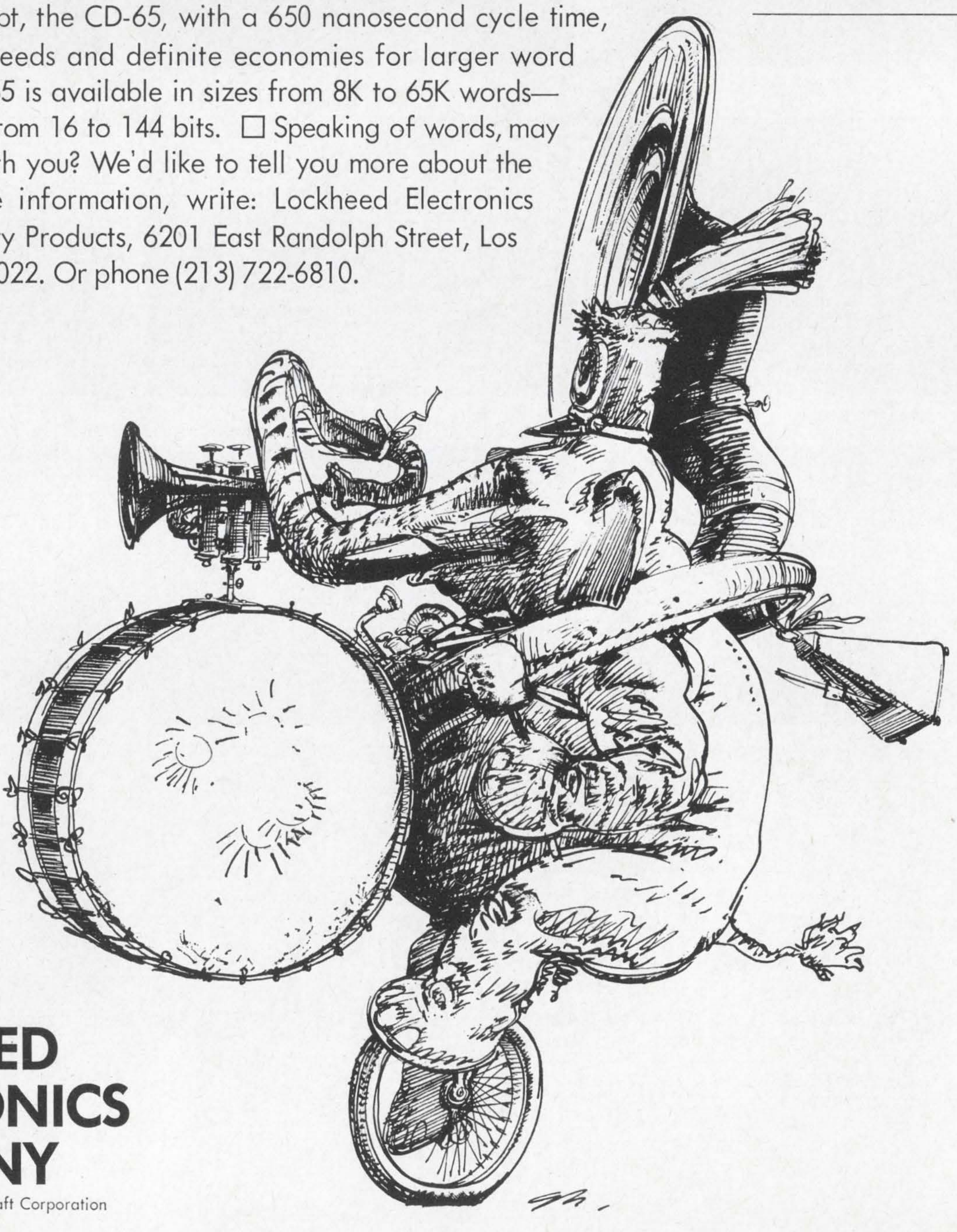
In precision computing applications using integrating tachometers, variations in output characteristics with temperature must be held to a minimum. To obtain the required performance, Clifton, Division of Litton Industries employs temperature compensation. □ The improvement in performance resulting from temperature compensation is shown graphically above. □ Responsible for the contrast is a Keystone Thermistor assembly. This is one of hundreds of different configurations made to specific customer requirements to the highest standards of quality and performance. May we have your inquiry? KEYSTONE CARBON COMPANY, St. Marys, Pennsylvania 15857

Keystone *leads* in creative thermistor technology

What does the CD-65 have that all other 2½D memory systems don't?

MORE STRINGENT DESIGN CRITERIA + HIGHER RELIABILITY + GREATER USER VERSATILITY.

The CD-65 is designed with the demanding user in mind. Operating margins in this unit are significantly greater than accepted industry standards. Mechanical packaging of key circuits and magnetics in the CD-65 provides a system organization easily adapted to custom application. All circuits are worst case designed and are verified by customer examination. ☐ Featuring a newer 2½ D packaging concept, the CD-65, with a 650 nanosecond cycle time, permits faster speeds and definite economies for larger word systems. The CD-65 is available in sizes from 8K to 65K words—each containing from 16 to 144 bits. ☐ Speaking of words, may we have some with you? We'd like to tell you more about the CD-65. For more information, write: Lockheed Electronics Company, Memory Products, 6201 East Randolph Street, Los Angeles, Calif. 90022. Or phone (213) 722-6810.



LOCKHEED ELECTRONICS COMPANY

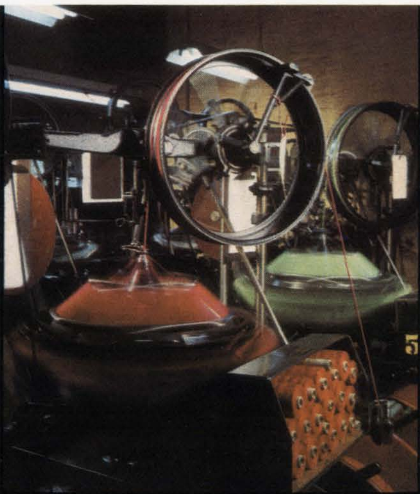
A Division of Lockheed Aircraft Corporation

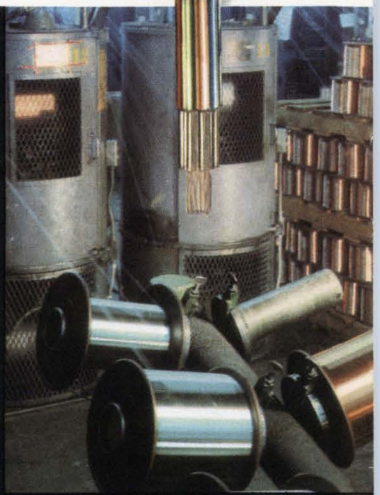
Chester's growth through service

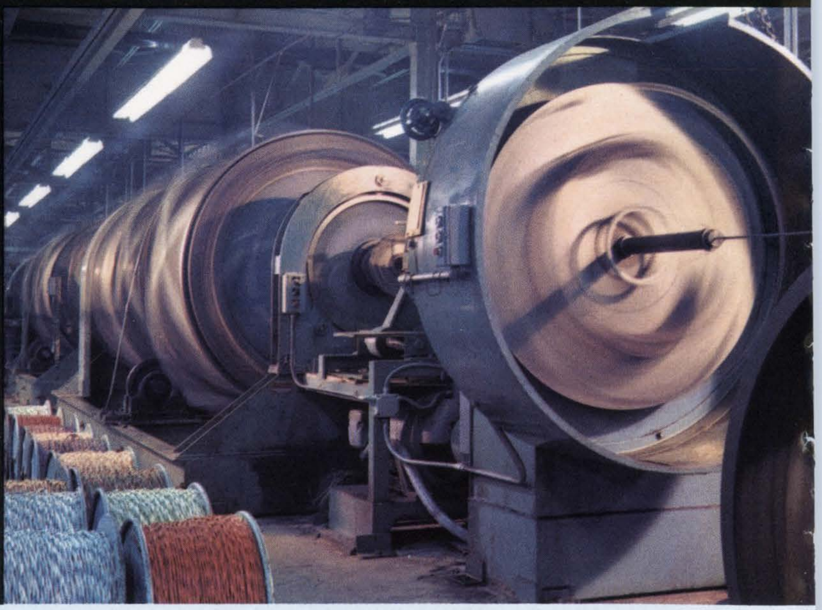
We can't think of a more graphic way to portray "Growth Through Service", than the illustration on the preceding page. The dark roof area represents Chester's plant expansion during the past ten years . . . expansion made necessary by the increasing requirements of our many valued customers in the electrical and electronic industries.

Actually, though, it's what's under the roof that counts: — The newest and most advanced production machinery . . . expanded research and test facilities . . . exacting quality control techniques . . . modern materials handling systems . . . and most important — experienced people, skilled in the manufacture of Plasticote® Wire and Cable.

Today . . . while we plan for the future . . . we still continue to meet industry's present requirements with unequalled service. The ultimate ingredient of this service is the most important facet of Chester's story of growth . . . the close, personal attention to each customer's requirement.







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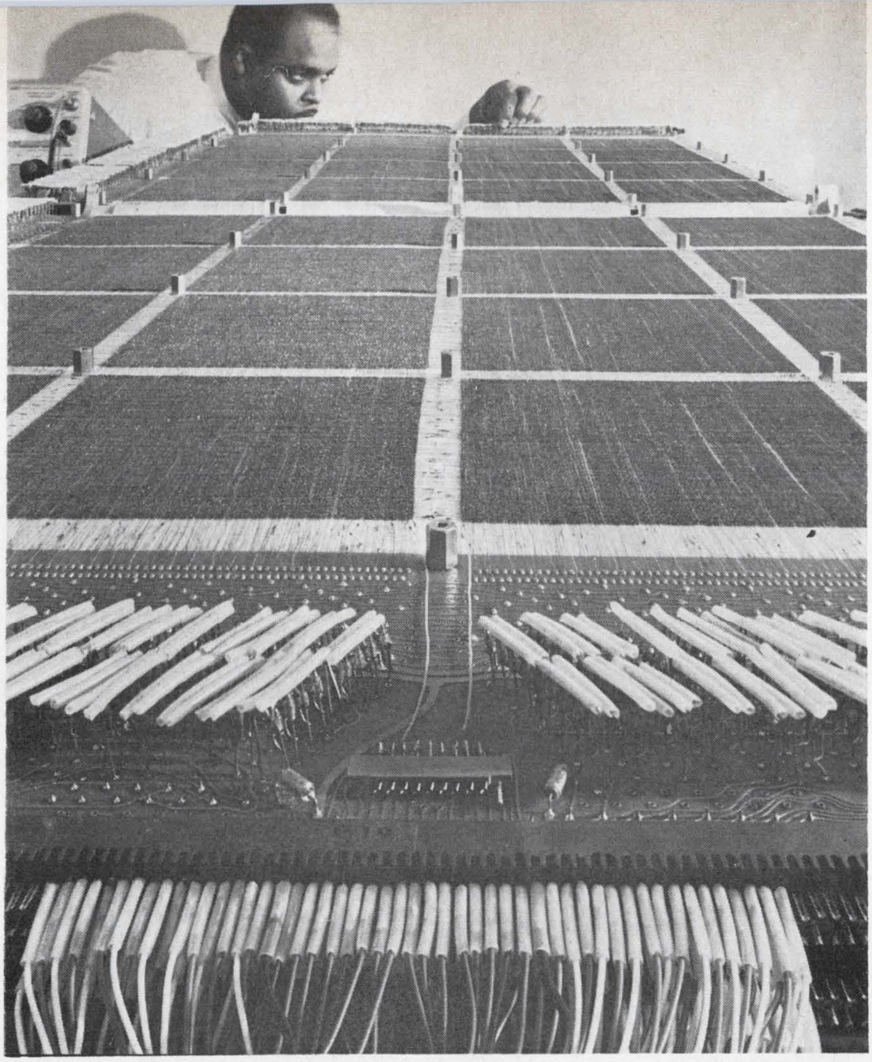
Superior thermal and electrical properties make Mystik 7000 suitable for an unusual range of cryogenic and elevated temperature applications. Uniquely inorganic, it has a tightly woven high tensile glass cloth backing with a pressure-sensitive silicone adhesive. Mystik 7000 has exceptionally high dielectric strength and offers high conformability and excellent shear resistance.

Here is a remarkable tape, perfect for insulating motors, generators or other components which must perform in critical operating environments.

This is only one of the Mystik family of tapes for the electrical industry. If you have an insulating problem or extreme temperature requirement, call your Mystik distributor. He's in the Yellow Pages under "Tape". Or write: The Borden Chemical Company, Mystik Tape Div., 1700 Winnetka Ave., Northfield, Illinois.

BORDEN CHEMICAL



Flat plane. A single five-million-bit section opens, like pages in a book, for maintenance and repair.

word windings that are common to each. One word-winding wire threads two corresponding cores, one in each set. For increased reliability, each wire passes through the fold in the array, thus reducing the number of solder connections that must be made during fabrication of the memory.

Data is stored in the form of 262,144 words of 72 bits each. These 72 bits are written into or read out of the memory in parallel, and can represent eight standard computer bytes of nine bits each, or two 36-bit words, or any other submultiple of 72. Each section of 65,536 words is mounted on its own folding ground plane, resembling a four-page booklet having 16 square mats of cores on each page.

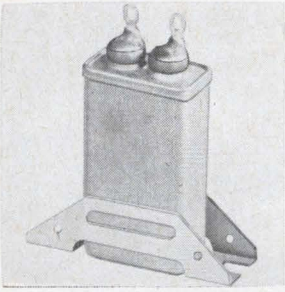
The memory's high speed was attained by minimizing the length of lines, and running the bit and word lines close to the ground plane, thus limiting inductance. The bit lines also go out and back, through adjacent rows of cores—another way of minimizing inductance.

Double duty. Even higher speed would have been possible if the designers had not sacrificed some features to minimize costs. Only two wires thread each core; so the same wire is used for bit current when writing, and for sensing when reading. Every memory cycle consists of a read half-cycle followed by a write half-cycle. When reading, the write half-cycle restores the readout information. Because of the wiring's double duty, transients on the lines must be allowed to die out before bit current can be sent. This takes time.

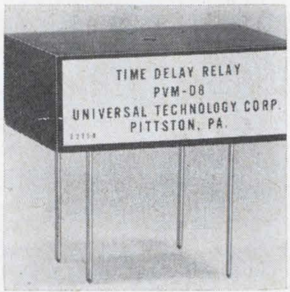
There is also only one sense amplifier per bit, which cuts costs but increases the number of cores serviced by a single amplifier. This increases the amount of noise that a single amplifier must screen out.

Ampex Corp., Computer Products Div., Culver City, Calif. **[338]**

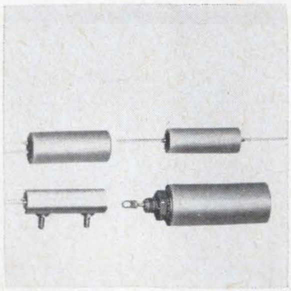
New Components Review



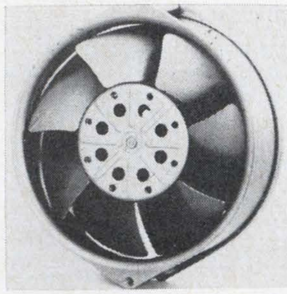
The Modiflex capacitors, using a combination of synthetic film and a liquid plastic dielectric, are rated up to 250 μf. Standard tolerance for nominal values of 0.1 μf and higher is ±10%; under 0.1 μf, ±20%. Power factor is 0.004 at 60 hz and 25°C. Operating temperature without derating is −40° to +125°C. Industrial Condenser Corp., 3243 No. California Ave., Chicago 60618. [341]



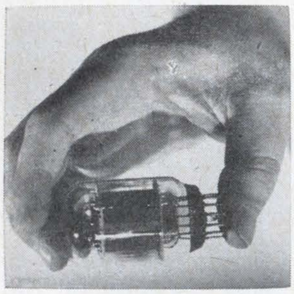
A fixed time delay relay encapsulated in epoxy is for p-c and aerospace uses. It is a spst, normally open unit with an input-output isolation resistance of 1,000 megohms at 100 v d-c. It operates from −40° to 60°C. Life expectancy is 15 million cycles. The unit is $1\frac{11}{16}$ x $1\frac{33}{64}$ x $\frac{9}{16}$ in. Price starts at $25.65. Universal Technology Corp., 107 New St., Pittston, Pa. 18640. [342]



Metalized polycarbonate capacitors series 22E, in hermetically sealed tubular cases, come in 200, 400, and 600 v ratings in sizes from 0.174 x 0.500 in. to 0.750 x 1.875 in. Capacitance values are 0.001 to 5.0 μf with tolerances from 20% to 1%. Temperature coefficient is 1.5% max. change from −55° to 25°C. SEI Mfg., 18800 Parthenia St., Northridge, Calif. 90324. [343]

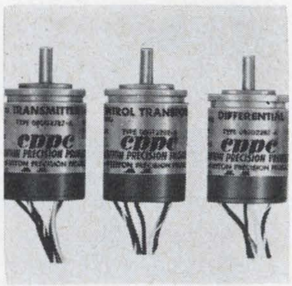


Miniature axial fans series 7500 combine high air delivery and low noise level. They feature aerodynamic design of the pressure type blades. With a free air delivery of 275 cfm, the unit will sustain delivery as high as 225 cfm at 0.2 in. of water back pressure. The venturi design limits noise factor to a low of 40.5 db at 3,350 rpm. Pamotor Inc., 312 Seventh St., San Francisco 94103. [344]

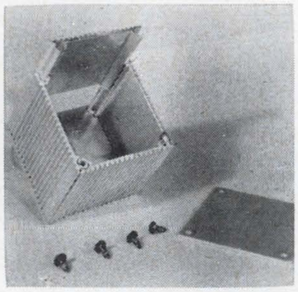


Double-triode-pentode compactrons are for color tv receivers. The 6AK9 has a heater voltage of 6.3 ±0.6v, a heater current of 1.6 amps. The 16AK9 has a heater voltage of 16.4 v, a heater current of 0.6 ±0.04 amp. The pentode section is suited for vertical deflection amplifier use; triode sections, for general purpose uses. General Electric Co., Owensboro, Ky. 42301. [345]

Tuning-fork resonator TF600 is a ½-oz, 0.2-cu-in. unit that can be provided with any fixed frequency from 400 hz to 2,400 hz. Accuracy is 0.01% at 25°C. Operating temperature range is −55° + 85°C. An input of 6 ma at 28 v d-c is typical. Output is up to 5 v rms into 20 kilohms when used with proper drive. Bulova Watch Co., 61-20 Woodside Ave., Woodside, N.Y. 11377. [346]



Size 8 synchros are available with over-all length of 1.015 in., which is 0.226 in. less than standard size 8's. Weight is also reduced to 1.15 oz. Standard accuracy of 7 minutes max. error is maintained. The line includes transmitters, control transformers, and differentials. Units have stainless steel housing. Clifton Div., Litton Industries, Marple at B'way, Clifton Heights, Pa. 19018. [347]



Enclosures known as Mini-Cool are constructed to contain a variety of precision devices. The line is available with integral heat sink walls. Made of lightweight aircraft alloy aluminum, they feature a lock joint at each corner which tightens when the screw fasteners are installed. Sizes range from 2 x 2 x $1\frac{1}{2}$ to 2.6 x 2.6 x 10 in. Sarex Corp., 1001 Roosevelt Ave., Carteret, N.J. 07008. [348]

New components

Avalanche brightens photodiode outlook

Detector combines high gain of photomultiplier tube with small size and power requirements of photodiode

Combining the best of two worlds is a silicon photodiode that operates in an avalanche mode. Developed by EG&G Inc. and designated the AV-102, the unit offers the low-voltage and small-size advantages of solid state light detectors while providing the high-gain and low-noise characteristics of photomultiplier tubes.

