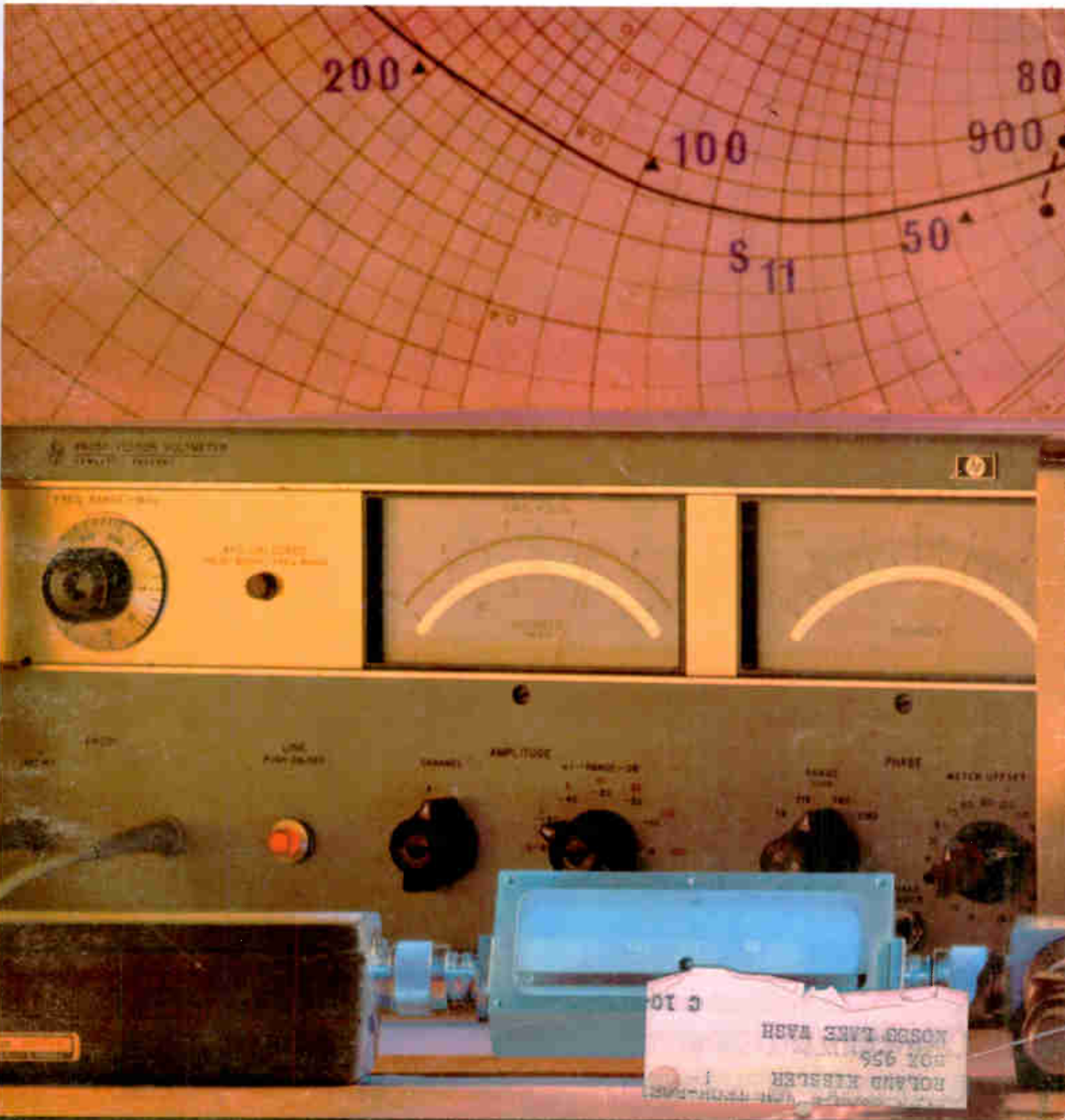
Electronics

Integrated circuits shrink sense amplifiers: page 89
Navigating with a high-speed computer: page 105
Laser hardware for industrial use: page 115

September 5, 1966
75 cents
A McGraw-Hill Publication

Below: Using scattering parameters in design, page 78



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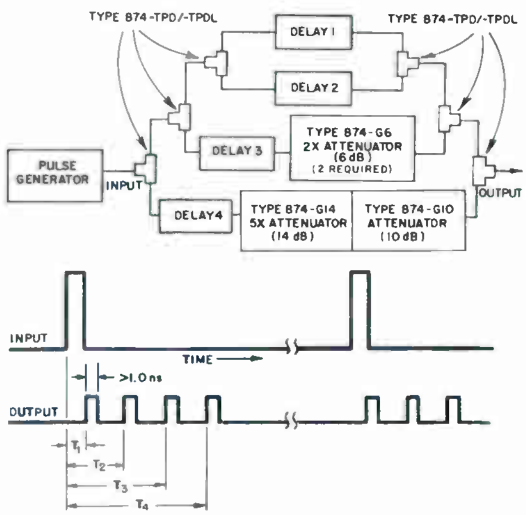
GR874 Coaxial Connectors are wide-bandwidth, low-reflection devices that are made-to-order for fast-rise-time, high-frequency pulse systems. VSWR is less than 1.02 up to 7 GHz, less than 1.08 to 9 GHz for the rigid air-line locking version, which means that these connectors pass pulses faithfully without ringing or deterioration of rise/fall times.

The GR874 is a versatile coaxial system with a wide variety of elements and components . . . power dividers, air lines, trombones, tees, elbows, pads, terminations, adaptors, etc.

The GR874 offers high performance at low cost . . . price of a basic GR874 Coaxial Connector is $2.25, and purchases in quantity yield discounts.

The GR874 saves setup time . . . it is both a hermaphroditic (no male or female versions) and quick-connect/ -disconnect connector.

Here is an example of how GR874 Coaxial elements can be used to produce bursts of high-rep-rate pulses with a low-frequency, fractional-nanosecond pulse generator.



The cascaded GR874-TPD Power Dividers first reproduce the original pulse many times and, later, recombine the individually delayed signals into a higher-rep-rate pulse burst. Rep rates up to several hundred MHz can be obtained by this technique.

GR874 Air Lines can be used to provide small delays (up to 1 ns). GR874 Attenuators can be used when compensatory reductions in amplitude are required (the GR874-TPD Power Divider has a port-to-port insertion loss of 6 dB).

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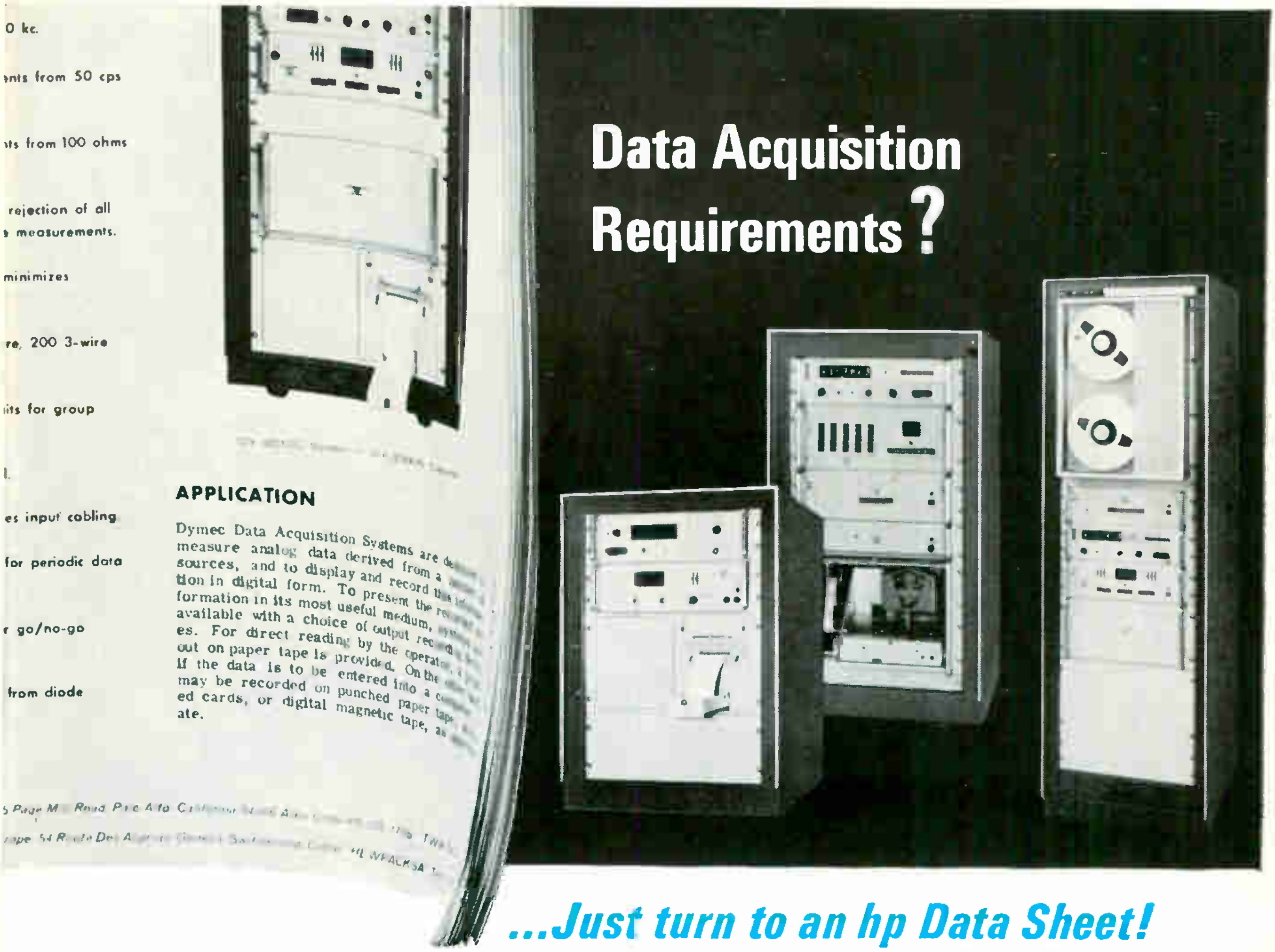

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Feature	2013 Series (economy)	2010 Series (noise rejection)	2015 Series (speed, accuracy)	2017 Series (readout in engr. units)
Number of Input Channels	25 (2-wire) or 50 (1-wire) 2013 A-D	25 (3-wire) expansible to 100 2010A, B, E, H	25 (3-wire) expansible to 100 2015A, B, E, H	25 (3-wire) expansible to 100 2017A, B, E, H
	25 (3-wire) expansible to 100 2013 J-M	200 (3-wire) or 100 (6-wire) 2010C, D, F, J	200 (3-wire) or 100 (6-wire) 2015C, D, F, J	200 (3-wire) or 100 (6-wire) 2017C, D, F, J
Noise Rejection NMR	30 dB at 60 c/s (filter)	inf. at 60 c/s (integrating)	inf. at 60 c/s	20 db min. all freq. (integrating)
Noise Rejection ECMR		At least 105 dB, all frequencies (floating)		
DC Voltage Range	10, 100, 1000 V, fs	0.1, 1, 10, 100, 1000 V, fs	1, 10, 100, 1000 V, fs	0.1, 1, 10, 100, 1000 V, fs
Resolution (mV/digit)	100 μV 10 μV with amplifier	1 μV standard 0.1 μV with amplifier	10 μV	1 μV standard 0.1 μV with amplifier
Accuracy (% rdg.)	.05%	.015%	.005%	.015%
Max. Speed, Readings/Sec, DC Volts	1.7 (4 digits)	18 (3 digits) 7 (4 digits) 1 (5 digits)	12 (5 digits)	18 (3 digits) 7 (4 digits) 1 (5 digits)
Optional Measurement Capability	AC voltage, resistance, dc current	AC voltage, resistance (frequency is standard)	AC voltage, resistance	AC voltage, resistance (frequency is standard)
Programming		standard with DY-2901A; add DY-2911C or DY-2560A with DY-2911		
Types of Output Recording	Printed strip, typewriter, punched tape, cards	Printed paper strip, perforated tape, punched card (IBM 52[illegible]) magnetic tape		
Price Range (Basic System)	$4495 - $6000	$8310 - $18,550	$8160 - $18,400	$10,960 - $2[illegible],200

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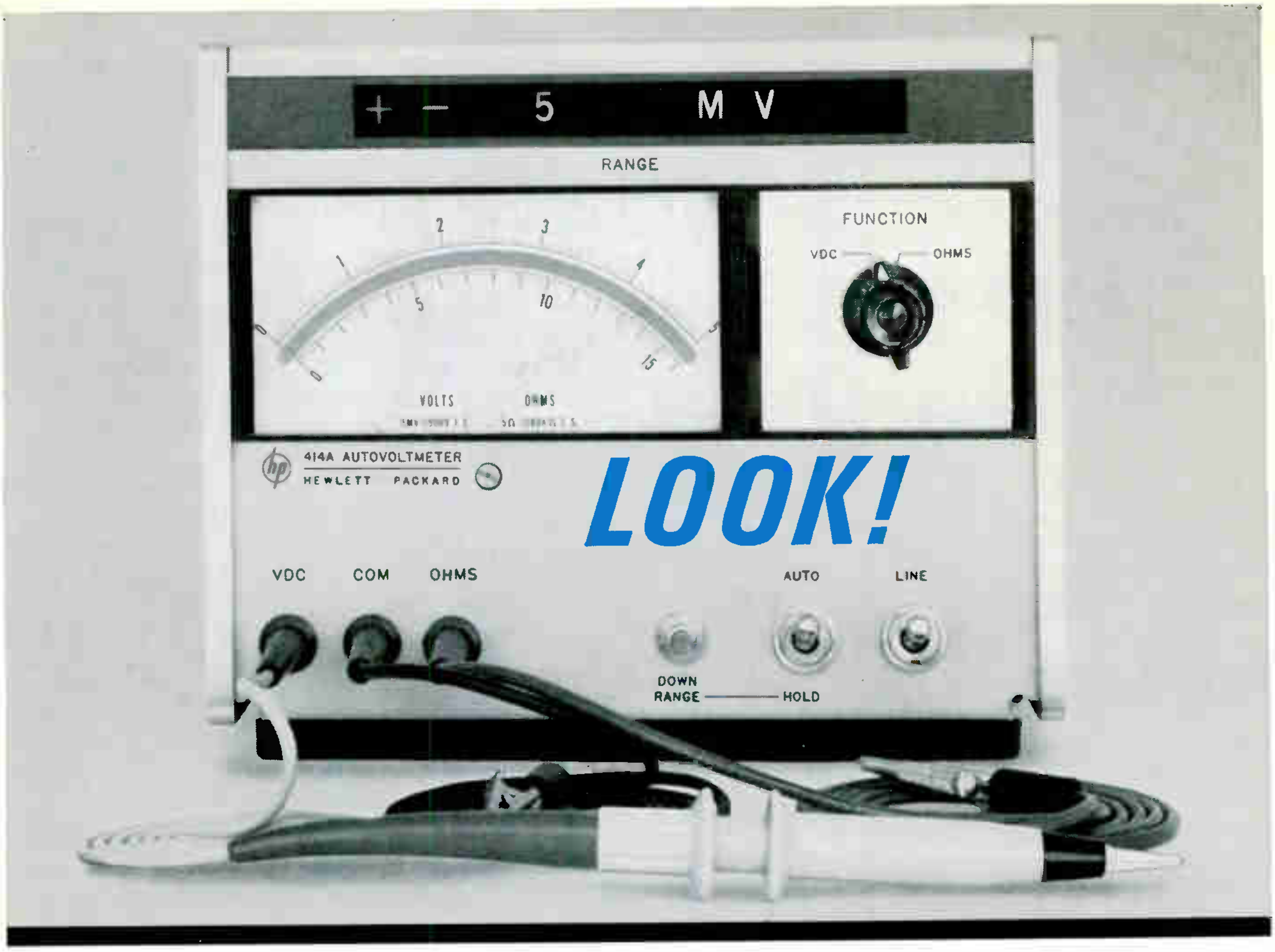

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Electronics

September 5, 1966
Volume 39, Number 18

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Readers Comment

Modern marvel

To the Editor:

F.J. Wilkerson is incorrect in assuming that the size of an object determines its cost or value [May 16, p. 4]. Time was when hearing aids were less expensive than they are at present, and they were a lot bigger then, too—almost as big as the color tv set to which he refers.

Now the hearing aid industry has produced a marvel of electronics, an intricately designed and assembled unit that fills in the tonal gaps of human hearing loss, and consequently, fills in the gaps in human lives where otherwise, great emotional and psychological loss might occur.

A hearing aid is truly a bargain at any cost.

John Kojis
President
Hearing Aid Industry Conference, Inc.
Chicago, Ill.

An extra ground

To the Editor:

In reading the article "Improving the performance of multipurpose IC's with feedback" [June 27, p. 70], I came upon one circuit that seems to be wrong. On page 73 is a schematic for an exclusive OR gate. With the base of Q_3 at ground potential, the base resistor would not be in the circuit.

Marvin Lee Nolan
U.S. Navy
Charleston, S.C.

▪ Reader Nolan is right; an extra ground symbol crept in.

Foreign engineer's lament

To the Editor:

It seems evident that the present demand for engineers in the United States exceeds the supply ["Recruiting at IEEE," April 14, p. 46]. One of the few countries in the world with a surplus of engineers is Norway, where a sizeable proportion of graduates have to emigrate to obtain a job. Although a few U.S. firms have tried to recruit engineers from Norway, with some success, the engineers who most

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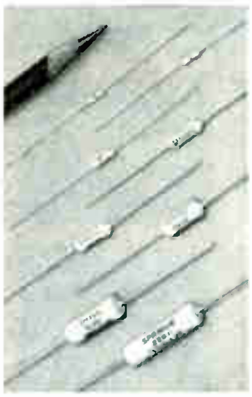
Filmistors offer extended resistance values in size reductions previously unobtainable. For example, you can get a 4.5MΩ resistor in the standard 1/4 watt size, which had conventionally been limited to 1 MΩ. Filmistor Metal-Film Resistors are now the ideal selection for "tight-spot" applications in high-impedance circuits, field-effect transistor circuits, etc.

Other key features are ±1% resistance tolerance, low and controlled temperature coefficients, low inherent noise level, negligible coefficient of resistance, and rugged molded case.

Filmistors *surpass* the performance requirements of MIL-R-10509E.

Write for Engineering Bulletin 7025C

ACRASIL® PRECISION/POWER WIREWOUND RESISTORS



These silicone-encapsulated resistors combine the best features of both precision and power wirewound types, giving them unusual stability and reliability.

Acrasil Resistors are available with tolerances as close as .05%, in power ratings from 1 to 10 watts. Resistance values range from 0.5 ohm to 66,000 ohms.

Their tough silicone coating, with closely matched expansion coefficient, protects against shock, vibration, moisture, and fungus.

Acrasil Resistors meet or exceed the requirements of MIL-R-26C.

Write for Engineering Bulletin 7450

BLUE JACKET® VITREOUS ENAMEL PRECISION/POWER WIREWOUND RESISTORS

Axial-lead resistors available in ratings from 1 to 11 watts, with resistance tolerances to ±1%. Non-inductive windings available to ±2% tolerance.

All welded end-cap construction securely anchors leads to resistor body. Vitreous coating and ceramic base have closely matched expansion coefficients.

Write for Engineering Bulletins 7410D, 7411A

Tab-terminal Blue Jacket Resistors can be had in a wide selection of ratings from 5 to 218 watts, with several terminal styles to meet specific needs.

Tab-terminal as well as axial-lead Blue Jackets can be furnished to meet the requirements of MIL-R-26C.