In photomultiplier tubes, which usually have 10 sections (dynodes), the emission from one section triggers the next so that a cumulative effect produces high gain. The disadvantages of these tubes are that they are large and require both a high-voltage power supply and a high-impedance load. But at high frequencies, high impedance causes a noise problem.

Photodiodes, on the other hand, are small, low-voltage devices requiring low-impedance loads, thus avoiding the high-frequency noise problem. But they lack high gain. What EG&G engineers wanted was a device that incorporated the advantages of both a photodiode and a photomultiplier. The company considered such a product highly marketable, particularly for laser communications systems in which high gain and low noise at high

... avalanche mode boosts gain ...

to diversifying through acquisition of smaller companies, it is designing lines of high-speed devices to detect and measure nuclear events. The new diode is a further extension of this program into special semiconductor devices.

The avalanche diode's spectral range is from 0.35 to 1.13 microns, with its response peaked at 0.9—the wavelength of light emitted from gallium-arsenide lasers. The major problem with laser systems is that because the beam has to travel long distances, the amplitude of the signal portion of the beam gets lost in noise. To reduce the effects of noise, the detector's impedance must be low and its signal-to-noise ratio, high. The AV-102 satisfies both conditions.

Avalanche threshold. If the AV-102 is operated below 11 volts—the point at which it goes into avalanche—its gain would be that of a conventional photodiode. But when operated in the avalanche mode, with a cumulative multiplication of carriers taking place, the diode's gain is increased 300 times. This increase is caused by the entire junction area being active. In conventional photodiodes, only part of the junction is active.

Memory systems is another application in which the AV-102 could be teamed with a laser. Reading out information after it has been recorded on photographic film, for example, requires a highly sensitive detector because much of the light is lost to the film. Also, the detector requires the capability of rapid response to a wide range of frequencies. This type of memory has applications where a large quantity of read-only data is to be stored for future recall.

Specifications

Signal-to-noise improvement	300 to 1 for 50-ohm load
Sensitivity at 0.9 microns	0.5 $\mu a/\mu w$
Spectral range	0.35 to 1.13 microns
Frequency response	d-c to 1 Ghz
Operating avalanche voltage	8 to 15 v
Junction capacitance	1.5 pf
Dark current at 1 v	0.001 μa
Active area	2×10^{-5} cm^2
Package	TO-18
Price	$275

EG&G Inc., 160 Brookline Ave., Boston, Mass. 02215 **[357]**

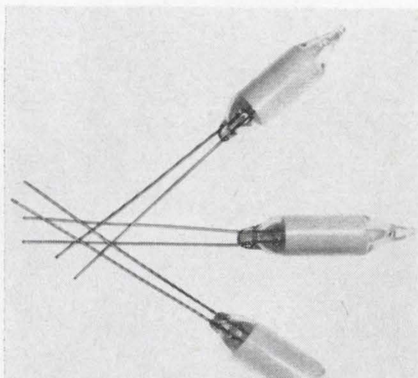
Walls of bulb are color-full

Pilot lights can be used to color-code information on electronic equipment

Electronic equipment may soon blossom out with tiny fluorescent pilot bulbs in different shades of the rainbow. Manufacture of the cold-cathode gas-filled bulbs has been started by Toyo Musen Co.

Conventional neons work on the principle of an electric potential exciting gas molecules. When the molecules are excited, electrons jump from one energy level to another. This change in state of internal electrons causes energy to be released in the form of light. The colored bulbs operate on a completely different principle, similar to a cathode ray tube. The potential across the electrodes causes the gas in the envelope to emit electrons, not photons. These electrons strike the fluorescent coating on the inner wall of the bulb, causing the coating to emit photons. Changing the color of the bulbs necessitates changing only the fluorescent material, not the gas.

The bulbs are similar in electrical



Lighting the way. Colored fluorescent bulbs make for easier reading on instrument panels.

. . . color bulbs help computer debugging . . .

and mechanical specifications to high-brightness NE-2 neon bulbs. The big difference is that the Japanese units have fluorescent material on the side walls of the bulb, and use an unidentified gas that is not neon. Colored light is emitted from the entire wall surface, not just from a small region around the electrodes. The brightness of the new bulbs is of the same magnitude as high-brightness neon units.

In computers, where neon bulbs are used on front panels to indicate the logic state of different sections of the memory, the colored units will make debugging an easier chore. Neons are now used because there is no filament to burn out, they require very little current, and there is no initial current surge that could damage the logic circuitry that drives them.

If a program doesn't work, or if the computer stops at some point, the only clue to the trouble comes from the neons, telling the operator about each section of the memory. To look at a maze of orange lamps is almost as confusing as looking at the memory cores themselves. Using the three colors for different sections simplifies the process of finding out what went wrong.

The first bulbs being produced are red, yellow, or green. Other colors have been manufactured experimentally. The units (in Japan) are priced at about 15 cents each in small quantities. This compares with about 10 cents for high-brightness NE-2's and 6 cents for standard NE-2's.

A major American manufacturer of indicator lamps says that it could have built colored neon bulbs years ago, but the demand for such devices is not as great as the demand for multicolored alphanumeric readouts. The color approach to alphanumeric readouts is not going the gas tube route, but rather to solid state electroluminescent panels, according to the U.S. company. The ideal result of the electroluminescent panel research would be an alphanumeric readout that can change its color by changing the frequency of the applied voltage.

Toyo Musen Co., Tokyo **[358]**

New components

Double feature pickup tube

Can view laser patterns; short decay time permits detection of motion

A pickup tube that operates like a vidicon but has an unusual double feature has been developed by Tokyo Shibaura Electric Co. It is highly sensitive to long infrared wavelengths yet has a short decay time. Other infrared detectors offer one feature or the other but seldom both. The range of sensitivity widens the applications of the tube. The short decay time makes it useful for viewing moving objects.

Toshiba's tube has a lead oxide target similar to those in its Sensicon tube and in the Plumbicon developed by Holland's NV Philips Gloeilampenfabrieken. The addition of antimony sulphide to the lead oxide provides the sensitivity to infrared. Toshiba hints that it mixes the two while the lead oxide material is being evaporated.

Plumbicon, like vidicon, is based on the principle of photoconduction. However, Philips engineers claim that performance of the Plumbicon is better because it uses a large-area p-i-n photodiode as the light-sensing target mechanism. This, they say, gives it the advantages of an extended linear transfer characteristic, no discernible dark current, and a very small photoconductive lag.

The sensitivity range runs from visible light to wavelengths up to two microns. The tube can detect objects heated at 200°C or more.

Toshiba expects the tube to be used to view infrared laser mode patterns and to observe dislocations in germanium and silicon crystals; also for supervision of dark rooms in photographic film plants, and for remote measurement of temperature distributions in hot objects. The tube also has security and military applications.

Tokyo Shibaura Electric Co., Tokyo **[359]**

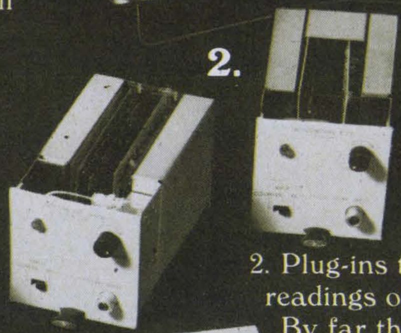
If you buy HP counters, we have news for you.

Systron-Donner makes advanced counter instrumentation that has no equivalent in the HP catalog. That's why it pays to check with Systron-Donner before you buy. You'll find equipment with unique capability like:

1.

1. A plug-in that will extend your counter's frequency range to 15 GHz – measuring FM and pulsed RF as well as CW and AM. The only way to get the full dc to 15 GHz range in one cabinet. No calculations. Displays final answer.

2.



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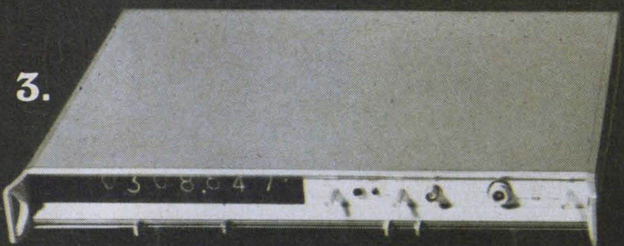


2. Plug-ins that produce automatic readings of microwave frequencies. By far the most compact and economical equipment for producing automatic readings in the 0.3 to 3 GHz band or the 3 to 12.4 GHz band.

3. "Thin Line" counters that take only 1¾" of rack space. Built with ultra-reliable integrated circuits to give you automatic frequency measurements – dc to 100 MHz or 0.3 to 12.4 GHz.

These are the highlights of expandable systems that will make just about any measurement possible with counters. The accuracy of our basic 50 MHz and 100 MHz counters is unsurpassed. (Time base aging rate is only 5 parts in 10^{10} per 24 hrs.) All devices to extend the range or add functions are convenient plug-ins – not rack mounts. The newest are a prescaler to extend counter range to 350 MHz and a heterodyne converter to measure noisy signals in the 0.2 to 3 GHz range.

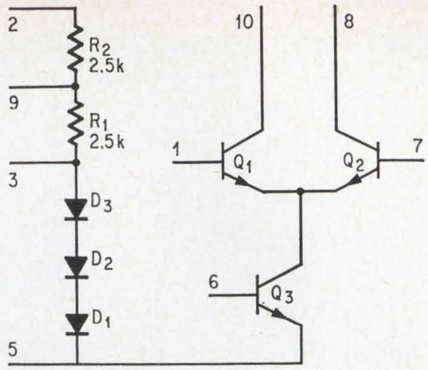
Are you surprised that Systron-Donner is a step ahead of HP in counter technology? How else could we stay in business?

Send for catalog.

Systron-Donner Corporation, 888 Galindo Street, Concord, California 94520

SYSTRON DONNER

Circle 131 on reader service card



Access. Component placement enables simple external connection.

connection patterns are used on the wafers containing the basic structures.

Versatility. Aimed at the consumer entertainment equipment market, the 911 was designed to be versatile yet sell for $2.55. It is an npn differential amplifier with an npn current source. D-c biasing is achieved by a self-contained bias chain that is made up of the resistors R_1 and R_2, and diodes D_1, D_2, and D_3. To establish a desired operating current, R_1, or a combination of R_1 and R_2, forces a current from the positive supply, through the diodes, to ground. Because the diode characteristics are known, the current causes a predictable voltage drop across each diode. When the voltage is applied to the base-emitter junction of a transistor, and if the transistor is matched to the characteristics of the diode, a current will flow in the transistor's emitter equal to the current forced in the diode. This matching is accomplished because D_1 is actually a transistor, identical to Q_3 in geometry, with its collector-base junction shorted.

Circuit designers accustomed to choosing r-f transistors for high-frequency applications, and audio transistors for d-c and low-frequency applications, will find that there is no difference between the two types in the monolithic construction of the 911. For example, collector-emitter breakdown voltages better than 30 volts, typical d-c current gain of 100 at 1 milliamp, and current gain-bandwidth products from 500 to 800 megahertz are common to monolithic IC's.

Combinations. Four interconnected combinations of the 911

. . . complete r-f sections on one monolithic chip . . .

and the 911 itself are being offered initially. These range from the 912, a dual emitter-coupled amplifier, to the 915, a complete amplitude-modulation intermediate-frequency strip, with built-in automatic gain control (agc).

In designing the 912 as a single-function device, the packaging cost is minimized by requiring only eight pins for the two independent stages. Since each stage has its own bias chain, the need for external biasing components is reduced. When two 912's are connected, for example, in a 10.7-Mhz frequency-modulated i-f strip with conventional transformers, there is an over-all gain of about 100 decibels. This combination, offered as the 914, is a complete f-m i-f strip, with only external transformers and bypass capacitors required.

While the 912 trades flexibility for package pin reduction, the 913 —two connected 911's—requires a 16-pin package, but performs a variety of functions. Each half of a 913 can be used independently as a cascode, emitter-coupled, or self-contained d-c amplifier.

The most complex configuration is the 915, a 16-pin package that is made up of four basic modules. Three cascode amplifiers, capable of 30 to 40 db power gain per stage, and a self-contained agc loop are connected. Components from the fourth module form a diode detector, an emitter-follower agc buffer, and an emitter-follower output buffer. The accessibility of various internal points, in the 16-pin package, allows external control of the agc threshold, determination by external capacitor values of detector response, agc time constants (fast attack, slow decay characteristics are possible), and shaping of the i-f bandpass characteristics.

According to a company spokesman, no insurmountable system problems have been encountered with the four-module chips, indicating that further increases in complexity to six or eight modules per chip are currently possible in r-f systems.

Amelco Semiconductor Inc., Box 1030, Mountain View, Calif. 94042 **[444]**

Still another IC for television

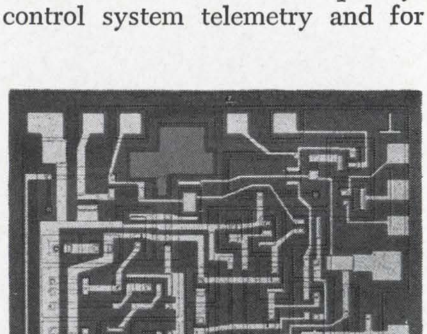
Single-coil winding minimizes tuning of detector-limiter

Trying to get integrated circuits designed into television sets is a kind of mating game.

The IC maker will tailor the characteristics of his device to make it highly compatible with existing circuitry—to minimize redesign problems for the set manufacturer; and he will pack as much function into the chip as economics will permit—to lessen the number of external interfacing components and the number of adjustments.

Above all this, however, the paramount consideration is cost. If the IC price is not right, the mating game is off. So the IC maker will usually hedge his product investment by including features attractive to the easier-to-sell industrial and military market. Such seems to be the approach followed by Sprague Electric Co., latest member of the IC club to enter the lucrative consumer market [Electronics, Aug. 7, p. 88].

Sprague has developed a linear IC frequency-modulation detector and limiter, aimed at tv channels and f-m receivers. The device is also suited for automatic-frequency-control system telemetry and for



Chipfull. Circuit includes 25 active elements and 18 diffused resistors.

. . . balance network lowers distortion . . .

radar applications.

Designated the ULX-2111A, the complex chip contains 19 transistor elements, 6 diodes, and 18 resistors. It requires only one single-winding coil for tuning, so a screwdriver is all that is needed to tune the detector. Most counterparts in discrete semiconductor networks and in IC's require complex phase-shift networks.

Some competing devices also offer simplified tuning, but they do not provide the limiting action associated with the balanced phase detector.

On the Sprague chip is a three-stage amplifier, a limiter, and a balanced detector, all of which work in tandem to provide linear gating. Filtering out of unwanted signals is high—the a-m rejection of signals riding on the f-m carrier is 45 decibels. The circuit's capture ratio is 1.4 db, and its distortion products are 1.5% maximum.

The IC's bandwidth extends from 5 kilohertz to 50 Mhz. Its output is sufficient to drive either vacuum tube or transistor power amplifiers in tv sets directly. An output-connection option is provided, so the IC may be used as a 60-db broadband amplifier. In nearly all applications for the device, only a 12-volt power supply is required.

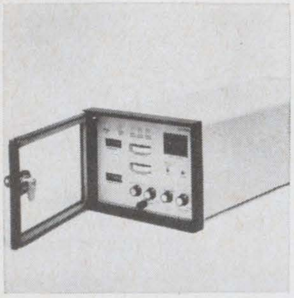
Sprague says the price of the device cannot be determined until the process is moved from its research laboratory to production facilities in Worcester, Mass. The unit is the first of a series of consumer-oriented IC's to be introduced on a one-a-month basis during 1968.

During the past six months, at least six major competitors have been introducing IC's aimed at the same tv and f-m receiver sockets [Electronics, June 12, p. 38; June 26, p. 163].

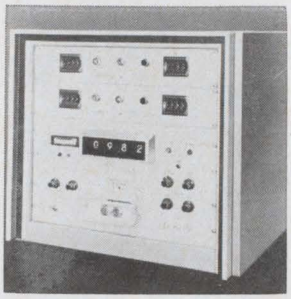
Specifications (tv application)

f_o	4.5 Mhz
Deviation	± 25 khz
V_c	+12 v
P_{dis}	200 mw
V_{out}	0.60 V rms
Limiting threshold	400 μv rms
A-m suppression	46 db
Distortion, maximum	1.5%

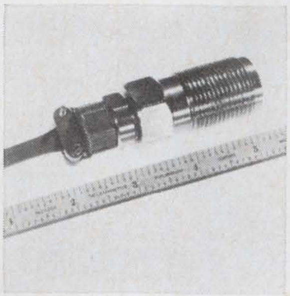
Sprague Electric Co., North Adams, Mass. **[445]**



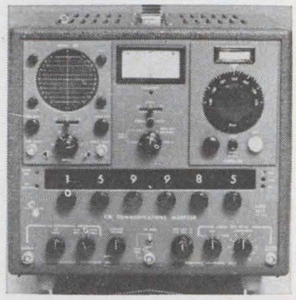
Two-component blender model 99C is available in 2 configurations: to ratio one flow to the other or to ratio one flow to the total flow. It will accept high-frequency turbine meter inputs or low-frequency meter inputs. Equipped with memory capability, the 99C produces a 10-15 ma signal to control the ratioed flow. Foxboro Co., Mechanic St., Foxboro, Mass. 02035. [361]



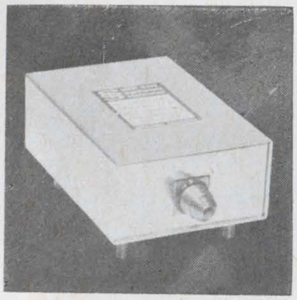
Capacitance test system 1201-DS-2 sorts or grades up to 1,200 components per hour into several categories (5%, 10%, 20% or 4 to 8 pf, 8 to 11 pf, etc.) with 0.1% absolute accuracy. Components are inserted into a guarded test fixture or test jig, with capacitance indicated on a 4-digit readout. Micro Instruments Co., 12901 Crenshaw Blvd., Hawthorne, Calif. 90250. [362]



High-pressure transducer model GT-24 is designed for dynamic measurements. Pressure range is 0-20,000 through 0-100,000 psig; sensitivity, 3.0 mv/v minimum; natural frequency, 50 khz; nonlinearity, ±0.5% full scale max; repeatability, 0.1% full scale max.; operating temperature, cryogenic to 300°F. General Transducer Co., Corvin Dr., Santa Clara, Calif. 95051. [363]

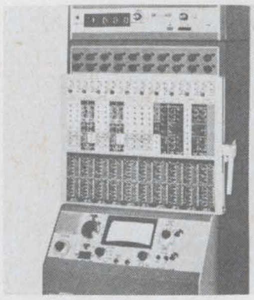


F-m communications monitor CE-3 makes off-the-air measurements of base stations up to 50 miles away. It offers a choice of 3 r-f preselector plug-ins—20-80, 120-180, and 450-512 Mhz—or a broadband r-f mixer plug-in for close-in monitoring and in-shop measurements. The instrument weighs 38 lbs. Cushman Electronics Inc., 166 San Lazaro Ave., Sunnyvale, Calif. 94086. [364]



Pressure-to-frequency transducer PF-1001 is for missile, spacecraft, aircraft, and industrial f-m telemetering. Pressure ranges are from 0 to 200 psig up to 0 to 5,000 psig. Any center frequency from 400 hz to 12 khz with a deviation of ±7.5% is available. IRIG channels from 1 to 12 can be specified. Solid State Electronics Corp., 15321 Rayen St., Sepulveda, Calif. 91343. [365]

Short stroke, d-c/d-c linear motion transducer model 15 delivers 5 v d-c output for 0.010-in. travel with better than ½% linearity. It incorporates a linear variable differential transformer with a completely integrated oscillator-demodulator-amplifier built into the potted enclosure. Prices start at $145. C-E Electronics Inc., 363 W. Glenside Ave., Glenside, Pa. 19038. [366]



Digital voltmeter series 6250 mounts magnetically to the top of computers. It provides 4-digit readout of analog voltage signals. Voltage ranges (1 and 10 v) are push-button selected. Input impedance of the dvm is 10 megohms; conversion time, 100 msec. Accuracy is ±0.1% of full scale ±1 digit. Price is $495. Electronic Associates Inc., West Long Branch, N.J. 07764. [367]

Automatic noise figure meter model 792A offers variable impedance and balanced outputs. It provides complete measurements up to 26.5 Ghz and metered noise figure ranges of 5 to 30 db for waveguide and diode sources and 0 to 20 db for hot wire and diode sources. Input sensitivity is 0 to 75 dbm; input impedance, 50 ohms nominal. Kay Electric Co., Pine Brook, N.J. 07058. [368]

New instruments

Hands-off frequency sweeping

Plug-in checks range from 0.1 hz through 100 khz; can be teamed with new log converter to make Bode plots

For different categories of electronic devices, frequency-response tests are key stages in the design and manufacturing processes. A hearing aid, for example, must amplify only those frequencies which the wearer cannot hear well. A hi-fi speaker must be carefully tested with variable-frequency input signals. The servocontrol system on an aircraft can go into oscillation if wrong-frequency signals are let loose.

To meet these differing needs, a new sweep plug-in built by Hewlett-Packard Co. permits frequency-response checks to be made over a range from 0.1 hertz to 100 khz quickly and accurately. It sweeps over these measurement ranges without the need for any knob-twiddling between ranges or for switching from one instrument to another.

Designed to work with the company's 3300A function generator and to provide it with both wide- and narrow-band capabilities, the model 3305A plug-in sweeps from 0.1 hz to 100 khz in three overlapping four-decade ranges.

Any part or all of one range can be swept by setting calibrated start-frequency and stop-frequency

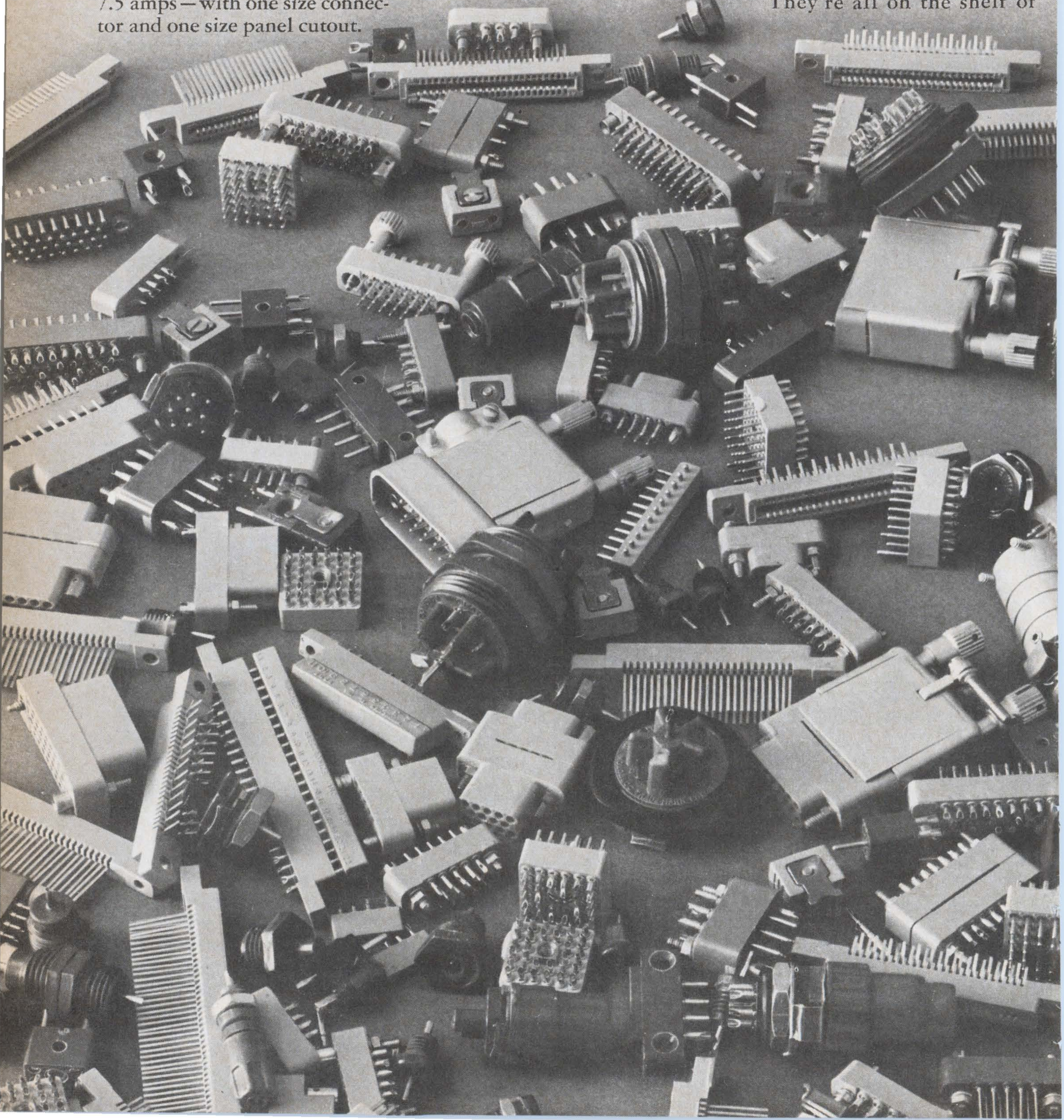
Always connect subminiatures with Winchester Electronics.

Take cable and panel mounted rectangulars. We've got them with solder or crimp removable contacts. From 4 to 50 contacts with current ratings of 3 to 7.5 amps. Standardized high-density rectangulars also, that allow you three current ratings — 3, 5, or 7.5 amps — with one size connector and one size panel cutout.

Need pc connectors? We've got edge-board, right-angle or flat-mounted pc's on .050, .078 or .100 contact centers. With solder, eyelet or dip solder terminations for 1/32 to 1/4-inch boards. And we've got microminiature pc connectors for use with integrated thin film and semi-conductor circuitry.

If you're looking for circular cable or panel mounted connectors, you'll find them with 1 to 12 contacts. Contact centers from .025 to .040 with current ratings of 3 to 7.5 amps.

They're all on the shelf of



voltage-to-current converters which supply the currents necessary to sweep the main oscillator—the 3300A. Precision converters insure less than a 1% symmetry error for the full range of frequencies and environmental temperatures from 0° to +55°C.

At the end of the sweep a multivibrator is triggered, blanking the main-frame's sine and triangle outputs. When the sweep output is reset to zero, blanking is removed and the 3300A begins to oscillate at the start frequency. After a short delay, the multivibrator again changes state, and the frequency is swept again. This delay provides for system recovery between sweeps.

Hewlett-Packard Co., Loveland Division, Loveland, Colo. **[377]**

New instruments

Materials sensor measures heat flow

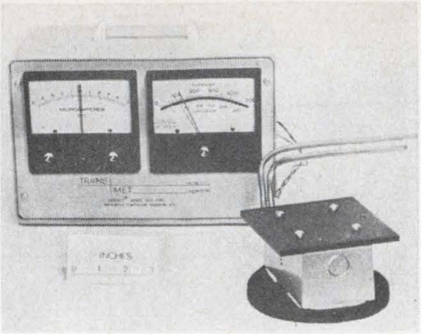
No-contact device operates on convection principle instead of measuring infrared

No-contact temperature sensing of materials, once the exclusive domain of infrared equipment, is now being accomplished by measuring heat flow instead of thermal radiation.

Called Nontact, the technique avoids some problems of infrared systems, such as having to compensate for different colors which radiate different amounts of energy, or looking through the material and picking up radiation from some other material behind it.

Nontact was developed by David Hornbaker and Dieter Rall, consulting engineers specializing in heat transfer and temperature measurement. They established a new company, Trans-Met Engineering, to produce the system.

Balances heat. The equipment consists of a sensing head and a temperature readout and control unit. It operates on a null-heat-balance principle employing convective heat exchange between the



Standoffish. Sensor measures heat flow without touching surface of material.

sensing head and the material being studied.

The system can be used either to monitor temperature or to control the temperature of the material being processed, such as a hot plastic strip. In monitoring, the sensor head detects the heat flow from the hot strip. If the material is hotter than the head, a servo signal triggers an electric heater in the head assembly which heats the sensor assembly until its temperature is the same as that of the material. At this point there is no heat flow between the head and the material, the system is in null balance, and there is no output signal.

If the head is hotter than the material, output signals trigger a water- or air-cooling system and the coolant is circulated through passages in the sensor assembly until its temperature is the same as that of the material.

The sensor head measures about 2 x 2½ inches and is embedded in the center of a flat aluminum plate measuring about 6 inches in diameter. The sensor is a solid, potted assembly and is covered with a special reflective coating to cut out all radiant energy.

Sink plus sensor. Rall says the sensor assembly is basically a heat sink or heat reservoir, with a heat-flow sensor in the face to detect whether heat is flowing in or out. Included in the assembly are a potted electric heater and passages for air or water coolant. A thermocouple in the head monitors the temperature, which is read out on a meter.

When heat flows into the sensor, a positive d-c signal proportional to the rate of heat flow is generated for the control unit. When heat is flowing out, the voltage is negative.

In simple temperature tracking,

. . . output signals control process . . .

the voltage—approximately 0.5 millivolt per degree F—goes to the solid state control unit where it is used to turn on either the heater or coolant to drive the sensor back to the null condition, equal to the temperature of the material being monitored. The sensor tracks at a rate of up to 10°F per minute, according to Trans-Met.

When the system is being used to control the temperature of material being processed, it is preset at the desired temperature and, as the temperature varies, the output signals are used to switch on controls to heat or cool the material.

In this mode, an indicator on the galvanometer is set at the required temperature. If the material is not at the right temperature, signals from the sensor head operate through a 5-amp relay to switch on controls to heat or cool the material.

When the galvanometer's temperature readout needle reaches the correct temperature, the needle vane shuts off light which has been passing through the set point indicator to a photoelectric cell inside the unit. This imbalances a bridge circuit, cutting off power.

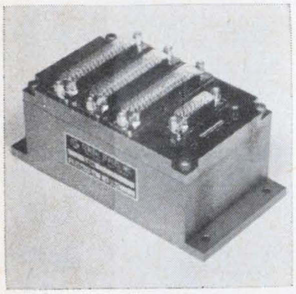
Container application. A prototype unit is in operation at a plastics company in the Los Angeles area, where it monitors the temperature of styrene plastic sheet and controls a bank of heaters in an oven to keep the sheet at the right temperature. This is done just before the sheet enters a thermoforming press, where it is made into containers for cottage cheese. The plastic will not form properly if it is not at the right temperature.

Trans-Met is marketing two versions of the NCT 4,000 series system, one with a range from 75 to 300°F and one with a 75-400°F range. Accuracy is ±2% of full scale.

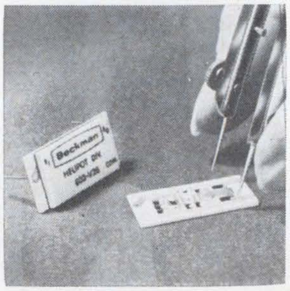
Price is $1,875, including sensor head and mounting bracket with positioning mechanism, controller, readout system, and 10 feet of cabling. Rall says a comparable infrared system would cost $2,000 to $2,500.