Write for Engineering Bulletins 7400B, 7401

KOOLOHM® CERAMIC-SHELL POWER WIREWOUND RESISTORS

Koolohm Resistors are furnished in axial-lead, axial-tab, and radial-tab styles, in a broad range of ratings from 2 to 120 watts. Both standard and non-inductive windings are available.

Exclusive ceramic-insulated resistance wire permits "short-proof" multilayer windings on a special ceramic center core for higher resistance values. The tough non-porous ceramic shell provides complete moisture protection and electrical insulation. Koolohms can be mounted in direct contact with chassis or "live" components.

Axial-lead Koolohm Resistors to MIL-R-26C are available in MIL styles RW55 and RW56.

Write for Bulletins 7300, 7305, 7310

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Sprague Stackohm Resistors are especially designed for equipment which requires power wirewound resistors of minimum height. Their flat silhouette permits stacking of resistor banks in close quarters.

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Stackohm Resistors are available in both 10-watt and 20-watt ratings, and can be furnished with resistance tolerances as close as ±1%. Resistance values range from 1 ohm to 6000 ohms.

Both 10- and 20-watt types meet the stringent requirements of MIL-R-26C.

Write for Engineering Bulletin 7430

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desire to emigrate to the United States have to struggle through too many difficulties to get there.

For example, our salary structure is so low one cannot afford to take a trip across the Atlantic on the odd chance of getting a job. Then, the procedure for obtaining an entry visa to the U.S. is a long and tedious one. Without a sponsor or a job contract, one might not get an entry visa. Thus we have a paradox: it is difficult to get a job without first going to the U.S., but one might not be able to go to the U.S. without first having a job.

I suggest that U.S. firms advertise more in the local newspapers, send their recruiting people to conduct interviews in Europe, for example in Oslo, or invite the candidates to interviews in the U.S. and pay the fares. (It would be fair, I think, to deduct this from the salary if the candidate accepted a job. After all, companies pay fares from coast-to-coast in the U.S.)

And they should assist the candidates with their entry visa applications.

Kjell Haug

Electrical Engineer
International Telecommunications Union
Baghdad, Iraq.

Kafka or Koufax?

To the Editor:

Author Wallenstein [June 13, p. 142] is not really offering a solution to the obsolescence problem when he suggests broadening of engineers' perspective. I believe he is making the classical error of assuming that two things which vary together are cause and effect, when in fact they are both functions of some third phenomena.

An engineer with a high degree of intellectual curiosity will dig through quantities of technical material and still have time for Kafka because he enjoys the stimulation of a creative mind. If, as a result, he is technically up-to-date and can command a high consulting fee in his senior years, it is because of this intellectual curiosity, which has enabled him to take advantage of his years rather than submitting to them.

The engineer lacking interest in the arts would be better advised to avoid the museums and concert halls since, lacking this interest, he will not develop into a better designer but simply become bored.

In fact, there has always been in every profession those with varying degrees of motivation. Consequently there have been some who have been current and knowledgeable from the day of graduation through retirement. Any rapidly expanding technology is not going to change this picture but will result in higher degrees of specialization. Those at the top of their profession, in every profession, will have a higher degree of specialization built on a broad foundation. Those at the other end of the scale will be poorly motivated, lacking special skills and having little breadth. The former doesn't need to be told to broaden his outlook because he has been doing it all his life for the sake of the intellectual challenge. The latter is not going to study Taoism because he is too busy watching the ball game, which he enjoys.

A. J. DeBerardis

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People

A hole in a laboratory door at the Raytheon Co.'s research division in Waltham, Mass., serves as a reminder of the gas laser's rapid advance in the last few years from a low-power curiosity to a high-power "weapon." A central figure in that technological leap—and the researcher whose laser accidentally drilled the hole a few years back—will join the National Aeronautics and Space Administration this month. **Roy A. Paananen,** 46, will head a group working on molecular lasers at the space agency's Electronics Research Center.

New materials. In the space optics laboratory of the Cambridge, Mass., center, Paananen will explore molecular lasers for deep-space communications. These devices, which stimulate coherent radiation by manipulating the energy levels of molecules instead of atoms, include carbon dioxide systems, the new nitrosyl chloride and the still newer carbonyl sulfide systems.

Recent studies of solar noise background indicate that lasers with outputs in the 2- to 5-micron region are the most promising candidates for interplanetary communications. "There are both atomic and molecular gases that emit in that band," says Paananen, "but the molecular gases give promise of higher efficiency."

Paananen, who moved into laser development from microwave tube work, is a native of Michigan and earned degrees at Michigan State University and the Massachusetts Institute of Technology. He was on the staff of MIT's Research Laboratory of Electronics and of Lincoln Laboratory before joining Raytheon 13 years ago.

Record holder. In recent years Paananen has worked with ionized argon lasers. His 53-watt continuous-wave output stands as the highest announced to date for ionized argon [Electronics, June 27, p. 25]. He was also the first to ob-

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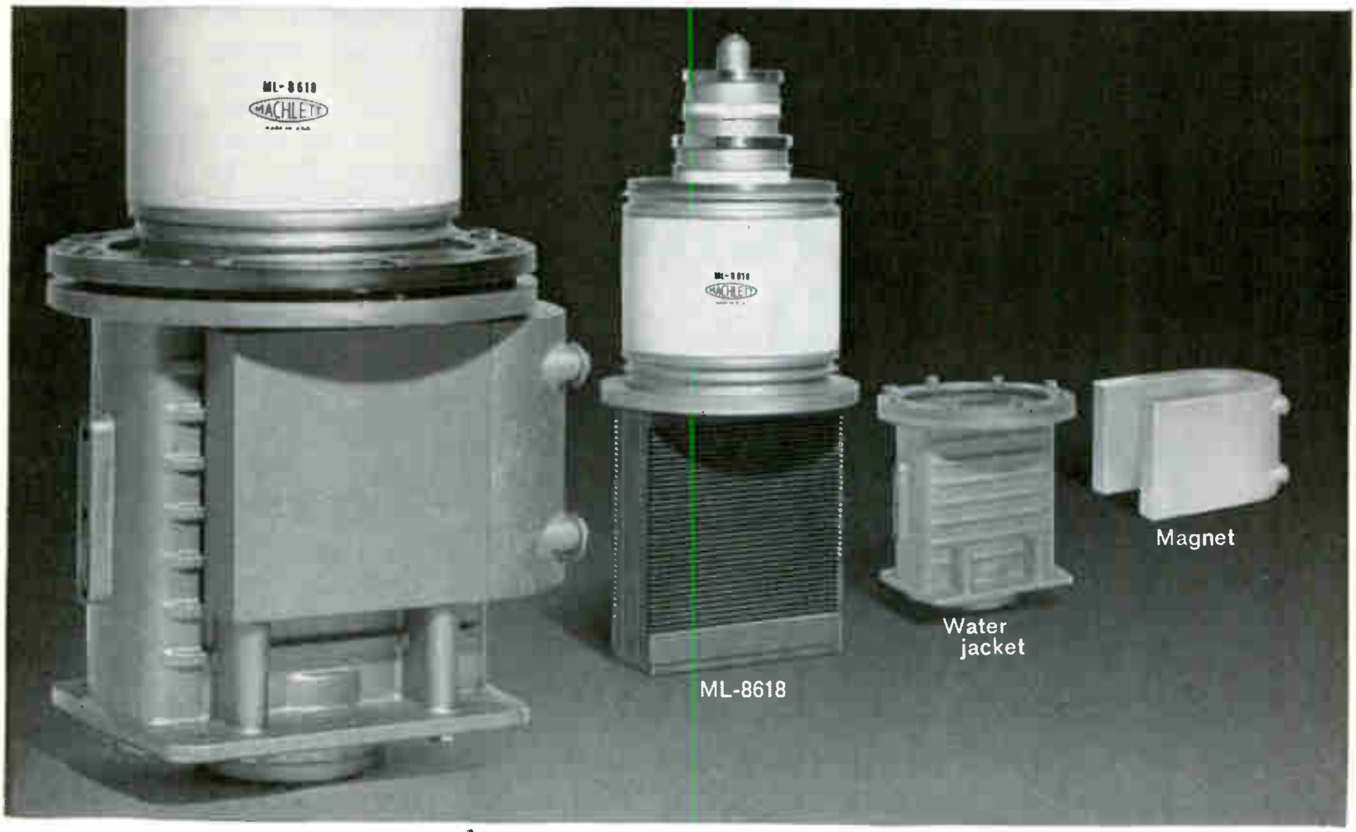
200 kW power output with .7 kW drive from magnetically beamed MACHLETT triode



ML-8618, Machlett's new magnetically beamed water-cooled triode, provides high power gain, high plate efficiency and maximum cathode utilization. Electron trajectory from cathode to plate is magnetically controlled to greatly reduce electron interception by the grid . . . and therefore decrease grid current and heating and allow significantly higher performance levels.

Result: the ML-8618 delivers a typical 200 kW power output with .7 kW drive as a Class C rf amplifier or oscillator. As a switch tube in pulse modulators, it is capable of a maximum 8 Mw high duty pulse. For full operating details, write to The Machlett Laboratories, Inc., Springdale, Conn. 06879.

RAYTHEON

THE MACHLETT LABORATORIES, INC.