Trans-Met Engineering, P.O. Box 56, Whittier, Calif. 90608. **[378]**

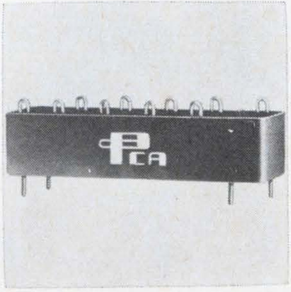
New Subassemblies Review



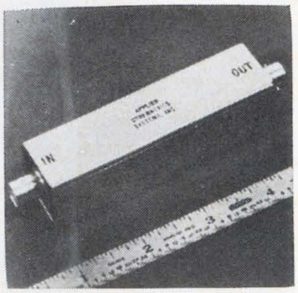
Stepping commutator type 1724 Digicom is designed for multichannel telemetry. It provides up to 30 break-before-make signal channels with as many as two separate differential input sets of poles. Stepping rates as high as 200 samples/sec are reliably achieved. Production quantities sell for about $1,100 each. General Devices Inc., P.O. Box 253, Princeton, N.J. 08540. [381]



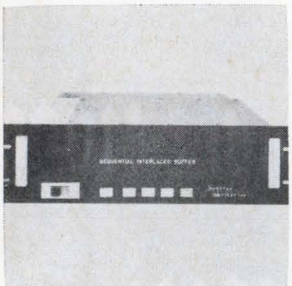
D-c voltage regulators series 803 permit ±0.05% regulation for line and load variations. Standard models offer fixed outputs of 24, 28 or 32 v. They supply up to 7.6 w to load at +25°C in free air, or 16 w with a heat sink. Operating temperature range is −55° to +125°C. Units measure 0.990 x 0.490 x 0.170 in. Beckman Instruments Inc., 2500 Harbor Blvd., Fullerton, Calif. 92634. [382]



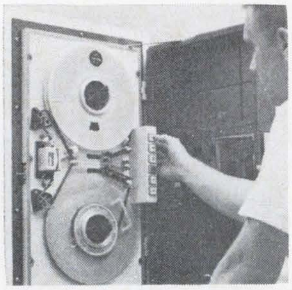
A delay line providing 16 combinations of nsec delays in 10-nsec steps is for installation in telemetry code and de-code circuits, computers and automation equipment, as well as on p-c boards. It has a maximum attenuation of 1 db, 510-ohm impedance, and a maximum 55-nsec output rise time. PCA Electronics Inc., 16799 Schoenborn St., Sepulveda, Calif. 91343. [383]



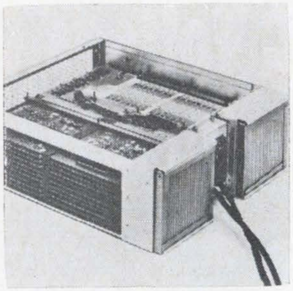
Instrumentation preamplifiers offer continuous operation for over a year from internal mercury cells. They are for use in upgrading the sensitivity and input impedance of scopes, counters, and vtvm's. Specs include input impedances up to 1,000 megohms, gains up to 40 db, and noise levels of 3 μv broadband. Applied Cybernetics Systems Inc., 880 Bonfant St., Silver Spring, Md. 20900. [384]



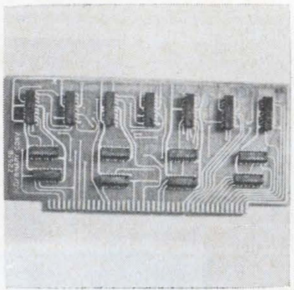
Keyboard communications buffers series 608E-1000 are adaptable to fill almost any buffer memory requirement for asynchronous input or output character rates of up to 500 khz or for synchronous rates up to 4 Mhz. The basic system provides storage of 4,096 8-bit characters and can be expanded to 131,072 characters. Digital Devices Inc., 200 Michael Dr., Syosset, N.Y. 11791. [385]



Digital tape transport GTM-14 generates computer-compatible data and features tape speeds up to 105 in./sec. It is designed for land-mobile and shipboard use in such applications as geophysical data gathering, oceanography, and reconnaissance. The unit is 14 x 25 x 12 in., weighs 90 lbs. Price ranges from $16,000 to $22,000. Ampex Corp., 401 Broadway, Redwood City, Calif. 94063. [386]



Core memory ICM-500 uses IC's in all electronic functions, including sensing and direct drive of selection lines. Full-cycle time is 600 nsec; access time, under 300 nsec. Capacities are from 4,096 to 32,768 words. Mean time between failure is over 25,000 hours for an 8,192-word, 28-bit-per-word memory at 35°C. Honeywell Inc., Old Connecticut Path, Framingham, Mass. 01701. [387]



Decimal-to-binary converter card Z-253 is for use in transforming decade thumbwheel switch outputs to straight binary. It accepts 3 BCD digits on 12 lines and delivers a 10-bit output. Conversion is accomplished by a parallel decoder matrix providing continuous output information. Price is $226. Metric Systems Corp., 736 N. Beal St., Ft. Walton Beach, Fla. 32548. [388]

New subassemblies

Making sure of dotted i's and crossed t's

Magnetic deflection amplifier gives fast, undistorted readout for computer displays, electronic typesetting

When a ransom note or a love letter appears blurry on the television screen, you can usually guess the contents from the context of the story.

This is not good enough in computer-driven alphanumeric displays, nor in electronic typesetting. If letters and figures become rounded at the corners and plotted points become smears, computer speed must be sacrificed to improve resolution or the equipment loses its usefulness.

For fast, undistorted readout in any cathode ray tube or storage tube display using magnetic deflection, the speed of the deflection amplifiers is crucial. A new line of amplifiers introduced by Beta Instrument Corp. provides very high speed deflection performance. The all-silicon solid state modular packages are d-c coupled operational-type difference amplifiers designed for any magnetic deflection system.

"The market is not a big one, about $250,000 a year, but due for a quick rise when electronic typesetting gets off and running," says Norman Fine, president of Beta.

Fine says the new Beta line, available in three models, offers a 1-megahertz small-signal band-

. . . device symmetry adds bandwidth . . .

settling time and broadbandedness are achieved by means of the transistor output arrangement in the amplifier. This complementary symmetry output (npn-pnp) keeps the output impedance constant in both sweep directions, and therefore the settling time is equal in both directions.

In some deflection amplifiers, the yoke sees a different impedance depending on deflection direction. Thus settling occurs at a different rate in each direction. This type uses dual npn transistors and can be coupled through the emitter in only one sweep direction. When the output is from the collectors, impedance is higher than it is when the emitters are emitting. The circuit in the Beta amplifiers gives low-impedance emitter output in both directions, and this is a major reason for achievement of the 1-megahertz small-signal bandwidth and high speed.

The three models—priced from $1,000 to $2,000—can supply up to ±2, ±4, or ±6 amperes of deflection current respectively to each axis of a directly-coupled deflection yoke. They offer maximum performance in bandwidth and settling time when operated from ±35 volt power supplies.

Most deflection amplifiers use a potentiometer across the yoke to adjusting damping. But this costs power. The Beta devices incorporate the pot—adjustable by screwdriver—in the feedback loop. In this way, gain can be optimized for a given yoke without power loss due to a paralleled resistance across the yoke.

Specifications (Model DA 225)

Inputs	
a-c power (for fan)	115 v 60hz
d-c power (for full output)	±35 v, 14 amp
signal	
amplitude*	±5 v
impedance	1 kohm
Output	
deflection coil current (each axis)	±6 amp
Linearity (deviation from best straight line)	
class AB	±0.04% max
class A	±0.02 % max

* Input signal may be d-c, sawtooth, random positioning, sine, square, pulse, resolved sweeps, and/or complex waveforms.

Beta Instrument Corp., 377 Elliot St., Newton Upper Falls, Mass. 02164 **[397]**

New subassemblies

Color tv camera sells for $9,850

Simplified optics lower cost of unit for schools, hospitals

The insides of the color television camera introduced this month at the National Association of Educational Broadcasters convention in Denver are so bare that the trick of producing a good picture is seemingly done with mirrors.

And it is. The International Video Corp. says the biggest single factor in getting the cost of its camera below $10,000 was a radically redesigned optics system. The camera will sell for $9,850.

Closed-circuit television in color has been a big-ticket item mainly because of camera cost. A broadcast-quality model can easily run $75,000, and even the stripped-down model introduced by Cohu Electronics, Inc., last spring sells for about $30,000. CBS Laboratories has built a $10,000 camera using field-sequential techniques [Electronics, June 12, p. 33], but it does not produce a National Television Standards Committee signal and thus requires a special monitor.

International Video, founded two years ago by two graduates of Ampex Corp. and Memorex Corp., is marketing a complete CCTV system—camera, color tape recorder, and standard monitor—for $15,000. President Donald F. Eldridge stresses that the camera does not produce a broadcast-quality signal. Its principal market, he believes, will be in hospital and educational CCTV systems.

Called the IVC 100, the camera has a self-contained encoder and a sync generator with integrated circuits. It is intended for use with the IVC 800 color recorder, introduced last spring.

One obvious difference between the IVC 100 and broadcast cameras is that the signal in the closed-circuit camera has a resolution of only 400 lines; broadcasters specify 525. Yet a broadcast signal is degraded,

... only 4 mirrors in optics system ...

in some cases down to 300 lines, by the time it reaches a home set; and Eldridge says that the IVC 100 picture appears to be equal in resolution and hue to one on a home receiver.

Zoom lens. Merely relaxing specs did not bring about the big cost reduction. The company developed a simplified optics system, consisting of a Nikon 50- to 300-millimeter zoom taking lens, relay lenses, and a system of plate beam-splitters. The relay lenses are necessary in order to shorten the back plane focal length of the taking lens.

The light from the relay lens passes first through a red-reflector dichroic mirror that reflects the long-wavelength portion of the spectrum to one side; another mirror redirects the reflected beam so that it is parallel to the main optical axis and imaged on the red vidicon. The main beam then passes through a blue-reflector dichroic surface that reflects to one side the short-wavelength portion of the spectrum. This beam is then redirected and imaged on the blue pickup tube. What is left of the main beam goes onto the green vidicon.

Doubling trouble. Plate beam-splitters are cheaper than solid glass block beam-splitters, but they can produce a double image—one from the front of the plate and one from the back. Skipworth Athey, a consultant to IVC and a director of the corporation, who designed the optics, says that the blue channel is most bothered by this double vision, because blue is low in luminosity. The blue channel thus has special circuitry to trim out the undesired reflection. Also, the backs of both dichroic mirrors have a coating the thickness of which is computer-calculated to suppress the undesired reflection.

The entire optics system thus requires only four fixed mirrors. These mirrors and the relay lenses are mounted in a subassembly sealed in a plastic case and mounted on the camera chassis. It never needs adjustment, according to IVC.

Thus, the camera consists of optics, three vidicons, deflection circuits, an integrated circuit sync generator, and an NTSC encoder. There are no external racks of equipment. The encoder is on a single printed circuit board about 8 by 10 inches.

To obtain registration of the three signals, IVC says it uses "considerable feedback" in the deflection circuits. The company asserts that component stability is such that the camera will operate for eight hours without adjustment.

Athey says that color tv is usually encoded by a method in which two different bandwidths are used. The color subcarrier is modulated in quadrature with the narrow-band Q—channel, corresponding to colors along the orange-blue axis, and the wideband I-channel, corresponding to colors along the red-green channel. But decoding is on the R-minus-Y and B-minus-Y axes (Y being luminance), which are in quadrature. The IVC camera uses R-Y and B-Y encoding as well, which Athey says is much simpler and requires fewer components.

The sync generator is simplified. It does not lock the color signal to the horizontal sync. No one would know it by looking at the picture, says IVC.

Ronald Freid, IVC marketing manager, says he already has a $500,000 backlog from "two of the largest electronic manufacturers in the CCTV area." One is interested in audio-visual training, and the other in computer-aided education.

International Video Corp., Mountain View, Calif. **[398]**

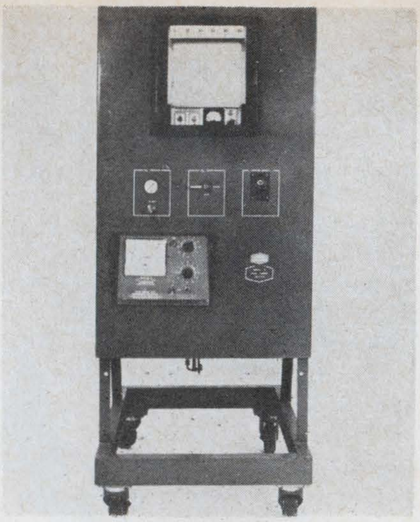
New subassemblies

2-minute detector of water pollution

Carbon analyzer system operates on-line for process control uses

Water pollution, according to recent government reports, is killing fish and spoiling recreation areas at an alarming rate.

Present systems for detecting organic pollution require hours or even days to determine the exact



Sampler. System measures carbon content for pollution detection or process control.

carbon content—and hence organic content—of a sample. This is just too slow. In most cases, if the pollution is detected fast enough, it can be stopped.

A carbon analyzer built by Union Carbide Corp. completes the pollution check in two minutes. Designated the model 1212, the unit can detect organic pollution as small as a few parts per million.

Its rapid response also suits it for process control applications. In the treatment of chemical waste, continuous monitoring of both influent and effluent streams accurately measures efficiency of the process and permits regulation of operations to avoid upsets. Continuous monitoring of sewers or cooling water detects spills and leaks within moments. Circuitry can be added to sound an alarm when the quantity of organic matter rises above a preset level.

The analyzer consists of two sections: the preparation equipment and the analyzing equipment. A 40-microliter sample is introduced in the test chamber in either a batch or continuous process. Through a hot-wire catalytic system, the organic sample is changed to carbon dioxide which is carried to an infrared analyzer by a nitrogen gas stream. By measuring the amount of infrared energy absorbed by the CO_2, the carbon content of the sample is determined.

Two readout devices, a panel meter and a strip-chart recorder, are provided in full scale ranges from 0 to 100 through 0 to 3,000 parts per million. Both units have a repeatability to within ±2%. The tester, priced at $8,600, operates at ambient temperatures from 32° to 120°F. In process stream installations, it requires a sample flow rate of 5 gallons an hour.

Union Carbide Corp., Electronics Div., 5 New St., White Plains, N.Y. **[399]**

New subassemblies

The price is right -- even with cores

Japanese firm produces $900 desk calculator with new techniques

In the U.S., it's considered uneconomic to use magnetic core memory registers in electronic desk calculators. Acoustic delay lines are employed instead. Cores are rarely designed into data processing systems which store less than about 10,000 bits.

Not so in Japan. Casio Computer Co. of Tokyo adds to the growing list of electronic calculators with an entry which will sell for $900 in Japan. Like the Hayakawa Electric Co. unit [Electronics, Aug. 21, p. 189] all its internal registers are made of magnetic cores.

Masakatsu Ara, Casio's submanager for new product development, says the low price is possible partly because of the magnetic core registers.

The limiting factor in core memories lies in the electronic circuitry which decodes addresses, drives current through the wires in the memory, and senses the output signals. Casio has used several techniques to help keep these costs down and make the use of cores economically feasible.

Noise dies. For one thing, the memory is designed to operate at very low speeds; at these speeds the pulse signals have relatively slow rise and fall times, and therefore generate little noise. In fact, capacitively-coupled crosstalk is virtually nonexistent. There is also plenty of time for the noise that is

Teamed. Programed mode permits semiautomatic coupling to typewriter.

generated to die away; the sensing circuits need not have a high noise-rejection capability. Thus the circuits themselves can be simpler and can be built with wide-tolerance components.

Another important design feature is the serial loading and unloading of registers, one digit, or four bits, at a time. The memory has only four sense amplifiers and four write drivers, compared to the dozen or two of each found even in small computer memories.

Up to 14 digits. Using these techniques for a small core-memory unit, the Casio machine works with numbers of up to 14 digits. It stores them in four 14-digit registers, and two 7-digit registers. It also has a 30-digit program register, each digit corresponding to a single instruction.

The machine has a 14-instruction repertoire, any of which can be stored in a single digit position; ten decimal digits require four bits for a binary-code representation, and the four bits can represent up to 16 different symbols—the 10 digits and six others. The machine's output is through indicator tubes; its input is from its keyboard or from a typewriter.

The operator enters a program of up to 30 steps. He then enters data into the various registers and the program makes its calculations on this data; results appear in the indicator tubes above the keyboard. A semiautomatic mode, using a typewriter, is also available.

Specifications

Instruction repertoire	Add, subtract, multiply, divide Clear memory, clear keyboard Set memory registers 1, 2, 3, 4 Set minus sign Square root Program stop, program restart
Size	17½ x 15 x 9 in.
Weight	5 lbs
Power	30 w

Casio Computer Co., Tokyo **[400]**

Our digital voltmeter costs $349, and measures Ohms free.

The Fairchild 7050 DVM is a digital rebuttal to analog meters. It measures volts or ohms with a resolution of 1mV or 1 ohm, and with an accuracy of 0.1%. Integrated circuits, dual slope integration, automatic polarity, floating input and display storage are all included as standard. The 7050 weighs less than four pounds and costs $349. The tilt stand doubles as a handle and costs $16 extra. Our data sheet is free. Circle Reader Service Number 72.

FAIRCHILD
INSTRUMENTATION

FAIRCHILD INSTRUMENTATION/A Division of Fairchild Camera and Instrument Corporation ■ 974 E. Arques Ave., Sunnyvale, California 94086 (415) 962-2011 ■ TWX: 910-379-6944

. . . frequency multiplication features may account for switching speed . . .

the test bench, but can't explain it mathematically.

With a snap. The device uses two of the company's snap varactor diodes to do the switching. Bandpass filters at input and output keep both switching transients and drive power out of the microwave transmission line. They seem to do their job—drive-signal attenuation reaches 50 decibels just below about 150 Mhz and keeps increasing as frequency decreases. Attenuation above the passband is almost as steep.

A third filter stands between the driver terminals and the transmission line as added interference protection for the microwave signal. This filter presented a knotty tradeoff problem. To keep the microwave energy from entering the driver circuitry and thus keep insertion loss low, the filter's impedance had to be high. That meant a low cutoff frequency.

But to get a fast-risetime switching pulse through the filter to the diodes, a high cutoff frequency was necessary—about 700-Mhz bandwidth was needed to get the required pulse and the bulk of its Fourier components to the diodes.

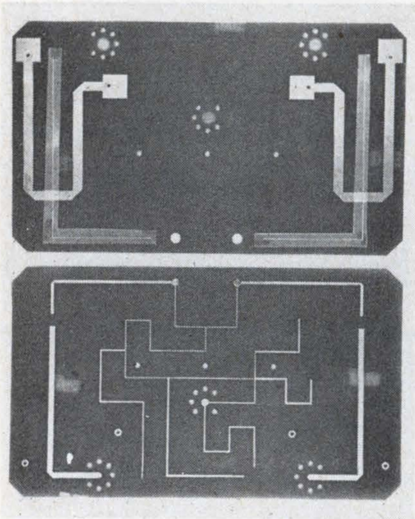
The compromise was a seven-element Chebyschev stopband filter with 40-db attenuation between 600 and 900 Mhz; above and below the stopband, attenuation drops off rapidly.

The compromise seems to have worked. Across a 200-Mhz bandwidth centered at 800 Mhz, there is less than 1.5-db insertion loss when the switch is turned on; isolation exceeds 40 db when the switch is off. Input and output voltage standing-wave ratio is a maximum of 1.67.

Bootstrapping hinted. Bascon believes the varactor diodes' frequency-multiplication characteristic may account for the speed. Perhaps the diodes are multiplying the Fourier components of the switching pulse to even higher frequencies, thus bootstrapping their way to ultrafast switching speeds. On oscilloscope traces, the switching signal was found to have frequency components well above 1,000 Mhz after it had passed through the diodes.

But Bascon also found that the diodes changed between the on and off states long before the switching pulse had completed even a small part of its 2-nsec rise to peak amplitude. It may be that the diodes need little power to switch and are being overdriven to high speed performance.

Preliminary applications are in military and research programs. The switch, designated the MA-8306-ILIN, was built for the Hughes Aircraft Co. for use in a classified system. Bell Telephone Laboratories, interested in switches that can stop a radio-frequency signal in mid-cycle, seeks a 300-Mhz switch with 2-nsec speed —another impossible combination of speed and frequency. And the Air Force wants an ultrahigh speed switch for an S-band application.



Stripped down. Both faces of stripline circuit boards are shown with filter stubs and interconnections.

Specifications

Switching speed	0.5-0.8 nsec
Bandwidth to 1.5-db attenuation points	700-900 Mhz
Bandwidth to 3-db attenuation points	650-950 Mhz
Drive voltage	+1, −2 v
Drive-pulse risetime	2 nsec
Drive-pulse falltime	1.5 nsec
Power capability	more than 700 mw continuous

Microwave Associates Inc., Burlington, Mass. 01803 **[409]**

New microwave

Coaxial connector for fast crimping

Uniform contacts assured by mechanical process including cable preparation

There was a time when the installation of solder-type coaxial connectors, with their many loose parts, was difficult and time-consuming. Stray braid strands were a common cause of trouble. This situation was somewhat alleviated by crimp-type connectors but the process still took too much time—especially when it came to stripping subminiature cable.

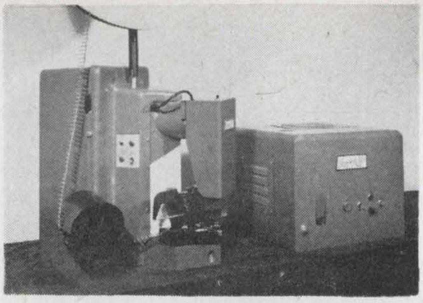
To eliminate these problems, AMP Incorporated has developed a system—including connectors and installation equipment—that does the job in 20 seconds. The contact exhibits a voltage standing wave ratio of less than 1.5:1 at 500 megahertz.

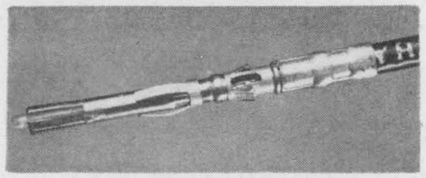
Designed for high-density, multiple-circuit connector applications, the subminature, 0.11-inch contact fits into any AMP connector housing that accepts size 16 pin-and-socket contacts. Either pin-and-socket or coaxial contacts will fit into any of the 14 to 156 positions of the 19 connector styles available.

The contact body is stamped from strip brass conforming to MIL-B-50. A polypropylene dielectric surrounds and supports the inner contact for accurate mating alignment, and a tin-plated copper retention spring attached to the outer contact surface secures the crimped contact from axial pullout.

Application tooling for the strip-fed connector includes two electrically operated bench machines—an applicator and a crimping press—that complete the assembly in 20 seconds.

Collared. Operation of the applicator tool is simple. A piece of cable is inserted through a funnel-like opening, a button pushed, and the stripped cable removed with a crimping collar put in place. Inside the machine, a vibratory hop-





Strip fed. Connectors are automatically supplied to crimping tool from spool.

per orients the crimping collar so that when the cable is inserted the collar slides on.

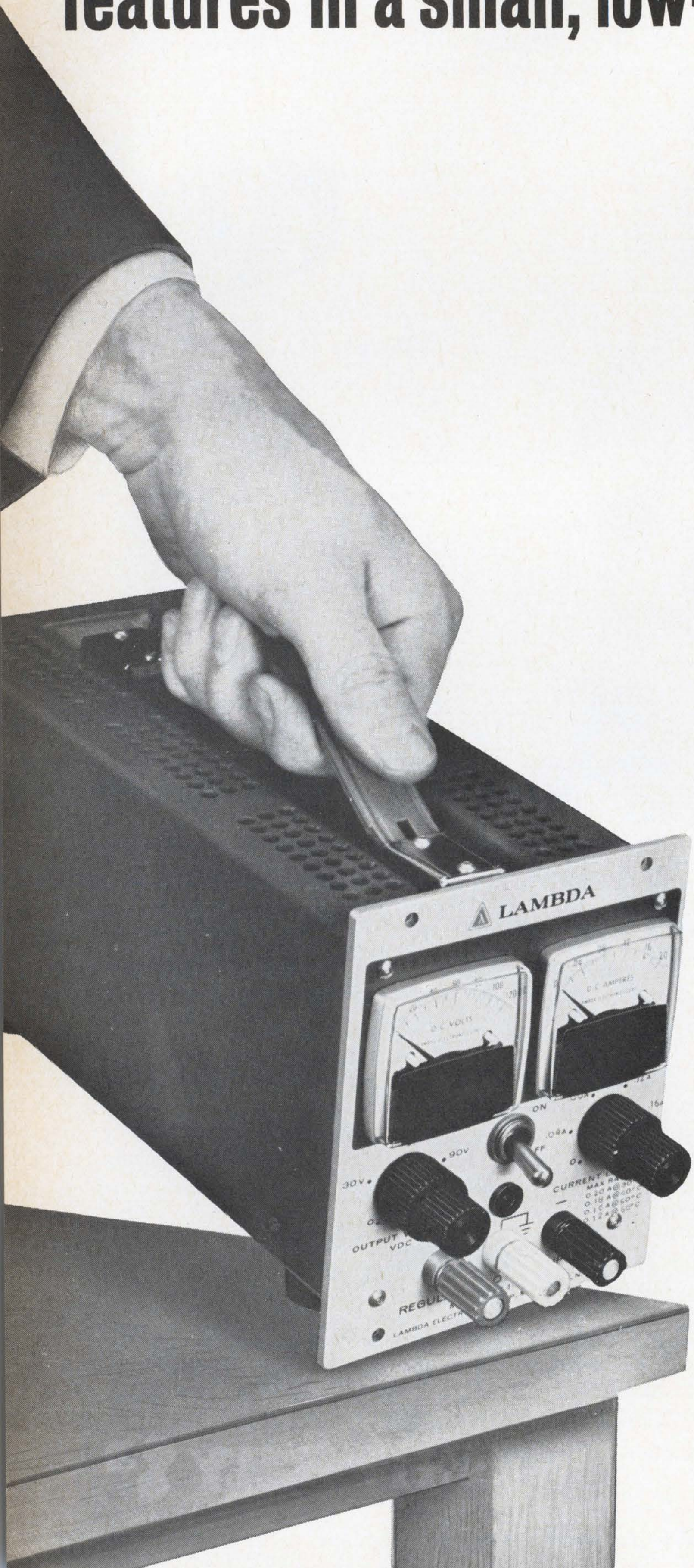
When the button is pushed, a series of shear blades close to trim the outer jacket, braid, dielectric, and center conductor to the proper length. The shear blades then move axially away from the cable, stripping each layer of the cable to its trimmed length. Oscillation of the center conductor and dielectric flares the braid to a mechanically fixed limit and the jaws open, permitting the operator to withdraw the prepared cable.

The crimping is done in one of AMP's newer electric bench presses fitted with a set of dies designed specifically for this new contact. The operator positions the cable, locates the collar, and depresses a foot pedal. Closing of the crimping die simultaneously crimps the outer jacket, braid, and center conductor, then releases the installed contact.

The collar is crimped over the outer jacket to provide rigidity and to prevent cable damage due to flexing at this point. The cable braid is crimped between the collar and the rear of the contact outer body. Peripheral V-groove serrations on the body grip the braid and help secure the cable against a maximum axial pullout force of 25 pounds. Two slender protrusions on the die extend through ports in the outer portion of the contact to crimp the center conductor.

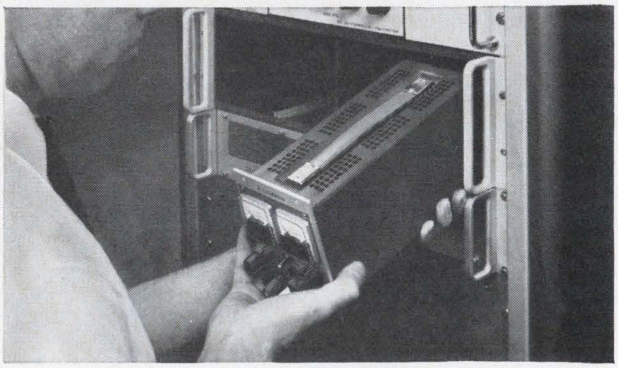
AMP Incorporated, Harrisburg, Pa. 17105 **[410]**

Only new Lambda LP Series lab power supplies provide all these big system features in a small, low-cost package.



Starting at only $114.

- High power output—up to 28 watts.
- Wide voltage range versatility—0-10 VDC up to 0-250 VDC.
- Bench or rack use—without adapters.
- Unusually wide automatic current limiting—from 1% (or 5 MA) to 105% of rated output current.
- Two meters for voltage and current.
- Both coarse and fine adjustment of voltage and current.
- Over-temperature protection by thermal relay—prevents overheating.
- Convection cooled—no blower failures.



You can mount up to 4 units in a standard LRA-1 or LRA-2 rack adapter.

Other features

- Regulation (line or load): .01% + 1 MV.
- Ripple: 500 μV RMS, 1.5 MV p-p
- Temperature coefficient: .015% + .5 MV/°C.
- CV/CC with automatic crossover.
- A-C input: 105-132 VAC 45-440 Hz (ratings based on 57-63 Hz operation).
- All Lambda power supplies are guaranteed for 5 years.

Select from six models

Model	Voltage Range	MAX. CURRENT AT AMBIENT OF:				Price[1]
		30°C	40°C	50°C	60°C	
LP 410	0-10 VDC*	2A	1.8A	1.6A	1.4A	$129
LP 411	0-20 VDC*	1.2A	1.1A	1.0A	0.8A	119
LP 412	0-40 VDC*	0.70A	0.65A	0.60A	0.50A	114
LP 413	0-60 VDC*	0.45A	0.41A	0.37A	0.33A	129
LP 414	0-120 VDC	0.20A	0.18A	0.16A	0.12A	149
LP 415	0-250 VDC	80MA	72MA	65MA	60MA	164

*Overvoltage Protection available as an accessory—$40.00 each.

[1] Prices are for non-metered models. For metered models, add suffix (FM) and add $10.00 to price.

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LAMBDA ELECTRONICS CORP.

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VEECO HIGH VACUUM EQUIPMENT/LAMBDA POWER SUPPLIES

Circle 510 on reader service card

. . . process slow, so no hot spots . . .

a program to develop equipment for in-house use by Bunker-Ramo, a major supplier of custom-designed hybrid thin-film circuits. The machine is used with a digital voltmeter, which reads out resistance values.

No hot spots. According to Jack W. Ireland, director of the company's microelectronics and advanced technology operations, the controlled, relatively slow nature of the new process eliminates the hot spots and noise that are characteristic of chemical and mechanical adjustment techniques.

The new technique alters the temperature coefficient of resistance (TCR) of resistors. This is not true of mechanical adjustment techniques such as scribing or the use of shorting bars. "When you adjust with our equipment," Ireland says, "you get a TCR change at a predictable rate with respect to the change in resistance. This TCR change can be advantageous for tracking purposes—where you have two adjacent resistors that have to remain identical in resistance over a wide temperature range. For every degree of heat, you add maybe 10 to 50 parts per million, depending on the TCR factor of the material."

Balancing the bridge. The equipment consists of a Wheatstone bridge, power supplies and associated circuitry to selectively energize and de-energize the bridge arrangement. The bridge has four arms, two of which have the resistors to be adjusted—and standard wire-wound resistors against which they'll be checked—sequentially switched into them. The resistors and the standards are so arranged that when a switch positions the resistor to be adjusted into the Wheatstone bridge, the standard resistor is placed in the adjacent arm of the bridge. A current from a secondary winding of a transformer in the circuitry flows through the bridge arrangement, including both the resistor and the standard. Current flowing through the resistor to be adjusted is controlled by the setting of an autotransformer in the circuitry, and a reading of the current is provided by a milliam-

New production equipment

Welding fasteners quick as a flash

High-speed stud welding unit numerically controlled for parts production

Numerical control, used extensively to run drilling machines, boring mills and punch presses, has been coupled to stud welding techniques for mass-production of parts for the electronics industry.

Stud welding is the joining of metal fasteners of various dimensions. The use of a tape-fed numerical control machine means that intricate welding patterns can be accomplished on items ranging from electronic housings to appliance panels without the need for auxiliary tooling or multiple welding heads, according to KSM division of Omark Industries Inc.

The company coupled its production welding unit to a numerical control system and positioning table made by Hughes Aircraft Co. The resulting system permits about 30 welds per minute, in virtually any pattern and within 0.001 inch of the desired location. The company sees primary applications in electronic parts production, where precisely-positioned fasteners are often needed in a small area to secure components.

Studs of up to one-quarter inch in diameter can be attached by the welding unit, which can be stocked with more than 15,000 fasteners. A weld is completed in a few milliseconds, so quickly that there is no burning on the reverse side of the thinnest-gauge materials, KSM says. The capacitor-discharge method of welding is used. A steel stud with a small, protruding tip is placed on the workpiece. Electrical energy stored in the capacitors is then released, instantly melting the projection and the surface of the material, and permanently joining the stud and the piece. The process can be used on a variety of metals, including aluminum.

Omark Industries, Inc., KSM Division, Moorestown, N.J. 08057 **[430]**

New Books

Less guesswork

Handbook of filter synthesis
Anatol I. Zverev
John Wiley and Sons, Inc.,
576 pp. $19.95

Today a systems engineer can specify almost any type of filter response as a subsystem on a block diagram and be reasonably sure that it can be approximated and built into an operating electronic filter. This handbook makes it easier for filter designers to satisfy such specifications. It combines the best features of a theoretical text with those of a practical filter design manual.

Performance and design data for all possible filter types—inductance/capacitance, crystal, and coupled resonators—are given in both the time and frequency domains. Designed primarily as a guide to solving filter problems, the book also covers basic network synthesis.

Zverev starts with the underlying theory, concepts, and techniques of selective networks and then moves to the responses that are provided by passive, linear, bilateral filtering structures. These are illustrated by specialized networks such as crystal and helical filters.

Other sections cover polynomial filters with monotonic attenuation curves, design tables for lowpass element values, normalized coupling coefficients, quality factors, and network-transformation techniques.

Although the author does an excellent, comprehensive job of describing passive filters, the reader will not find an extensive treatment of active networks and microwave structures.

A for effort

Introduction to Quantum Mechanics for Electrical Engineers
P.A. Linsay
McGraw-Hill Book Co., 240 pp., $9.50

Few books have been aimed at making quantum mechanics palatable to electrical engineers. Any that try to are like coeds at Princeton—on the basis of rarity alone they demand attention. This book tries and partially succeeds.

The importance of quantum mechanics to today's inventive electrical engineer is summed up by Rudolf Kompfner of Bell Telephone Laboratories in his introduction: "I expect to see a reversal of a trend . . . that the major inventions in the recent past in the sciences of communications and electronics have been made by physicists." Presumably, notes Kompfner, the physicists studied quantum mechanics at school.

In a discussion of waves Lindsay glosses over the first experiments that suggested the wave properties of matter and omits illustrations that might be helpful. He assumes the reader is familiar with wave equations, and points out the similarities between Heisenberg's uncertainty principle and the time-frequency domain correspondence. Liberal use is made of transmission line theory throughout to support the author's presentations.