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Circle 9 on reader service card

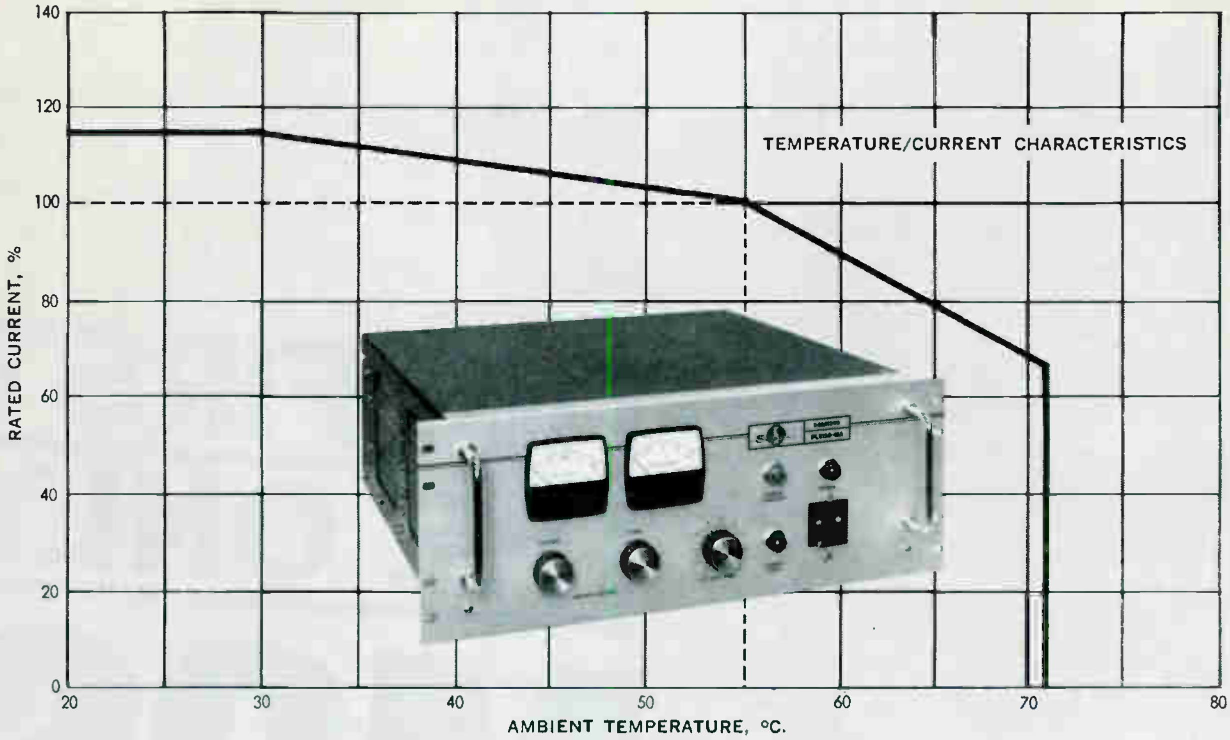
tain an ultraviolet output from an ionized argon c-w laser.

Varian Associates is setting up a new division to cash in on what it sees as a booming market for light-sensing and light-emitting equipment. Varian calculates that the market is currently at $50 million, but that it will double in five years, passing microwave and power grid tubes in importance. To direct this new activity in Palo Alto, Calif., Varian has lured Vienna-born **Wilfrid F. Niklas** from the Zenith Radio Corp.'s Chicago subsidiary, the Rauland Corp. [Electronics, Aug. 8, p. 109].

"Light sensing and emitting" is Varian's phrase for photodetectors and vidicon and orthicon television camera tubes, cathode-ray tubes, delay storage tubes and image intensifiers. The company had intended to call the activity "light sensing and display" when someone suggested that an "LSD division" might put Varian's image in the wrong light.

War and peace. There are rather obvious military advantages in using storage tubes—for information retention of bright displays—and image intensifiers, which convert an optical signal to electricity, amplify it and reconvert the result to light. "Guerrilla warfare has become so widespread in the past 20 years that night surveillance devices for the battlefield are more and more important," says Niklas. There are also applications in plant security and, according to Niklas, even in navigation. He suggests that an image intensification system might make it possible to do away with automobile headlights.

In medicine, where so much activity in electronics is directed today, Niklas wants to do more work with X-rays and nuclear techniques. He predicts great opportunities for light-sensing and emitting equipment.



Sorensen DCR Series now with temperature capability to 71°C.

Sorensen Wide Range Power Supplies to 20 kW.

Sorensen's wide range DCR Series has been up-dated and improved. What's new about the DCR's? They are now 100% silicon; ambient temperature capability is now to 71°C. • Four 3-phase models have been added extending power capability to 20 kW; 24 models are now available with ranges up to 300 volts. • Multiple mode programming—voltage/current/resistance. • Voltage regulation, line and load combined, is ±.075% for most models • Constant current range 0 to rated current. • DCR's meet MIL-I-26600 and MIL-I-6181 specifications and conform to proposed NEMA standards. • Front panel indicator for voltage/current crossover. These features of the improved DCR (model numbers will have an "A" suffix) are offered at no increase in price. For DCR details, or for data on other standard/custom power supplies, AC line regulators or frequency changers, call your local Sorensen rep, or write: Raytheon Co., Sorensen Operation, Richards Avenue, Norwalk, Connecticut 06856. Tel: 203-838-6571.

MODEL SELECTION CHART

Voltage	Amps.	Model	Price	Amps.	Model	Price	Amps.	Model	Price	Amps.	Model	Price
0- 20	125	DCR 20-125A	$1055	250	DCR 20-250A	$1495	—	—	—	—	—	—
0- 40	10	DCR 40- 10A	325	20	DCR 40- 20A	525	35	DCR 40- 35A	$ 710	60	DCR 40-60A	$925
0- 40	125	DCR 40- 125A	1350	125	DCR 40-125A	1995	500	DCR 40-500A	2950	—	—	—
0- 60	13	DCR 60- 13A	525	25	DCR 60- 25A	710	40	DCR 60- 40A	900	—	—	—
0- 80	5	DCR 80- 5A	325	10	DCR 80- 10A	525	18	DCR 80- 18A	710	30	DCR 80-30A	875
0-150	2.5	DCR 150- 2.5A	325	5	DCR 150- 5A	525	10	DCR 150- 10A	710	15	DCR 150-15A	825
0-300	1.25	DCR 300-1.25A	325	2.5	DCR 300- 2.5A	525	5	DCR 300- 5A	710	8	DCR 300- 8A	825

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(Digital Differential Analyzer Integrator)

Meetings

Space Simulation Conference, American Institute of Aeronautics and Astronautics, Institute of Environmental Sciences; Rice Hotel, Houston, Texas, **Sept. 7-9.**

International Conference on the Physics of Semiconductors, Physical Society of Japan, International Union of Pure & Applied Physics, Science Council of Japan; Kyoto Kaikan, Tokyo, Japan, **Sept. 8-13.**

International Nuclear Industries Fair, Swiss Industries Fair; Basel, Switzerland, **Sept. 8-14.**

International Conference on Instrumentation for High Energy Physics, International Union of Pure & Applied Physics; the Stanford Linear Accelerator Center, Stanford, Calif., **Sept. 9-10.**

Eastern Convention on Aerospace and Electronics Systems, IEEE, Washington Hilton Hotel, Washington, **Sept. 12-14.**

Petroleum Industry Conference, IEEE; Sheraton-Chicago Hotel, Chicago, Ill., **Sept. 12-14.**

Electromagnetic Compatibility Conference, Society of Automotive Engineers; Birmingham Airport Motel, Birmingham, Ala., **Sept. 13-14.**

Assembly Meeting, Radio Technical Commission for Aeronautics; Statler-Hilton Hotel, Washington, **Sept. 14-16.**

Institute on Modern Solid-State Design Meeting, National Aeronautics and Space Administration; University of Santa Clara, Calif., **Sept. 15-16.**

Institute on Research Contracting, the American University, the George Washington University; Twin Bridges Marriott Motor Hotel, Washington, **Sept. 19-22.**

Conference on Tube Techniques, IEEE; United Engineering Center Auditorium, New York, **Sept. 20-22.**

Broadcast Symposium, IEEE; Mayflower Hotel, Washington, **Sept. 22-24.**

Communication Symposium, IEEE; Cedar Rapids, Iowa, **Sept. 23-24.**

National Conference on Non-conventional Energy Conversion, IEEE; International Hotel, Los Angeles, Calif., **Sept. 25-28.**

Joint Engineering Management Conference, IEEE; Statler-Hilton Hotel, Washington, **Sept. 26-27.**

Symposium on Gallium Arsenide, British Institute of Physics, Air Force Avionics Laboratory and the Physical Society of England; Reading University, Berkshire, England, **Sept. 26-28.**

Intersociety Energy Conversion Engineering Conference, IEEE; International Hotel, Los Angeles, Calif., **Sept. 26-28.**

Air Force Science and Engineering Symposium, Air Force Systems Command; Arnold Air Force Base Development Center, Tennessee, **Sept. 27-29.**

Instrument Society of America Conference & Exhibit, Instrument Society of America; New York Coliseum, New York, **Oct. 24-27.***

Machine Tools Industry Technical Conference, IEEE; general application group; Sheraton-Schroeder Hotel, Milwaukee, Wis., **Oct. 24-26.**

International Congress on Air Technology, Valley Education and Research Foundation; Hot Springs, Ark., **Oct. 26-29.**

Meeting of Metallurgical Society of American Institute of Mining, Metallurgical and Petroleum Engineers; Sheraton-Chicago, Chicago, Ill., **Oct. 30-Nov. 3.**

Technical & Electronic Ceramic Manufacturers Exhibit & Seminar; New York Trade Show Building, New York City, **Nov. 1-3.**

Call for papers

Technical Meeting and Equipment Exposition, Institute of Environmental Sciences; Washington, April 10-12. **Oct. 1** is deadline for submitting papers to technical program committee, Institute of Environmental Sciences, 940 East Northwest Highway, Mount Prospect, Ill. 60056.

International Scientific Radio Union Meeting, U.S. National Committee of the International Scientific Radio Union; Cabana Motor Hotel, Palo Alto, Calif., Dec. 7-9. **Oct. 1** is deadline for submission of 200-word abstracts to R.A. Helliwell, Radioscience Laboratory, Stanford University, Stanford, Calif. 94305.

International Conference on Communications, IEEE; Minneapolis, Minn., June 12-14. **Dec. 1** is deadline for submission of a 50-word abstract and a 300-word summary to Robert J. Collins, technical program chairman, 1967 ComTech Meeting, department of electrical engineering, University of Minnesota, Minneapolis, Minn. 55455.