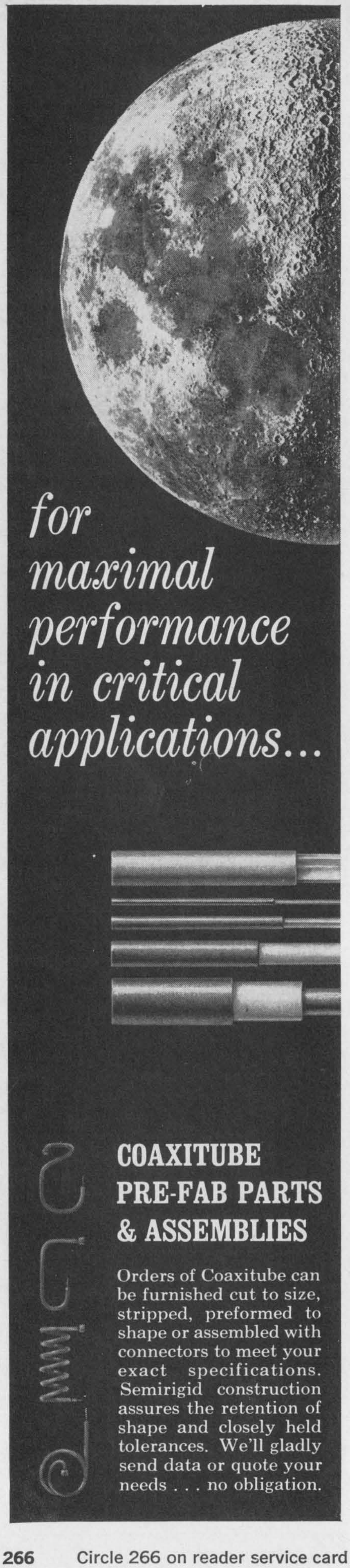
The book concludes with a discussion of the concept of energy bands in crystals. Most readers would expect, and profit by, a discussion of the relationship between this concept and semiconductor physics—but it is lacking. Instead the reader must refer to texts on solid state physics, for which Lindsay's book is an excellent introduction.

For those who are seriously interested in the subject, he includes problems at the close of each chapter. Some instruct the reader to "discuss" specific areas. One wonders with whom the solitary student will discuss such problems; wives, for example, are notoriously poor conversationalists when it comes to quantum mechanics.

Two in one

Tunnel Diodes
M.A. Lee, B. Easter, H.A. Bell,
Chapman and Hall Ltd.,
Distributed in the U.S. by Barnes & Noble Inc., 196 pp., $6.25

As one of a series of brief, inexpensive monographs on selected topics in electronics, it's easy to see why this book has been published. The



New Books

topic of tunnel diodes is narrow and lends itself to coverage in less than 200 pages.

Tunnel diodes, today, are useful in only two applications: microwave amplifiers and high-speed logic circuits. This book covers both areas. But a reader interested in logic circuits would care little about microwave amplifiers, and vice versa. Thus, either reader, if he buys the book, is also paying for information that will probably be useless to him in his work.

One wonders, in fact, why two books were not prepared for the series, one on each major application area. This would have allowed deeper coverage of each type circuit and made each one more useful to a particular reader.

The best section in the book is the first one, on physical aspects of tunnel diodes. This is a well-written discussion of the tunneling phenomenon and the construction and metallurgy of the devices.

Bright hope

The Physics of Electroluminescent Devices
P.R. Thornton
E&F.N. Spon Ltd., 382 pp., $14.50

After candidly indicating the breadth of topics needed to cover the subject in his very first sentence—"The study of electroluminescent devices is not one for faint hearts"—the author goes on to deliver one of the best books yet published on the subject. It is complete, well written, and will be useful for a long time as this embryonic segment of electronics grows to major importance.

It highlights the changing nature of electronics engineering. With the advent of new devices, today's engineer must be part metallurgist, part thermodynamicist, part optics specialist, and still be all engineer.

As a primer for the understanding of the basic mechanisms of electroluminescence, the first two chapters are devoted to excitation and recombination processes. The author then moves on to avalanche breakdown and reverse-bias light emission, and then zeroes in on

New Books

electroluminescent behavior in zinc sulfide, cadmium sulfide, gallium arsenide, and gallium phosphide. He winds up with a discussion of injection lasers and points out in detail the many applications for electroluminescent devices.

In his section on applications, the author has looked far enough ahead to areas that are only theoretical today. Since the most likely applications for injection lasers will be in room temperature devices—where cryogenic cooling will not be required—the author discusses the thermal effects in detail. To minimize the contact resistance and provide better heat sinking, he points up the need to improve laser materials. Applications of noncoherent electroluminescent devices in optical coupling, x-y displays, and electrical scanning are also discussed.

The book concludes with the physics of failure. The author cites the built-in effects, such as mechanical defects, variations in doping levels, and surface contamination, and the operational effects, such as ionic movement, and thermal effects.

Why bother?

Servomechanisms
L.J. Bulliet
Addison-Wesley Publishing Co., 276 pp., $9.95

A major technical advance during World War II occurred in servomechanisms and, shortly thereafter, several basic books appeared on the subject. Two notable texts were by Brown and Campbell, and by Lauer, Lesnik, and Matson. The first treated servomechanisms on an analytical basis, the second described servo components and system design.

This duo was in the vanguard of a variety of works by others in the field of servos. For years, industry has not suffered from a lack of servomechanism textbooks. And, except for treating very specialized aspects, most authors have had the good grace not to produce additional readings.

But here is another book on servos. It would not warrant re-

New Books

view except for one thing—the author's admirable intention is to educate technicians among others. To accomplish this he "avoids the deeper theoretical subtleties which can be appreciated only through the use of higher mathematics."

Such a statement cannot acquit, in advance, the failure of a book to come to grips with its subject at the required level. Technicians are better educated than the author implies. Were they not, the book would be of little use to technician-readers, for the author doesn't spare the mathematics anyway. He just avoids mathematics to give a real insight into servomechanism principles.

For example, Bulliet overlooks a fundamental servomechanism concept—that of stability—and his insistence on eschewing mathematics is probably the reason. Any technician who thinks he can understand servomechanisms from this book will be in for a mighty big surprise when the real servomechanism on which he's working with a development engineer suddenly starts oscillating. Unfortunately, he won't have time to read another book on servos to discover why that's happening.

Perhaps to compensate for leaving out thorough treatment of stability, the author dwells at great length on ideas like saturation, isolation, and time constant. After defining time constant in a complex paragraph, Bulliet uses the term vaguely—parenthetically stating that the time constant is the "time to settle down." Settling time does relate to time constant, but the two are not the same.

Recently Published

Handbook of Numerical Methods and Applications, Louis G. Kelley, Addison-Wesley Publishing Company, 354 pp., $14.50

Designed mainly as a handbook, this volume is also a reference for engineers and scientists who program their own problems. The author discusses numerical analysis, curve fitting and data smoothing, nonlinear algebraic equations, Eigenvectors, and the Gram-Schmidt orthogonalization procedure.

Modern Transistor Electronics Analysis and Design, Fred K. Manasse, John A. Ekiss, and Charles R. Gray, Prentice-Hall, Inc., 555 pp., $12.95

Primarily for the electronics design engineer, this book focuses on development and analysis of semiconductors. Included are several

New Books

new areas of development—integrated circuits, avalanching and Gunn-effect diodes, charge-control models, and choppers.

Reusable Protective Packaging, Steven E. Mautner, Kayar Publishing Co., 101 pp., $8.50

Protecting electronic equipment during shipment and storage has become a problem that the electronic designer has to face. This book attempts to lead him through the maze of military specifications for shock, vibration, and hostile environments.

Magnetism and Magnetic Materials 1967 Digest, Edited by W.D. Doyle and A.B. Harris, Academic Press, 278 pp., $11

A concise review of papers on magnetism and magnetic materials published in 1966, designed as a reference for the graduate student or the practicing engineer.

Electric Power Systems, B.M. Weedy, John Wiley and Sons, 302 pp., $8.50

This introductory text provides students with the basic essentials of power system operation and analysis. Equivalent circuits, d-c transmission, and the limitations of transmittable power are discussed.

Handbook of Analog Computation, Maxwell C. Gilliand, Systron-Donner Corp., 40 pp., $5

Provides students as well as experienced computer users with up-to-date analog computer software. Basic fundamentals and advanced programing techniques are presented.

Marks' Mechanical Engineers Handbook, Seventh Edition, Edited by Theodore Baumeister, McGraw-Hill Book Co., $29.50

Latest edition of a standard work, most useful for electrical engineers in the areas of cryogenics, ultrasonics, optics, and thermal properties of materials.

Basic Analog Computation, Gerald R. Peterson, The Macmillan Co., 124 pp., $3.95

How an analog computer functions and what makes it function are covered in this undergraduate text. Simple linear, high-order linear, and nonlinear and time-varying systems programing are included.

Digital Logic and Computer Operations, Robert C. Baron and Albert T. Piccirilli, McGraw-Hill Book Co., 321 pp., $13.50

Beginning with a general introduction to the computer field, this textbook covers Boolean algebra, computer logic, storage, input and output functions, and control elements. Time-sharing, and multiaccess systems are also included.

High Frequency Communications, J.A. Betts, American Elsevier Publishing Co., 98 pp., $5

The application of error detection and correction is explained, showing the difference between systems used on one-way and two-way circuits. Also included are methods of ionospheric forecasting.

Electric Circuit Problems With Solutions, F.A. Benson, Barnes and Noble, 257 pp., $4.95

Aimed at the laboratory technician, this book contains a wide variety of problems in a-c, d-c, and polyphase circuits provides the reader with detailed solutions.

Characteristics and Operation of MOS Field Effect Devices, Paul Richman, McGraw-Hill Book Co., 146 pp., $10

The book covers the electrical characteristics of MOS transistors, MOS technology, fabrication techniques, and linear and digital MOS circuit applications. Included are recent developments in the fabrication of low power MOS complementary integrated circuits.

Technical Abstracts

Large repertoire

An LSI variable function register
Robert J. Lesniewski
Goddard Space Flight Center
Greenbelt, Md.

Although large-scale integrated circuits are usually designed for just one purpose, the true value of LSI may be in more versatile arrays—such as those that can be electrically programed to perform many different functions.

Such circuit versatility will soon be almost mandatory in sophisticated spacecraft with on-board data processing. As an example, a variable function register capable of four different operations has been built using metal oxide semiconductor technology, and 500 active devices on a chip.

A second-generation register, capable of parallel processing with 18 different operations using 1,300 active devices, also has been designed, but not yet built. The complementary MOS technology makes such design possible by reducing power dissipation and element count.

The variable-function repertoire includes seven basic operations—parallel loading and outputting, rotating data, shifting data to the right and left, and complementing the register's contents. The shifting and rotating operations can be electrically programed by setting MOS switches between the shift-register stages.

The register chips also can be cascaded to form large registers. With a bypass switch, information can be shifted past a register while it continues to operate.

Presented at Eastcon, Washington, Oct. 16-18.

Two-way etch

Anisotropic etching for forming isolation slots
H.A. Waggener, R.C. Kragness, and A.L. Tyler,
Bell Telephone Laboratories,
Allentown, Pa.

A technique that etches downward into a silicon wafer much more rapidly than it etches sideways gives narrow, precisely defined isolation slots. As a result, more beam-leaded integrated circuits can be fabricated in a silicon slice than is possible with standard etching techniques. The new method requires a unique orientation of the etching mask on a specific lattice plane of the silicon crystal, and an etchant that attacks one plane more than the others. Etchants now being investigated for silicon consist of strong alkaline solutions, such as a mixture of potassium hydroxide, propanol, and water.

To fully exploit the difference in etch rates, two conditions are required: the face of the silicon disk to be etched is made parallel to the lattice planes having a high etch rate; and the edges of masked areas are aligned parallel to a second lattice plane with a negligible etch rate. Under these conditions, slots are formed with slanted sides, in the shape of flat-bottomed wedges. Each slot steadily becomes narrower as the etching progresses, and thus the slot's depth and width are precisely defined by the etching mask and etching rate. Etching terminates when the two sloping sides of the deepening slot meet, or when it etches through the slide, whichever occurs first.

During the fabrication of beam-leaded integrated circuits, slots are etched out of the semiconductor slice to separate the many individual circuits and/or to isolate components within each integrated circuit. Standard (nonpreferential) etchants result in fewer integrated circuits because variations in the thickness of silicon slices cannot be reduced economically to less than a few tenths of a mil. To insure complete penetration at the thickest parts of the slice, considerable over-etching must be tolerated at the thinner portions. Since the isotropic, nonpreferential solutions etch as fast sideways as downward, the active devices on the opposite side of the slice must be spaced three to four time farther apart than the average slice thickness to protect them against over-etching during separation.

With preferential etching, the masking operation is done after the desired devices have been fabricated on one side of the slice. A silicon dioxide mask then is applied to the opposite side to delineate the slots for etching. Because the sides of the slots are stationary, only relatively simple etching controls are required.

An important feature of the improved etching technique is that the mask shape is altered to compensate for undercutting at the outside corners of the mask, where the third main lattice plane of silicon is exposed. The etch rate of this third plane can be made much slower than that of the primary etching plane, but it is still significant. Therefore, enlarged corner areas of calculated size and shape are added to the etch mask to compensate for the undercutting at these corners.

Presented at the International Electron Devices Meeting, Washington, Oct. 18-20.

Featherweights

A digitally implemented microelectronic i-f decoder

Richard S. Ocheret
General Instrument Corp., Radio Receptor Division, Brooklyn, N.Y.

Metal oxide semiconductor technology may slash the size and price of delay lines. Beaconry and interrogation-friend-or-foe (IFF) systems use delay lines for passive decoding of a pulse train to see if it agrees with a preselected code. The new digital equivalent for the IFF passive decoder—a shift register—is built on a single silicon chip with MOS technology that is easy to design and simple to make.

With the MOS device, transconductance can be determined by geometry so that all chip devices can be simultaneously diffused in a single step. Since both drain and source are reverse-biased with respect to the substrate, no isolation is required between devices, and, because the input impedance of each device is high, increased fanout is possible.

The single chip holds a 43-bit shift register, decoding logic, and input circuitry. The circuitry can operate down to d-c but if this is not needed, four-phase logic can be used. With the four-phase scheme, power is dissipated only during switching.

The shift register is continuously

clocked at 2.069 megahertz with three bits provided for every pulse interval in the IFF reply train. The decoding logic on the chip compares incoming trains with a code selected by external switches.

The input video signal is fed to a strobe circuit, which clocks the signal into the shift register. The outputs of every third stage are fed to logic circuits, NAND and NOR gates, and compared with the coded input.

Presented at Eastcon, Washington, Oct. 16-18.

Sound design

Monolithic limiter and balanced discriminator for f-m and tv receivers
A. Bilotti and R.S. Pepper
Sprague Electric Co.,
North Adams, Mass.

Quadrature detectors have found widespread use in f-m receivers and tv audio sections because they are simple to design and provide excellent performance. Less costly than other types such as ratio detectors and discriminators, they require inexpensive single-tuned coils rather than costlier double-tuned transformers. A design, based on the quadrature approach, for a monolithic limiter and balanced discriminator for f-m and tv receivers using full-wave coincidence gates offers even lower cost to manufacturers of television sets.

Basically, f-m detectors fall into three broad categories—slope, phase shift, and pulse averaging.

In the slope detector, the frequency deviation is transformed into a variable amplitude voltage by a reactive circuit's amplitude versus frequency slope. In the phase-shift detector, a reactive circuit's phase versus frequency characteristic transforms the instantaneous frequency deviation into a relative phase deviation, which is then detected by either a vector addition- or coincidence-type phase detector. In the pulse-averaging detector, single-polarity pulses are generated at each zero crossing of the signal. The resulting pulses of constant area are integrated and demodulated.

Of the three, a strong case can be made for an LC-type phase-shift network used in conjunction with a quadrature detector. Phase shifts can be transformed into amplitude variations without regard to the amplitude characteristics of the reactive circuit in which it is used. Complete linearity between the phase-shift deviation and the resulting output signal is also exhibited.

To enhance performance, a wideband limiter precedes the detector circuit.

F-m and tv applications require a high a-m rejection. Since wideband limiters tend to convert a-m signals to pulse-width asymmetries, rejection of these signals can be seriously degraded by the amplifier. This, however, is overcome by a full-wave quadrature circuit. This type of circuit has an added advantage: it can be used as either a high-performance synchronous demodulator or a double-balanced mixer.

Presented at the International Electronic Devices Meeting, Washington, D. C., Oct. 18-20.

A new image

Electron-beam-accessed silicon diode arrays for image-sensing applications

M. H. Crowell and E. F. Labuda,
Bell Telephone Labs,
Murray Hill, N.J.

Semiconductor diodes outshine thin-film photoconductive targets in vidicon applications. And a planar array of reverse-biased silicon p-n diodes can afford advantages over evaporated photoconductors as image-sensing elements in television camera tubes. Among these advantages:

- photoconductive lag problems don't arise;
- spectral response is broader;
- sensitivity is higher;
- there are no associated optical and electron-beam "burn-in" effects;
- higher temperatures can be tolerated during vacuum processing.

A 1-centimeter-square matrix containing a 660-by-660 diode pattern constitutes the array; the diodes are fabricated by photolithographic techniques. An optical image is focused on the laterally homogeneous n-type substrate, which is typically 1 mil thick.

The diode side of the array serves as a p-type target and is scanned by an electron beam. Resolution capability and spectral sensitivity are functions of the minority carrier lifetime in the substrate and of recombination velocity of the light-incident surface.

Collection efficiencies—the ratio of holes collected at the diode depletion regions to the photons absorbed in the substrate—have topped 50%, better than twice the level achieved by conventional means. Useful spectral range is 4,500 to 9,500 angstroms, and dark currents are kept below 10 nanoamperes.