*** Meeting preview on page 16**

AC metrology will never be the same after the Fluke 931A, the first true rms differential voltmeter. Measure the precise rms value of virtually any waveform within 0.05% from 30 Hz to 50 KHz. Overall frequency response is 10 Hz to 1 MHz. Range is 0.01 to 1100 volts. Ten to one crest factor accounts for effects caused by voltage spikes and pulse trains. Comes with or without probe. Both line or combination line/rechargeable battery powered versions are offered. Base price is $895.

The new Fluke Model 931A True RMS Differential Voltmeter yields accurate rms measurements of any waveform which previously could be made only by ac to dc comparison with a thermal transfer standard. Other features include high input impedance, in-line digital readout (lighted decimal), solid state design, and linear recorder output. The null meter indicates percent deviation from the dialed voltage. Ten percent overranging minimizes range changing. Battery operation gives ideal isolation from ground loops. Model 931A meets MIL-SPEC shock and vibration requirements. For complete information, please call your Fluke Sales Engineer or write.

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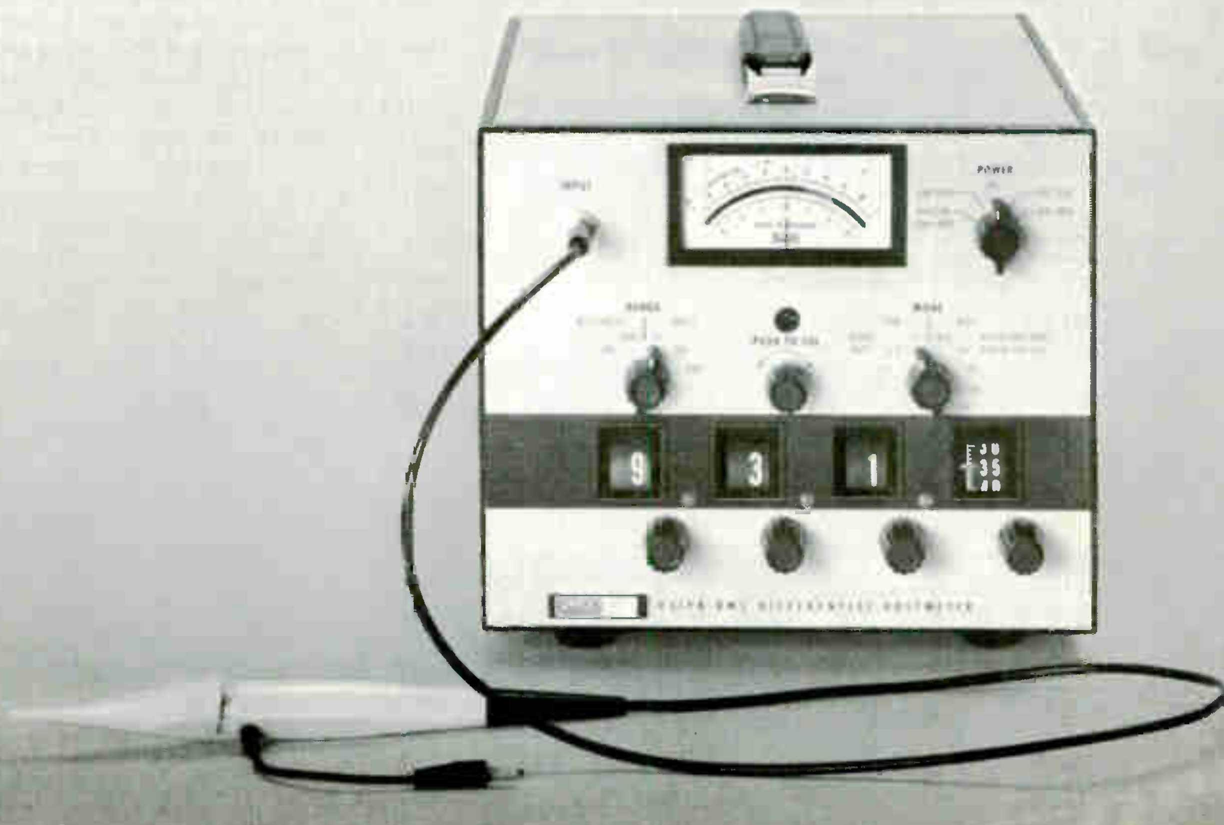

Meeting preview

Instrumented society

Three talks on the instrumentation needed in traffic control, pollution and biomedicine will highlight the 21st annual international conference and exhibit of the Instrument Society of America. The meeting will be held at the Coliseum in New York City, Oct. 24-27.

These subjects will be pursued in several of the 38 technical sessions scheduled. The rest of the sessions concentrate on instrumentation for specialized industrial problems, control systems, aerospace applications and oceanology.

Student project. Electrical engineering students from the University of Michigan will describe a proposal to automate highways. As a class project the students designed a system with magnetic devices buried in the pavement. Under the plan the magnets sense the presence and speed of vehicles and pass the information to small computers; the computers then calculate the proper commands to control the vehicles' acceleration, braking and steering. The students estimate that the system would sharply increase highway capacity by permitting cars to travel safely, five feet apart, at speeds up to 70 miles an hour. Aside from the cost of the automobile control equipment, the highway installation costs are estimated at $50,000 a mile for intercity highways and about $1 million a mile for intracity roads.

Other sessions. Two symposiums, sponsored by professional groups within the instrument society, will be held concurrently. The plenary session of the measurement standards instrumentation symposium will weigh effects of switching to the metric system in the United States. Allen V. Astin, director of the National Bureau of Standards, will review the problems U.S. business already faces because so many countries use the metric system.

The second symposium, on physical and mechanical measurement instrumentation, will treat the subject of instrumentation for urban problems, such as transportation, water and power supply, air pollution, waste disposal, fire fighting and law enforcement.

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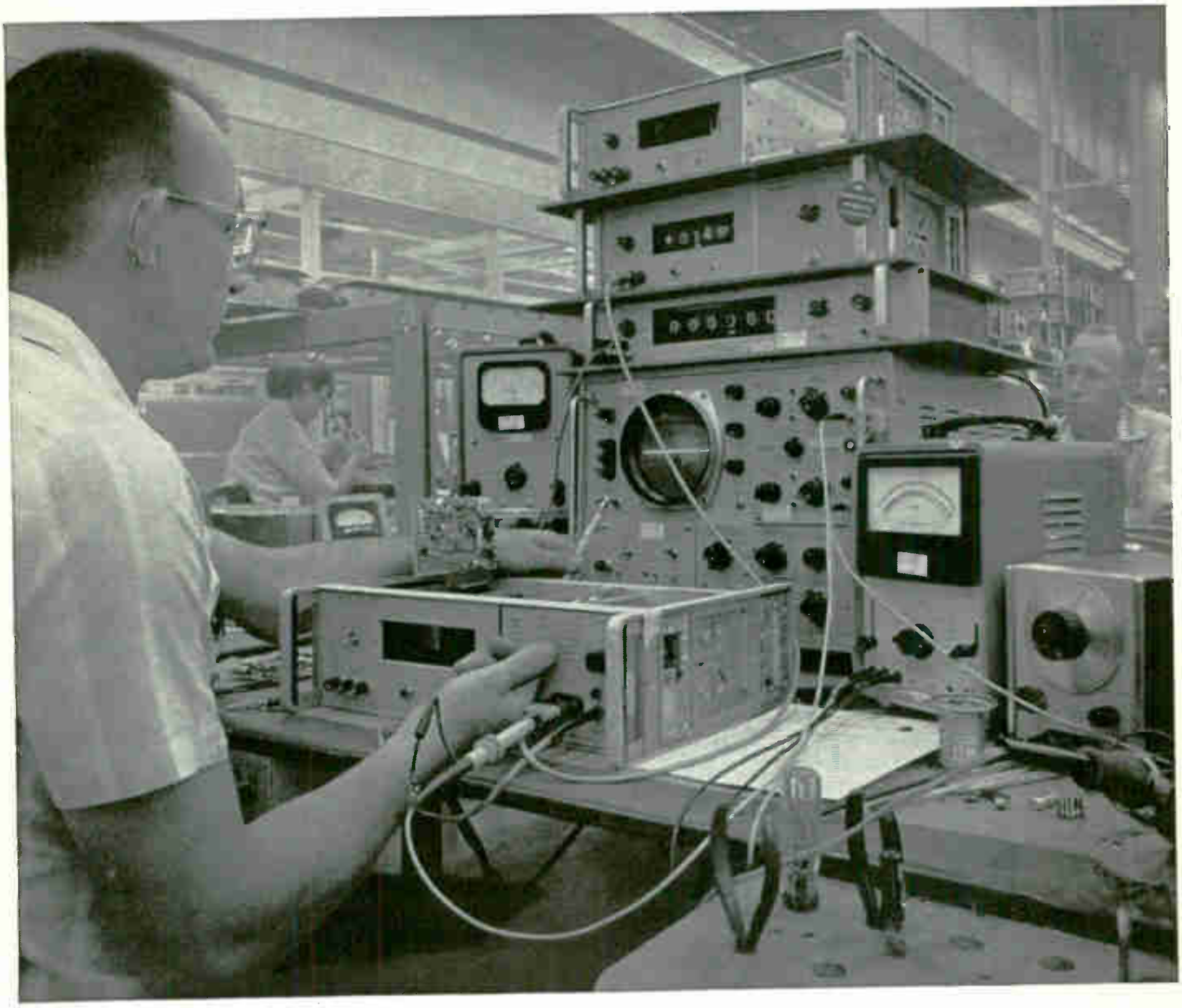

That's "testing" backwards. And that's what we do to every Hewlett-Packard 3439A and 3440A. Test it forwards, backwards, inside and out. ■ Here you see it going through complete testing and calibration after assembly. Every circuit board is checked, and then the entire instrument is calibrated to be sure it meets specifications. ■ But that's just the beginning. From here it goes into a 50°C "oven" for an overnight cycling. On, off, on, off, all night long. Then we recheck it the next day. If any failures show up, they're fixed. And the testing starts all over again. Finished? Not yet. ■ We test it once more at Quality Assurance before it goes into stock. ■ We go through a lot of trouble with your DVM. That's why you have so little trouble with it. ■ By the time it leaves our plant, we have enough faith in each 3439A and 3440A that we're willing to back it up with a year's guarantee. Ours is a confidence you don't find with other manufacturers. But then, they don't have the 3439A and 3440A either. ■ After testing it forwards and backwards, we're not afraid to get behind it. ■ The 3439A. Solid state. 4-digit readout. Manual, automatic and remote ranging. Extra-high sensitivity. Ac/dc voltage/current resistance measurements (dc accuracy better than ±0.05% of reading ±1 digit). Price, $950. The 3440A has BCD output. Price, $1160. Plug-ins, $40 to $575.

Data subject to change without notice
Prices f.o.b. factory.

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An extra measure of quality

1889

We couldn't find these computer-quality relays on the market. So we had to design our own.

Here's what they offer you.

IBM Wire Contact Relays—200 million operations at 45¢ per pole

Solderless connections, multiple coils, compactness and standardized mountings give you lower manufacturing costs, lower initial product costs, lower product servicing costs.

Also high operate speed—as fast as 4 ms; fast release time—under 5 ms; versatile contact arrangements—4, 6 and 12 PDT, Form C, 4 and 6 PDT latch; maximum reliability—1 error per over 400 million contact closures at 48 VDC is attainable; variable coil voltages—up to 100 VDC.

IBM 12-pole wire contact relays start at $5.40, 4-poles at $2.90, latch relays at $8.45 (even less in quantity).

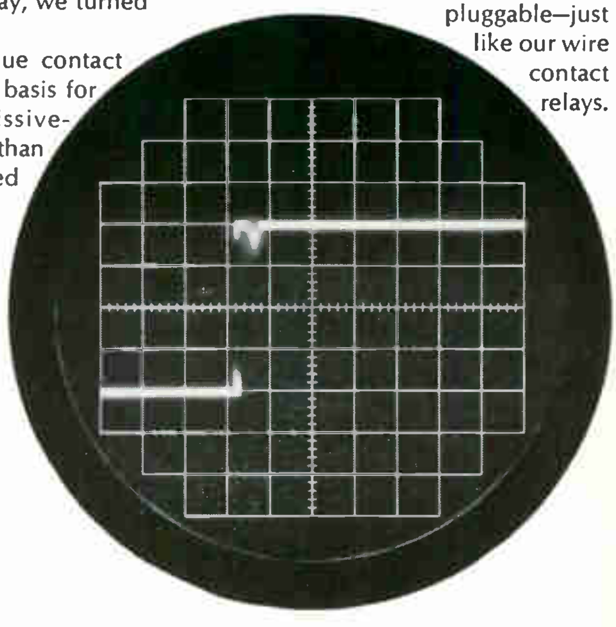
Permissive-Make Relays—high speed and virtually no bounce

To design this kind of relay, we turned to a computer for help.

The result was a unique contact spring configuration as a basis for assembly — the "permissive-make". Its bounce is less than 50 microseconds. Its speed is as fast as 2.0 milliseconds. What's more, this relay has an exceptionally long, *adjustment-free* life—over 400 million operations.

Permissive-make relays are well worth considering for counting, logic switching, switch registers and timing circuits.

The cost: $6.50 for 4-pole, Form C permissive-make relays; $7.75 for the 6-poles. Incidentally, IBM permissive-make relays minimize maintenance time and costs. That's because they're pluggable—just like our wire contact relays.



Typical bounce characteristics of the IBM permissive-make relay appear at the right. Time base is 20 microseconds per centimeter-amplitude base is 0.5 volts per centimeter.

IBM.
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PRODUCTS

Reed Relays—miniaturized and pluggable too

Newest of the IBM relays, the reed relays are especially suitable for interfacing relay logic and transistor circuitry.

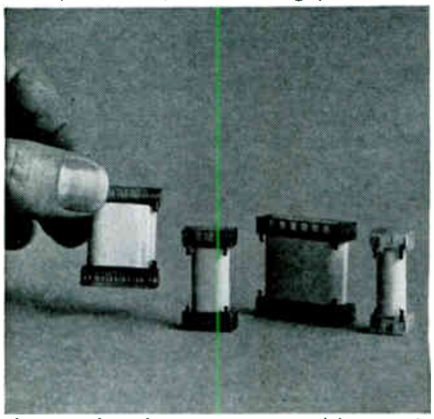
They have an operate time of 1 ms or less, an operate time variation of 0.5 ms, a release time of 100 microseconds. And, every reed relay is electronically inspected *after* assembly to insure long, trouble-free life.

These miniature relays are available in 1, 2, 4 and 6-pole Form A and B configurations; plus various combinations with either single or double coils. Prices range from $3.00 to $8.55 for Form A packages (always lower in quantity).

The IBM miniature dry reed switch serves as the heart of the reed relays, and is now double plated, rhodium over gold, to give you low noise characteristics.

They provide long life (up to 125 million operations—mean time to first error) and low contact resistance (less than 100 milliohms throughout life).

For highly consistent performance we *dynamically* set the air gap between



the reeds. This means a stable sensitivity of $\pm$ 7 NI (maximum) in every reed switch.

For illustrated literature on any of these products, write: IBM Industrial Products, 1000 Westchester Avenue, White Plains, New York 10604.

TEST THE BEST...WITH 50

before you buy...try TI's new

Our proposition is simply this:
We'll *give you 50* molded TI integrated circuits with each order of 1000 units or more placed before November 1, 1966.

Do anything you like with these samples . . . hammer them . . . test to destruction . . . wire into your circuits . . . soak in boiling water . . . compare with any others. Prove to yourself that they're best — by test!

Money-back guarantee—If you're still not convinced that TI molded integrated circuits do your job better than any competitive types available, just return the unused circuits. We'll give you full credit for them. This offer is good for 60 days from date of any order placed before November 1, 1966.

Offer includes popular series — Devices included in this offer are the popular digital circuits from the 930-type DTL and Series 74 TTL families shown below right. Series 74 TTL is first choice of many designers for new equipment. Circuits in this line typically are 48% faster, have 25% higher fan-out and 15% better noise margin than DTL . . . at competitive prices.

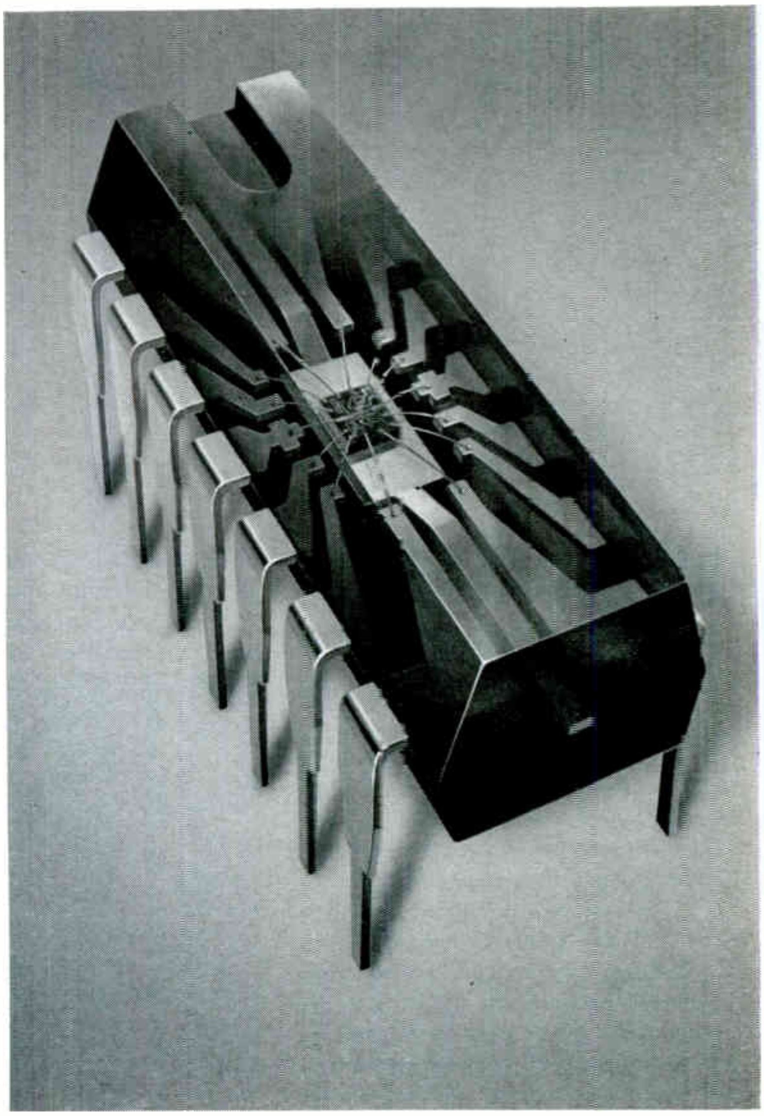
Whether your system design calls for DTL or TTL circuits, you'll find a wide selection of single and multiple gates and flip-flops available. With either series, high-speed logic is now available to you at lower prices per function than ever before.

Rugged design proved by test — TI molded integrated circuits offer outstanding durability. The rugged, high-density package is molded from the same encapsulant used in millions of SILECT™ transistors and is backed by over 2,000,000 actual hours of test. Resistance to impact, heat and moisture are further borne out by successful testing to the following rigorous schedule: *Thermal Shock* — MIL Std. 750, Method 1056A; *Temperature Cycling* — MIL Std. 750, Method 1051, *Moisture Resistance* — MIL Std. 202C, Method 106B, *Hydropressure* — 3% JOY, 110 PSI for four hours.