Presented at the International Electronic Devices Meeting, Washington, D. C., Oct. 18-20.

Noisy light

Pulse interval modulation laser communications
Monte Ross
McDonnell Douglas Corp.,
St. Louis, Mo.

Darkened somewhat by the problem of interfering quantum noise—from stray photons at light frequencies—the prospect of laser communications now appears brighter. A proposed pulse-interval modulation (pim) system takes into account the probability of stray photons ending up at the receiver by sending short, high peak power laser pulses in one of several possible coded time intervals.

Because the system's detector must only sample transmitted pulses for a short time period, there is less chance of its also seeing stray photons. Such a system would pack a lot of power into each pulse, making it possible to raise the detector's threshold so that it could easily distinguish between signals and quantum noise.

The number of bits one pulse could carry would depend on the number of possible time intervals in each time slot, because the number of time intervals determine the number of combinations of binary ones and zeros.

Pim laser systems might find application in space communications where it's particularly important to send the most information per watt of power. For example, assume a data link between Mars and the Earth. A pim system with a 150 watt input would require a four inch focusing lens and a 40 foot receiving antenna to send 1,000,000 bits per second using 1-nanosecond pulses. In contrast, an r-f system operating under the same power would require an eight foot transmitting antenna and a 210 foot receiving antenna and would only send 10,000 bits per second.

Presented at Eastcon, Washington, Oct. 16-18.

Semiconductor tube

A germanium space-charge-limited triode,
A. Shumka,
Jet Propulsion Laboratory
Pasadena, Calif.

A solid state triode that behaves like a vacuum-tube triode offers a low level of sensitivity to thermal change, high input impedance, and tube-like transfer characteristics. The first of these features is new to semiconductor devices; the latter two are more pronounced in the triode than in field effect transistors, until now considered the semiconductors most similar to tubes.

The new device, fabricated from germanium, has an electrode that controls and modulates the flow of space-charge-limited electron currents and is analogous to the vacuum tube's grid. The p^+ stripes forming this grid electrode are inserted in an $n^+ - \pi n^\dagger =$ type diode structure. The closely spaced stripes are capacitively coupled to the diode's terminals to establish emitter and collector regions analogous to a plate and anode.

Currents follow the three-halves power law when an electric field is impressed between the control electrode and the emitter. Over-all current-voltage characteristics show high transconductance, a large amplification factor, and an input impedance exceeding 1 megaohm.

Noise figures are a few decibels lower than those of conventional bipolar semiconductors, and susceptibility to temperature change is at least an order of magnitude less.

Presented at International Electron Devices Meeting, Washington, D. C., Oct. 18-20.

New Literature

Microwave glossary. Alfred Electronics, 3176 Porter Drive, Palo Alto, Calif., has published a four-page application note entitled "Glossary of Microwave Terms" that lists 115 microwave definitions. Circle **446** on reader service card.

R-f test instruments. Kay Electric Co., Maple Ave., Pine Brook, N.J. 07058, has released a 32-page brochure illustrating and describing a line of r-f test instruments. **[447]**

Capacitance probes. Wayne Kerr Corp., 22 Frink St., Montclair, N.J. 07042. A two-page, illustrated bulletin describes the company's capacitance probes. **[448]**

Slip ring capsules. Collectron Corp., 304 E. 45th St., New York 10017, offers a brochure describing a simplified method in designing a completely functional and highly reliable miniature and subminiature slip ring capsule. **[449]**

Tape reel drive motors. General Electric Co., Schenectady, N.Y. 12305. Technical data sheet GEC-1795 describes direct-current, fractional h-p motors for use as computer tape transport drives. **[450]**

Ultrasonic cleaning equipment. Delta Sonics Inc., 12918 Cerise Ave., Hawthorne, Calif. 90250, has released a 12-page brochure on ultrasonic cleaning equipment. Detailed specifications for tank sizes from 3- to 90-gallon capacity and 300 to 4,000 w are listed. **[451]**

Avalanche diode oscillator. Sylvania Electric Products Inc., 1100 Main St., Buffalo, N.Y. 14209, offers a brochure describing the SYA-3200, an X-band avalanche diode oscillator that simplifies construction of parametic amplifiers. **[452]**

Instrument motors. Amphenol Controls Division, Amphenol Corp., 120 S. Main St., Janesville, Wis. 53545. An eight-page catalog covers servocontrol, induction, reluctance and hysteresis synchronous motors. **[453]**

Vacuum coaxial switching. ITT Jennings Division, ITT Corp., P.O. Box 1278, San Jose, Calif. 95108. Brochure 108 describes the characteristics, construction, and application of vacuum coaxial switching systems. **[454]**

Emi/rfi shielding. Technical Wire Products Inc., 129D Dermody St., Cranford, N.J. 07016, has published an eight-page booklet containing information on its emi/rfi shielding products and services. **[455]**

Random data generator. Datapulse Inc., 10150 W. Jefferson Blvd., Culver City, Calif. 90230, offers a technical bul-

New Literature

letin on the model 213 random data generator for data error analysis and pattern sensitivity detection in transmission-medium systems and storage elements. **[456]**

Parametric amplifier systems. TRG Division, Control Data Corp., 535 Broad Hollow Road, Melville, N.Y. 11746, has issued brochures describing models 4-500 and 7-120 parametric amplifier systems. **[457]**

Motors. A.W. Haydon Co., 232 North Elm St., Waterbury, Conn. 06720. A four-page bulletin contains information on 16 types of d-c motors, synchronous motors, stepper motors and drives, and gearheads for timing, driving and positioning applications. **[458]**

Diode reliability. Unitrode Corp., 580 Pleasant St., Watertown, Mass. 02172, has available reliability report TR-129 covering rectifiers, zeners, and assemblies. **[459]**

Metal-to-ceramic components. Advac Division, GTI Corp., Stamford, Conn., offers a metal-to-ceramic components and assemblies folder. **[460]**

Dynamic bridge amplifier. Redcor Corp., 7800 Deering Ave., Canoga Park, Calif. 91304, has issued a booklet containing numerous applications for a dynamic bridge amplifier module designed for use in low level data acquisition and instrumentation systems. **[461]**

Pressure actuated switch. Electro Marine Corp., 4 Robbins Road, Falmouth, Mass. 02540. Bulletin 800 describes a pressure actuated switch for oceanographic instrumentation applications. **[462]**

Laser components. Oriel Optics Corp., 1 Market St., Stamford, Conn. 06902, has published a data sheet on carbon-dioxide-laser end reflectors made from germanium and silicon with high efficiency multilayer dielectric coatings. **[463]**

Card reader. Scientific Data Systems, 1649 Seventeenth St., Santa Monica, Calif. 90404. Model 7140 card reader, a high-speed peripheral device that reads punched cards at a rate of 1,500 cards per minute, is described in data sheet 64-24-16A. **[464]**

Synchro converters. Natel Engineering Co., 7129 Gerald Ave., Van Nuys, Calif. 91406, has issued catalog 101 on a family of synchro converters including synchro-to-sine/cosine converters, synchro-to-linear d-c converters, synchro-to-digital converters, and angle position indicators. **[465]**

Time-sharing computers. Scientific Data Systems, 1649 Seventeenth St., Santa Monica, Calif. 90404. The SDS940

New Literature

time-sharing computer system is the subject of brochure 64-03-29A. **[466]**

Audio interference suppressor. Narda Microwave Corp., Plainview, L.I., N.Y. 11803, has available a technical bulletin on the model 562 audio interference suppressor. **[467]**

Biased amplifier. Hamner Electronics Co., Box 531, Princeton, N.J. 08540, offers a technical bulletin covering the NA-18 biased amplifier that permits a section of the spectrum to be spread over a larger number of channels of a multichannel analyzer. **[468]**

Semiconductor products. Westinghouse Semiconductor Division, Youngwood, Pa., 15697. Condensed catalog B-9418 describes a wide variety of semiconductor devices ranging from a 250-amp transistor to a full line of low-cost plastic-case rectifiers. **[469]**

Computers on campus. Scientific Data Systems, 1649 Seventeenth St., Santa Monica, Calif. 90404. Interface 12, the latest issue of the company's quarterly magazine, contains a feature article describing the use of SDS computers in some 40 colleges and universities. **[470]**

Vacuum systems. Consolidated Vacuum Corp., 1775 Mt. Read Blvd., Rochester, N.Y. 14603. Two bulletins describe new vacuum systems that feature AutoMate control. **[471]**

Interchangeable thermistors. Victory Engineering Corp., 128 Springfield Ave., Springfield, N.J. 07081. Product bulletin MTM141 describes Isotherm interchangeable thermistors and contains a comprehensive resistance vs temperature table. **[472]**

Wire marking. W.H. Brady Co., 727 W. Glendale Ave., Milwaukee, Wis. 53209. A 20-page catalog lists over 5,000 different self-sticking wire markers and several dispensing methods to speed wire identification. **[473]**

Operational amplifier. National Semiconductor Corp., 2950 San Ysidro Way, Santa Clara, Calif. 95051. Bulletin SC-103 describes and illustrates the LM101 general-purpose operational amplifier. **[474]**

Thermal relays. G-V Controls Inc., Okner Parkway, Livingston, N.J. 07039, has available a file folder including information on two series of commercial thermal relays. **[475]**

Trimming potentiometers. Conelco Components, 465 W. Fifth St., San Bernardino, Calif. 92401. A four-page brochure details the Midgi-Trim line of precision wirewound/slidewire trimming potentiometers. **[476]**

New Literature

Temperature-humidity chambers. Tenney Engineering Inc., 1090 Springfield Road, Union, N.J. 07083, offers bulletin 106 describing an advanced version of its temperature and temperature-humidity chambers. **[477]**

RC networks. Electro Cube Inc., 1710 S. DelMar Ave., San Gabriel, Calif. 91776, has published a brochure on precision RC networks for contact protection and noise suppression. **[478]**

Vibration meter. Wayne Kerr Corp., 22 Frink St., Montclair, N.J. Three-color literature describes the B731B vibration meter that features linear output characteristics. **[479]**

Solderless terminals. Hollingsworth Solderless Terminal Co., Nutt & French Creek Roads, Phoenixville, Pa. 19460. A complete line of solderless terminals, splices and tools is described and illustrated in a 30-page catalog. **[480]**

Versatile digital instrument. Technology/Versatronics Inc., 506 S. High St., Yellow Springs, Ohio 45387. Three instruments in one—digital voltmeter, electronic counter, and electronic integrator—are provided by the model DM5000 Versa/meter described in bulletin 701-B. **[481]**

Plastic-encapsulated transistors. Motorola Semiconductor Products Inc., Box 955, Phoenix, Ariz. 85001. A 12-page brochure presents a reliability report on small-signal, plastic-encapsulated transistors. **[482]**

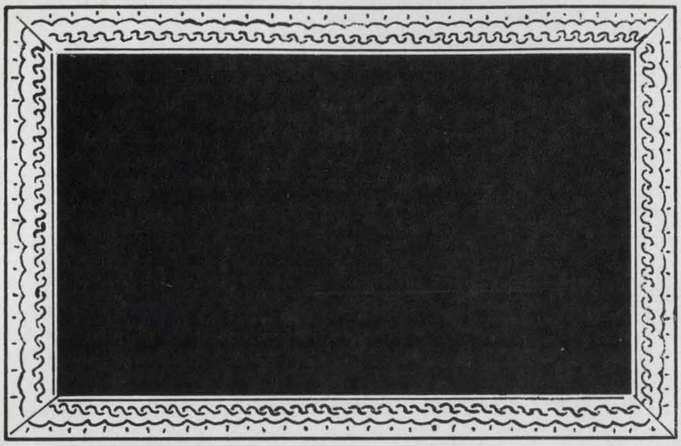
Casting system. Hysol Corp., Franklin St., Olean, N.Y. 14760. Bulletin E3-225 describes water white hardener H-3840, a room-temperature-cure casting system for electrical and electronic applications. **[483]**

Wirewound resistors. RCL Electronics Inc., 700 So. 21st St., Irvington, N.J. 07111. Engineering catalog 678 lists hundreds of types of wirewound resistors, together with complete engineering information. **[484]**

Ceramic capacitors. Gulton Industries Inc., 212 Durham Ave., Metuchen, N.J. 08840. High capacitance subminiature ceramic capacitors are described in bulletin H29. **[485]**

Electronic timers. Brooks Instrument Division, Emerson Electric Co., Hatfield, Pa. 19440. Digital-readout electronic timers that maintain accuracy regardless of power line frequency variations are discussed in technical bulletin DS-4580. **[486]**

High-vacuum system. Ultek Division, Perkin-Elmer Corp., P.O. Box 10920, Palo Alto, Calif. 94303. A bakeable, tabletop high-vacuum system is the subject of a six-page bulletin. **[487]**



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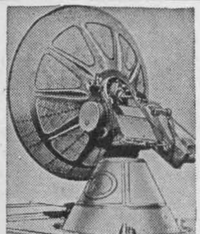

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VA-806H: 1KW output CW 7.5 to 8.5 KMC

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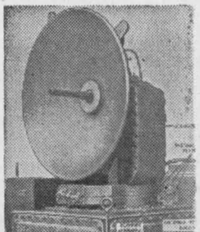

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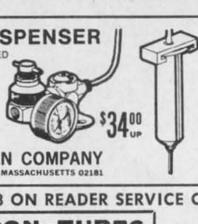

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The TR 8 series will also include a computer for military applications. This version will be smaller and have fewer channels than the commercial machine.

Tide of IC imports is rising in Japan

Japan is braced for a surge of integrated-circuit imports during the next few months. Such imports—all but a handful from the U.S.—totaled 270,000 packages in September but are **expected to climb to about 500,000 this month and hold at that level through the rest of the year.**

The industry guess is that Nippon Electric, Fujitsu, and Hitachi are gobbling up more than half the IC's coming into the country. Both Nippon Electric and Fujitsu are major producers of IC logic but their production schedules will keep them heavy importers of computer circuits for some time to come. Hitachi, which has put initial in-house emphasis on IC packages for calculators and consumer electronics, imports logic circuits for the RCA Spectra 70 computer it produces under license.

So sharp is the projected import rise that the flood of foreign IC's may temporarily top domestic production. But by early next year, Japanese producers figure to dominate their home market even though there's little prospect of a drop in imports.

Nippon Electric, currently the top Japanese IC producer, turned out 250,000 packages in September and expects a 600,000 monthly output rate by March. Mitsubishi production is close to 200,000 circuits a month; but the other two major producers, Fujitsu and Tokyo Shibaura Electric, are still below the 100,000-a-month mark.

AEI resists takeover bid

Defensive maneuvers by Associated Electrical Industries have so far blocked efforts by Britain's General Electric Co. to take over the firm.

Since its first bid of $330 million last month [Electronics, Oct. 16, p. 225], GEC has upped the ante twice. Arnold Weinstock, head of GEC (not connected with General Electric in the U.S.), describes the present offer of $450 million—rejected by AEI's management—as "final." **But there's speculation he may go higher since the latest bid is still some $80 million shy of AEI's total assets.**

Meanwhile, AEI has acquired a new chairman and come up with a plan to put its telecommunications equipment business into a joint venture with Standard Telephones and Cables, an ITT subsidiary. **These moves have helped AEI hold the fort, but insiders say the battle could still go either way.**

Kremlin programs tv production boost

New emphasis on consumer goods in Soviet economic plans will push television-set production to record levels next year. The target is 5.7 million sets, up nearly 20% from this year's estimated output of 4.8 million.

Most of the sets will be black and white. Although nationwide colorcasts started last week with a live showing of the Red Square festivities marking the 50th anniversary of the Bolshevik revolution, volume production of color sets won't come until 1970.

The stepped-up tv-set production apparently won't be at the expense of other electronic sectors. **Despite the secrecy surrounding sophisticated technology, there are indications that the Soviets have plotted a solid boost in automatic controls and computers over the next three years.**

IBM Circuit Design and Packaging Topics

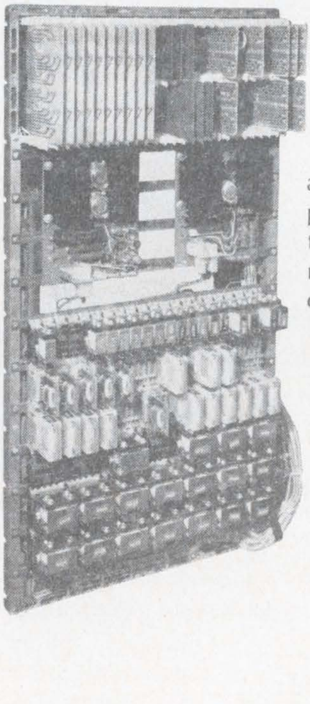
☐ **packaging cost reductions**
☐ **high-speed switching**
☐ **reed switch application data**

☐ packaging cost reductions

Performance Measurements Co., Detroit, Michigan, reports significant savings in packaging their new electronic recording system. The packaging method previously employed required two gates to mount the components in the main console. Now, with IBM's modular packaging as pictured below, only one gate is needed. That's because the IBM technique makes the most efficient use of console space with compactly mounted and connected circuit boards, relays and hardware.

Mounting time has been saved too. Pluggable components, low-cost card receptacles and interlocking card guides have so simplified the packaging job, that Performance Measurements now saves 70% on the cost of mounting hardware. Fewer and shorter wires are needed in the compact console—eliminating three feet of 1½-inch cable and shortening a second cable by eight inches. The modular chassis gave designers freedom to experiment freely with various mounting configurations. It also permits easy access for servicing and diagnostic analysis.