Exclusive features save you money — You realize big reductions in total manufacturing costs with TI molded integrated circuits because they are specifically designed for use in automatic handling, assembly and test facilities. Exclusive features such as the positive index notch, pretinned leads and side-mounted lead design make it possible. Even the cartridge-type shipping container lends itself to automated production line use.

Fast delivery — Deliveries of TI molded integrated circuits are prompt . . . prototype shipments can typically be made within days. And TI's high production rates assure *continued* availability to meet your most critical production schedules.

To obtain your 50 free evaluation samples immediately, just place your order with any TI sales office or authorized TI distributor.



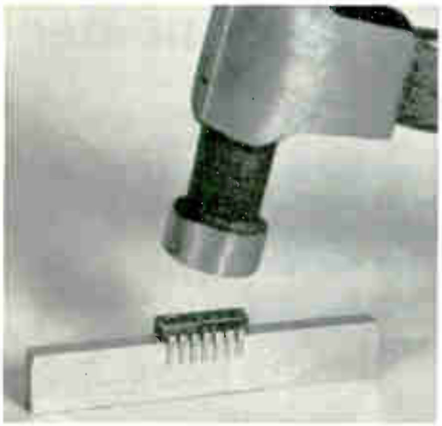
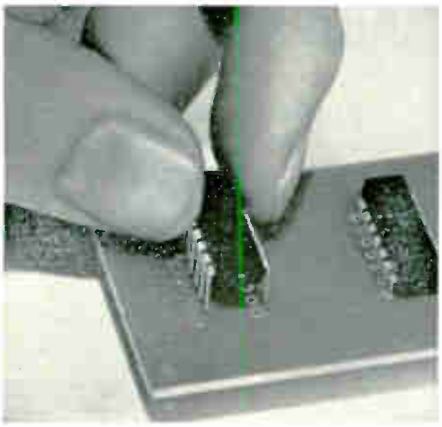
All these devices are included—

Series 74 TTL 0° to 70°C Operating Temp.			
SN7400N.	Quad 2-input NAND Gate	SN7460N	Dual 4-input expander
SN7410N	Triple 3-input NAND Gate	SN7470N	Single-phase Flip-flop
SN7420N	Dual 4-input NAND Gate	SN7472N	Master-slave J-K Flip-flop
SN7430N	3-input NAND Gate	**930 Type DTL 0° to 70°C**	
SN7440N	Dual 4-input NAND "power" Gate	SN15830N	Dual 4 Nand Gate
SN7450N	Expandable Dual AND-OR-INVERT Gate	SN15831N	RS/JK Flip-flop
SN7451N	Dual AND-OR-INVERT Gate	SN15832N	Dual 4 Buffer
SN7453N	Expandable 2-input 4-wide AND-OR-INVERT Gate	SN15833N	Dual 4 Expander
SN7454N	2-input 4-wide AND-OR-INVERT Gate	SN15844N	Dual 4 Power Gate
		SN15845N	RS/JK Flip-flop
		SN15846N	Quad 2 Nand Gate
		SN15850N	Pulsed AC Flip-flop
		SN15851N	One Shot
		SN15862N	Triple 2 Nand Gate

FREE SAMPLES FROM TI

molded integrated circuits




RESISTS SHOCK . . . TI molded integrated circuits resist impacts that would smash metal packages and shatter ceramic packages as shown in top photo. You benefit from fewer failures in handling accidents and greater reliability in service. The solid molded construction gives extreme resistance to acceleration, vibration and shock as proven in acual test (see opposite page).

EASY TO ASSEMBLE . . . TI molded integrated circuits are ideal for mechanized assembly, including automatic insertion and wave soldering. Faster, easier handling cuts total manufacturing costs. You realize big savings because of the in-line rigid lead pattern and convenient indexing notch. These features simplify assembly when compared with transistor-type circular lead packages.

RESISTS DAMAGE . . . You also realize savings from fewer rejects while achieving higher end-product quality because TI molded integrated circuits have outstanding durability. For instance, they'll hold up to heat that would induce failures in many competitive devices. Result: fewer assembly rejects due to high soldering temperatures.

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PDP-8/S: A new high speed general purpose digital computer. Modular construction for repackaging. Field proven reliability. 4,096 word core memory. Microsecond speeds. Complete software including FORTRAN. Flexible input/output bus. Deliverable 90 days ARO. Teletype included.

The single unit price for the PDP-8/S is $10,000, and there are liberal OEM discounts for multiple units.

Designed to be used in instruments or systems, the PDP-8/S can be rack mounted or repackaged.

The new PDP-8/S is a close relation of DIGITAL's PDP-8, the most successful on-line, real time computer in the history of the scientific community. At a base price of $18,000, more than 500 PDP-8 systems have been sold. Its success results from a design concept that makes it the most flexible, versatile, adaptable digital computer ever made.

The PDP-8/S uses the same programs, the same instructions, the same operations, and the same basic design as the parent PDP-8. It has the same size memory, is equally expandable, and indeed, uses the same line of modules and components.

But the PDP-8/S is a bit slower. It takes 32 microseconds to add. For process control and analysis, you probably won't even notice.

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Editorial

Custom IC's; a losing game

Apparently integrated circuit makers have everything going their way: boom business with rapidly rising sales and unexpected profits. But in one part of the microcircuit business, makers are "losing their shirt," as Robert Noyce, group vice president of Fairchild Camera & Instrument describes it. Almost every company is racking up giant losses in the custom manufacturing business—that part of the industry in which a semiconductor company designs and tests a special circuit for a particular function of a specific customer.

So many people in other semiconductor companies are echoing Noyce's evaluation that a major upheaval is brewing in the way new circuits are created.

The semiconductor companies are dropping their traditional insistence that they should have all the IC know-how and engineer and build circuits for customers and prospects. Instead, the firms want to transfer the design job at least to their customers' engineering staffs.

What's happened is perfectly clear-cut and painful. A semiconductor firm approaches a potential user and offers to design an IC exclusively for the customer, provided that future volume production is supplied by the designing firm. Once the circuit is designed, the semiconductor firm has a lock on that customer's business. But it rarely works that way. Too often, the semiconductor firm produces an IC that just fails to meet the customer's requirements or costs more than anticipated. So the customer walks away with a sample order of maybe a hundred circuits and the semiconductor firm painfully swallows an engineering bill that can run as high as $50,000.

Efforts to remedy the situation haven't worked so far. For example, at the Signetics Corp., president James Riley has set some stiff criteria for custom work. "We don't accept a job unless there is the prospect of producing at least 25,000 circuits a month for a minimum of one year," he says. But Riley grudgingly admits some jobs have never gotten to the production stage even though a volume commitment was made when work started. "The chances for success on a customer circuit project are no better than 50-50," according to Steven Levy, manager of operations at Motorola's integrated circuit department.

The solution the semiconductor companies would like to see is the acceptance of standard circuits by users of IC's. But almost everybody in the field admits that far too many customers will never buy such an idea. Too many companies feel as Hewlett-Packard Corp. does: Its proprietary edge comes from having an unique circuit; that is lost if its equipment is built with circuits anybody else can buy. At the Teledyne Corp., a user of IC's, vice president Teck A. Wilson, also casts a dissenting vote: "If you standardize on a circuit everybody can build, you've standardized on what is obsolete."

As large scale integration becomes commercially feasible—the next technological advance in microcircuits—the problem becomes even worse for semiconductor companies. "Chances that any other customer could use a large, array we've designed for a specific job are nil," complained one executive.

Still, the semiconductor companies have about run out of patience with their big losses in the custom circuit business. Some plan to make the customer pay all the design costs, a move that would at least double the fees charged for this service. Another step will be to do more computer-aided design, to reduce the amount of engineering in a circuit.

Fairchild's Noyce believes it will be possible to standardize on a low level of integration and build in proprietary circuits by ingenious wiring devised by a computer.

But the answer that is being offered more and more is to turn the job completely back to the customer. What the semiconductor companies want to do is work from a completed design: prepare the masks and then perform processing and testing.

Thus, the engineers who build equipment that uses IC's will have to know the limitations and capabilities of integrated circuits. The problem is complicated because the design constraints of any one manufacturer's IC processing are different from those of any other.

For the first time a pattern is evolving that plots how the acceptance of integrated circuits will affect the structure of the electronics industry. For a time, many people feared that the semiconductor companies would dominate electronics because the maker of the IC was also the designer. Now it seems clear that the maker of IC's will play the role of just another component supplier, albeit a very sophisticated one.

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CLIFTON steps in to the Stepper Motor field

CLIFTON STEPPER MOTORS

SIZE	8	10	11	11	8	8	8	11	8	15
LENGTH (M.F.)	0.770	0.770	1.215	1.215	1.062	1.112	0.770	1.215	1.062	1.535
WEIGHT (OZ.)	1.0	1.6	3.2	3.2	1.5	1.5	1.0	3.2	1.5	6.4
INERTIA (GM-CM²)	0.19	0.19	0.77	0.37	0.18	0.45	0.19	0.77	0.10	2.4
INDEX ANGLE	90° ±3°	90° ±3°	90° ±3°	15° ±1°	90° ±3°	90° ±3°	45° ±2°	45° ±2°	15° ±1°	90° ±3°
TYPE	PM 2∅	PM 2∅	PM 2∅	VR 3∅	PM 2∅	PM 2∅	PM 2∅	PM 2∅	VR 3∅	PM 2∅
RATED D.C. VOLT.	28V	28V	28V	28V	28V	28V	28V	28V	28V	28V
RESISTANCE (OHMS/PHASE)	300	300	300	150	300	300	135	130	150	150
NO LOAD RESPONSE RATE PULSE/SEC	320	350	185	600	360	280	500	440	950	150
NO LOAD SLEW RATE PULSE/SEC	930	700	190	1600	375	650	2700	1200	1300	150
HOLDING TORQUE OZ-IN ONE PHASE	0.35	0.50	1.4	0.60	0.80	[illegible]	0.60	1.5	0.54	3.2
DETENT, OZ-IN ZERO INPUT	0.05	0.05	0.24	—	0.17	[illegible]	0.05	0.12	—	0.8
TYPE NUMBER	MSA-8-1	MSA 10-A-1	MSA 11-A 1	RSA 11 A-1	MSM-8 A-1	MSA 8 A-1	MSA 8 A-3	MSA 11 A-2	RSA 8 A-1	MSA-15-A-1

EXCITATION MODE: TWO PHASES PARALLELED ALTERNATELY   TYPICAL CHARACTERISTICS

After careful testing and having already had units in end-use equipment in the field, we are now ready to announce a full line of size 8, 10 & 11 stepper motors and the controllers that go with them.