The same design freedom, plus significant hardware and labor savings are available in many applications.

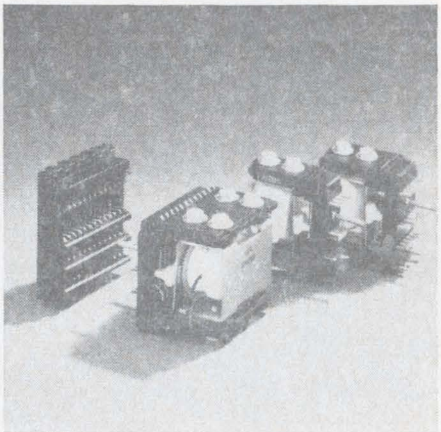


IBM components and packaging can help you in timing control, digital logic testing, telemetering, process or numerical control.

☐ high-speed switching

IBM wire contact relays were originally designed for data processing use. Now they are being used extensively in machine tool and assembly applications. One of these assembly applications is a numerically-controlled component insertion machine. It sequentially inserts random combinations of up to 24 different types of axial lead resistors and diodes into printed circuit boards. Such machines have been widely used, often on a round-the-clock, three-shift basis, in IBM's electronic assembly operations. Insertion rates range from 3,000 to 4,500 components per hour, depending upon the type of components being inserted.

Instructions from an 8-channel punched paper tape provide the logic input to the relay gate. The gate employs three rows of 6- and 12-pole IBM wire contact relays. These relays control the movement of each printed circuit board through the X and Y axis positioning of the board for each component insertion. They also control the component feed, component insert, and cut-and-clinch cycles for each insertion operation.



IBM wire contact relays can perform in excess of 200 million operations with an operate speed as fast as 4.5 ms, a release time of 5 ms maximum. The product line includes 4-, 6-, and 12-pole Form C relays, 4- and 6-pole latch models, all with compact, solderless, pluggable mountings—with coil-voltages up to 100 VDC.

☐ reed switch application data

Data on the magnetic switching characteristics of miniature dry reed switches is available to design engineers on request. The data was compiled from ex-

air tests during the early-morning hours when there are no programs and will report the results to the Federal Communications Commission early next year.

Market bound. N.V. Philips' Gloeilampenfabrieken, too, has developed a system that fills in the blanks between tv scanning fields and hopes to start marketing the equipment perhaps late next year. But where RCA's receiver reproduces the transmitted graphic material with an electrostatic printer, Philips' receiver photographs the image that appears on a cathode-ray-tube.

With the European tv broadcasting setup of 625 lines per frame and 25 frames per second (there are two fields in a frame), it takes as little as 2.5 seconds to transmit graphic material—a photo, for example, or a printed text. Because of the time it takes for the scan, only still material can be handled.

Philips thinks the Dutch police will be among the first to use the system. They may use the equipment to broadcast pictures of wanted criminals and missing persons to stations throughout the country.

The lineup. The vertical blanking period lasts long enough to transmit between 20 and 28 lines, but because of the time it takes to switch the auxiliary circuit in and out—and to provide a safety margin—Philips designed its equipment to transmit a maximum of 5 lines per interval. Any number of lines from 1 to 5 can be chosen.

The pickup equipment, which has its own camera, is tied into the regular tv video path by means of a relay. It switches on when the operator pushes a start button, and it develops a pulse that initiates transmission of the still material.

Vertical synchronization pulses of the normal tv signal are used to trigger a pulse generator that gates out lines scanned by the auxiliary camera. The camera's horizontal deflection circuits get normal drive pulses, also from a special pulse generator.

Vertical deflection circuits, though, are set up so the scan for a field is reduced from the normal 312.5 lines to 310 lines or 312 lines. That way, the reduced scanning pattern shifts gradually down, compared with the normal scan pattern, as each group of 1 to 5 lines is transmitted during the vertical blanking period. The reduced number of lines for the auxiliary camera's scan is obtained by slightly increasing the frequency of vertical deflection pulses by means of a frequency divider.

Receiver. Video information inserted into the vertical blanking interval is picked up on a receiver whose front end is identical to a normal receiver except that there's no sound channel.

Deflection circuits for the cathode ray tube are set up to match the horizontal and vertical pulse trains in the pickup equipment. The camera that photographs the crt display has its shutter opened and closed automatically.

Great Britain

New beat

Thus far, consumer radio set designers have played it conservative with integrated circuits. To be sure, there's many a set with IC's on the market. All, however, merely use IC's as a new kind of hardware to build an old circuit—the superheterodyne with an envelope detector.

This state of affairs won't last much longer, thinks R.C.V. Marcario of the University of Wales. Marcario maintains it's high time that designers revive a couple of circuit concepts that have been around for some time but weren't practical for domestic sets before low-cost IC's came along.

The concepts Marcario has in mind are homodyne reception and the single-span receiver. In the homodyne technique, a suppressed carrier is reconstituted in the receiver and added to the broadcast signal at the detecting diode. In the single-span receiver, the intermediate frequency is set higher than the highest carrier frequency to be received. Thus both the long-wave and medium-wave bands used in Europe for popular broadcasting can be covered by tuning the local oscillator with one variable condenser.

Off-the-shelf. Marcario already has breadboarded a homodyne circuit using standard linear IC's produced by Fairchild Semiconductor for the crucial circuits. He currently is putting together a single-span receiver whose kingpin component is a dual-gate field effect transistor.

And since the single-span receiver needs a broadband antenna, Marcario has designed one that can be tucked into the cabinet of a line-operated table set. A few feet of plain wire would serve the purpose equally as well, but Marcario is convinced that few consumers would buy a set that needed a living-room aerial.

This trio of developments, Marcario says, together add up to a receiver that would outperform conventional a-m superhets, especially for long-distance reception. Fading would no longer plague, as it now does, a Londoner listening to a station in Rome. That's because the coherent detection used in the homodyne concept adds the signals—but not the noise—in the two sidebands. This improves the signal-to-noise ratio by 3 decibels, a big advantage when the signal deteriorates during a fade.

Zeroed in. For homodyne reception, one obvious way to supply the demodulating frequency is to lock a local oscillator in phase onto the signal carrier. But unless the set were tuned more carefully than most consumers are in the habit of doing, the oscillator would tend to jump out of lock on a fade. Automatic frequency correction to prevent jump-out would cost too much for a consumer set.

Marcario's homodyne develops a demodulating frequency precisely matched to the carrier frequency by tying a Schmitt trigger circuit to a zero-crossing detector. The basis of the arrangement is that if a station can be picked up at all, the carrier will appear at the detector and will change polarity regularly at twice the carrier frequency. Because the zero-crossing detector drives the Schmitt trigger, then, its square-wave output stays locked to sion suitable for air-to-air weapons. "What we need," says the engineer who headed the Jaguar fire-control project, "is a laser with a much-higher firing rate."

West Germany

New geometry

In long-distance broadcasting, radical improvements in antenna design are rare happenings now.

A few years ago, American antenna designers bettered transmission characteristics significantly by rigging a log-periodic half-rhombic array of dipole elements vertically between supporting masts. Another step forward, says AEG-Telefunken, is the full-rhombic vertical array its designers came up with for an antenna field now going up at Usingen, near Frankfurt.

The full rhombus arrangement keeps the elevation angle of the radiation pattern down low and thus well-suited for long-distance transmission. Further, the pattern is independent of frequency and can be highly directional. A frequency range of 6:1 can be handled without any tuning.

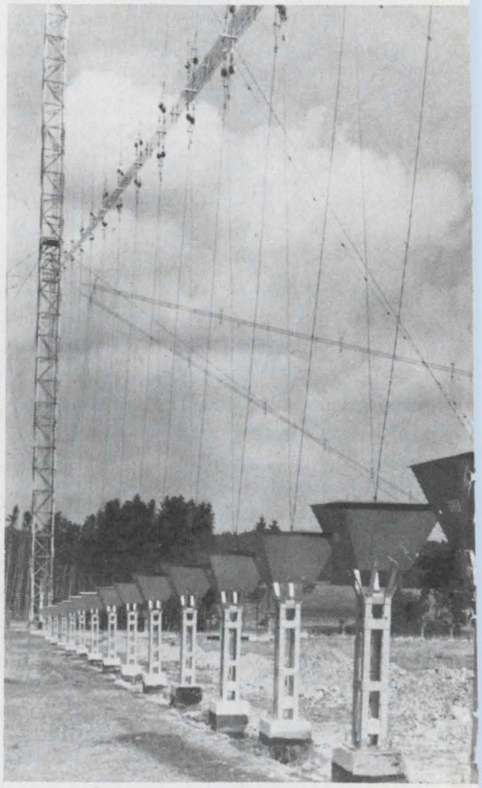
Five by five. The Usingen field, scheduled to go into full service by early 1968, will air intercontinental broadcasts at frequencies from 3 to 30 megahertz. All told, Usingen will have five arrays, each made up of five dipole curtains extending out from a center mast. One array, designed for transmission in the 3 to 18 Mhz range, will have a center mast 230 feet high. The other four arrays, for 5 to 30 Mhz broadcasting, will have center masts 130 feet high.

A typical antenna curtain has a vertical radiation pattern whose main lobe lies between 4° and 12° in elevation. This relatively low angle makes for optimum transmission characteristics at distances from 900 to 1,200 miles. The elevation angle isn't changed appreciably for greater distances. They are covered by "skips" between the earth's surface and the ionosphere.

Curtain time. Since the horizontal radiation pattern of each dipole curtain is about 72° at the half-power width, five curtains are required to get omnidirectional transmission characteristics for an array. Any of the curtains can be switched by remote control onto the transmitter to select the one best matched to the propagation conditions.

Each curtain is made up of 19 vertically rigged and vertically polarized rhombic half-wave dipole elements. At the top, the elements hang from an isolator attached to a guy wire; at the bottom the dipoles are joined to an isolator tied to a weight. The arrangement lets the rhombic elements "give" under high wind loads.

Energy feed to the array is by a two-conductor cable that runs through the center of each dipole. The dipoles are alternately connected to the conductors so that the energy in adjacent dipoles is 180° out of phase. Excitation, by means of a wire running parallel to the energy cable, starts with the



Weighted antenna. Lower ends of rhombic dipole elements in West German antenna are held down by weights that can move up and down.

of the oscilloscope comes from a narrowband amplifier linked only to the vertical rod antenna. The amplifier, whose resonant frequency can be set from 5 to 50 kilohertz, measures the spectral amplitude of the atmospheric. Its output is also fed to a differentiating network that derives a short, high-amplitude pulse that controls the oscilloscope's electron gun.

The screen is photographed with a long exposure. The result is a pattern of light spots distributed according to the direction and amplitude of incoming atmospheric noise.

Variations. The scientists have also come up with equipment modifications that make it possible to spot different noise sources lying on the same azimuth. In one variation, the pulse outputs of two narrowband amplifiers set at different frequencies are compared. In another, a combination of narrowband circuits develops a pulse proportional to the difference in the group delay times of the noise spectrum at two different frequencies in the range from 4 to 10 khz.

Japan

Tuned IC

Cost-conscious radio and television-set makers are always on the lookout for ways to do away with tuned transformers in intermediate-frequency amplifiers. Aligning i-f strips after a set is built adds a significant chunk to its labor cost.

Murata Manufacturing Co. thinks it has a way—hybrid integrated circuits incorporating ceramic filters. Although the company says the hybrids are still under development, it already has them available in sample quantities.

Murata's lead-zirconate-titanate piezoelectric filters have been used previously by the Sony Corp. as discrete components in a 455-kilohertz i-f amplifier for portable radios [Electronics, Nov. 14, 1966, p. 160]. As could be expected, a 455-khz i-f amplifier turns up in Murata's hybrid line. But the comfor the discriminator. On the substrate with the filters are three transistor chips, a pair of diodes, a dozen resistors and five capacitors. The diodes are used with the third filter in the discriminator circuit. Gain ranges between 40 and 46 decibels.

The 10.7-Mhz unit is similar to the 4.5-Mhz module, but does not include a discriminator circuit. Murata, however, is developing a filter that can be used as a discriminator at 10.7 Mhz.

Inside job

With much fanfare, Matsushita Electrical Industrial Co. and N.V. Philips' Gloeilampenfabrieken last month signed a pact extending for another 10 years their long-standing joint venture in Japan—the Matsushita Electronics Corp.

In view of such close cooperation, observers wondered why Matsushita Electric has quietly set up a semiconductor group in its central research laboratory to develop integrated circuits. Until now, the job has been handled by the joint venture.

Competing. Matsushita vice-president Tetsujiro Nakao says there's nothing sinister in the development, even though the new group is led by the former director of research at Matsushita Electronics.

Under the joint agreement, Nakao points out, Philips has access to any Matsushita Electric semiconductor developments. And he adds that there's no plan to set up separate semiconductor production facilities in which Philips won't share. Nakao insists the move was made mainly because the Japanese company likes some internal competition among its researchers and development groups.

Outsiders, though, feel there's another reason behind the new IC research group: a freer hand for Matsushita Electric. Apparently Matsushita has had trouble selling its partner on some research projects that look promising from a Japanese standpoint but nonetheless seem unattractive to Philips, whose prime market is Europe.

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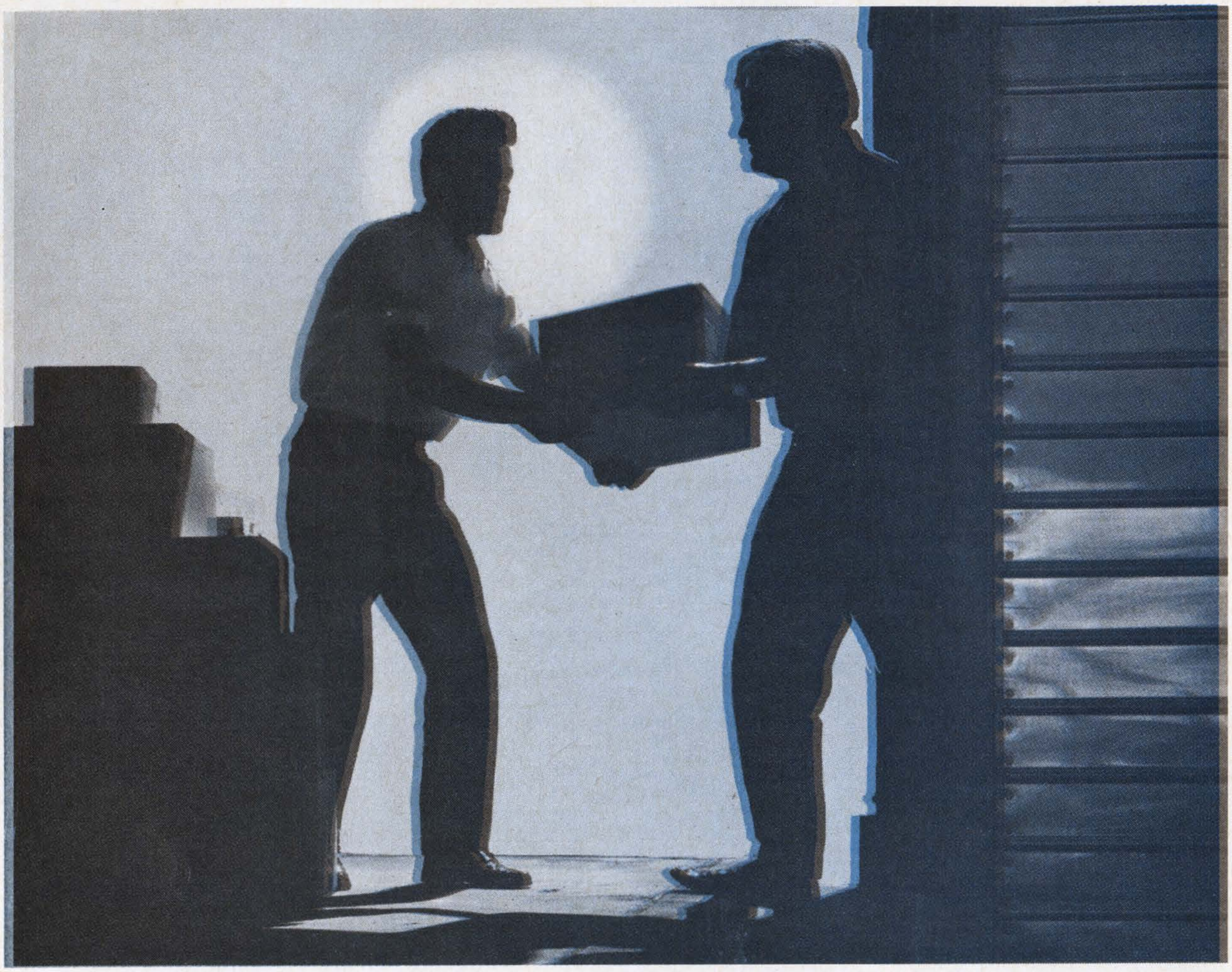

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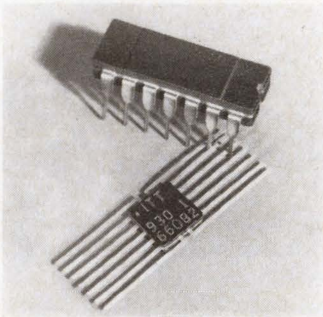

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