Steppers are gaining popularity rapidly in digital systems because of their quick response, high resolution, and many other distinct advantages over the conventional servo motor.

We'd like to step in to your stepper motor picture with Clifton Precision quality, reliability and application knowledge.

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Electronics Newsletter

September 5, 1966

Los Angeles keeps IBM computer and orders another

Los Angeles has partially resolved its data-processing dilemma: it's decided to keep its International Business Machines Corp. System 360 model 30 even though the computer isn't yet working at expected speeds. The city, however, had no other choice; had it sent the troublesome machine back to IBM, it would have been months before a replacement computer would have been ready. In deciding to keep the model 30, Los Angeles went one step further: it committed itself to accept, in addition, a model 40, scheduled for delivery by Nov. 1 [Electronics, July 11, p. 129].

Los Angeles continues to charge IBM $100 a day because software delivery has been delayed. And it has agreed to give the company more time to correct the fault with the data cell drive, which is a bulk-storage unit that can hold up to 400 million characters on strips of magnetic tape, kept in compartments, or cells, each containing 200 strips.

Comsat's tests of time division complete success

The Communications Satellite Corp. last month successfully completed the first test of time division multiple access with the Early Bird satellite [Electronics, June 27, p. 46]. John Puente, a staff member in Comsat's modulation technique department, said, "Tests were absolutely successful in every category—more successful than we expected."

Voice and data signals were transmitted between terminals at Andover, Maine, and Mills Village, Canada. The voice and data were first combined as pulse-code modulation signals. These signals then modulated carrier frequencies which were time division multiplexed by alternately stopping and starting the transmission in each terminal.

Puente would not reveal the minimum guard time—which prevents signal overlapping—used in the experiment, but said that it was much less than 1 microsecond and that the test equipment was capable of measuring time intervals of 40 nanoseconds.

Comsat now plans to test a 600-channel time-division system.

Navy to bounce signals off moon

Tests leading to the first operational use of the moon as a passive satellite to relay microwave Teletype messages in ship-to-shore communications are scheduled to begin this month. The $1.3-million shipboard system, built by the Lockheed Electronics Co., Plainfield, N.J., uses state-of-the-art transmission techniques coupled with elaborate aiming equipment to keep the 16-foot dish antenna pointed at the moon while the ship moves. Ground terminals for artificial satellite communications will be employed in the test, but Lockheed has a contract to build four ground terminals for the moon-bounce system. Lockheed is a subsidiary of the Lockheed Aircraft Corp.

The Navy and Lockheed decline to say how extensively the system will be used. Several shipboard units are on order, however, and it is believed that they will be deployed on vessels around the world. The system is to be operational by 1967. The system can simultaneously transmit and receive wideband carrier, frequency-shift telegraphy of 76 baud over two Teletype channels or one continuous-wave telegraphy channel.

The principal advantage in using the moon as a passive reflector is that microwave line-of-sight techniques can overcome conditions in the atmosphere and ionosphere that interfere with long-range communication at medium and high frequencies.

O'Neal getting Pentagon R&D job

Russell D. O'Neal, a 52-year-old physicist, is being nominated as Assistant Secretary of the Army for research and development, succeeding Willis M. Hawkins Jr., who recently resigned to become a vice president of the Lockheed Aircraft Corp. O'Neal was vice president for engineering and research at the Bendix Corp. He is a specialist in microwave radar test equipment, computer design and guided missiles.

Sylvania East cuts staff

The technical employment picture is not all rosy. Sylvania Electronic Systems East, in Waltham and Needham, Mass., laid off 175 employees this week because of a lack of work. They include engineers and technicians in addition to contracts and production personnel. The employment level there is now at 4,200. Sylvania Electronic Systems has overall responsibility for systems management of major Government projects for the parent company, the General Telephone & Electronics Corp.

While the Eastern operation is cutting back in personnel, **the Central operation, in Buffalo, N.Y., and the Western operation, in Mountain View, Calif., are recruiting.** A Sylvania spokesman says major contracts are "in the wings." **He describes the cutback as a temporary lull.**

New horizons

The Raytheon Co. moves into a new area of commercial diversification with the acquisition of the Seismograph Service Corp. of Tulsa, Okla., whose major business is exploration for oil and other natural resources. **Raytheon follows such companies as the Ampex Corp. and Teledyne, Inc., in entering the seismograph business.**

Air Force briefings to forecast needs for next 5 years

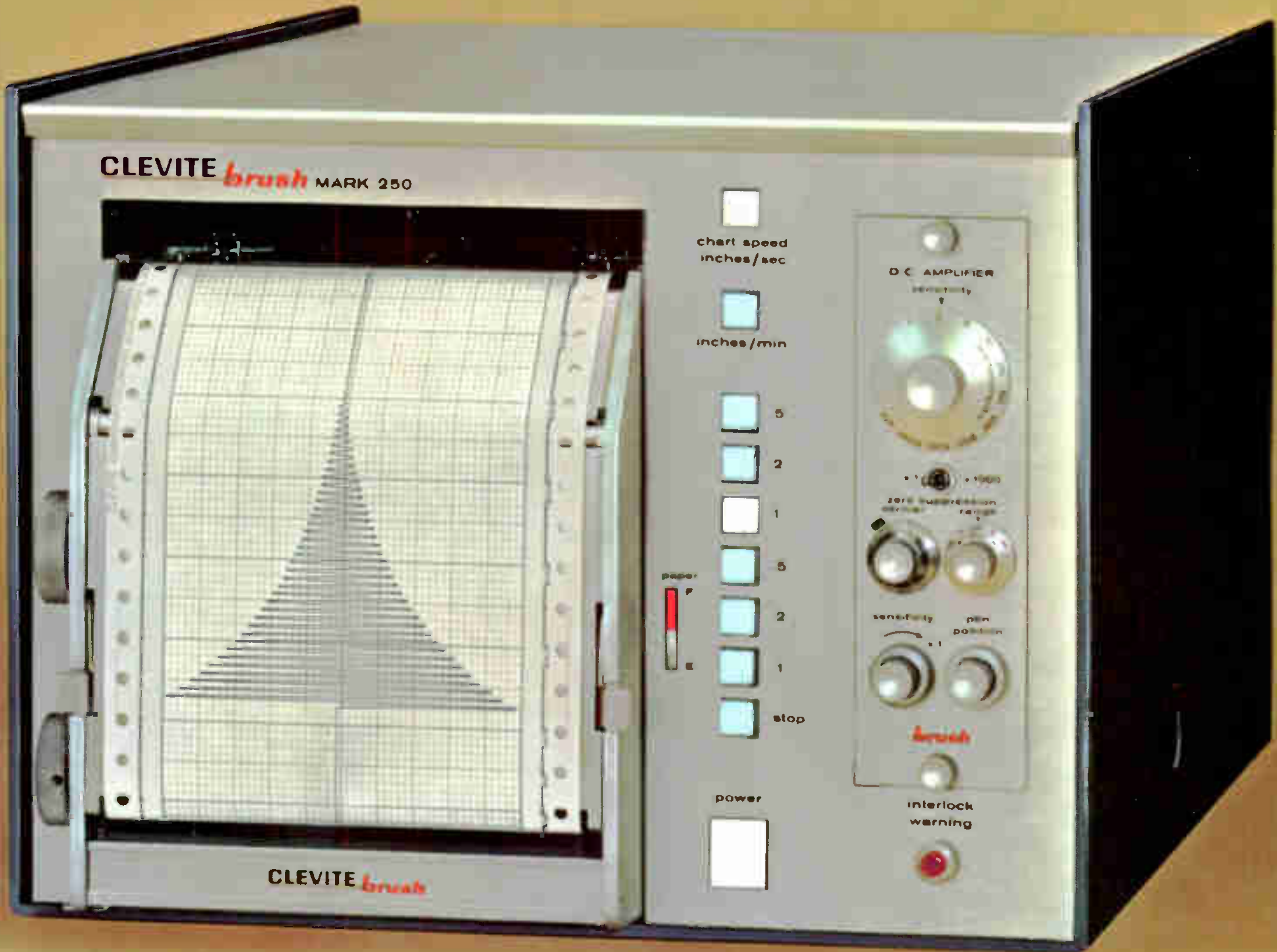
A secret briefing for industry, scheduled Oct. 18 to 20 in Boston, will spell out what the Air Force will need in command-and-control equipment two to five years from now.

"Industry doesn't want us to tell it what's coming the next eight months, or a year. We'll try to provide a background for planning beyond the work that is now on their books," says William J. Sen of the advanced planning staff at the Electronic Systems Division, Hanscom Field, Mass. The division and the National Security Industrial Association are cosponsors of the meeting. Reports on advanced technology at Rome Air Development Center, N.Y., and Wright-Patterson Air Force Base, Ohio, also will be included.

The information will be aimed at three kinds of company planners: directors of marketing, systems planning and research and development. It will include strategic and tactical defense systems, sensors, data processing, displays and trends in missile range technology. **The sessions will provide more detail than the Defense Department briefings earlier this year.** A subcommittee of the Defense Industry Advisory Committee has been set up to provide the Pentagon with feedback on the merits of service briefings of this kind.

Not all the sessions in Boston will be looking ahead. **The final one will be a post mortem on existing systems: it too will be secret.**

Announcing the Brush Mark 250, first strip chart recorder for the perfectionists of the world.



Shown with 1 μv preamplifier RD 4215-70; event markers optional.

(Turn the page and see what we mean)→

BUSINESS REPLY MAIL

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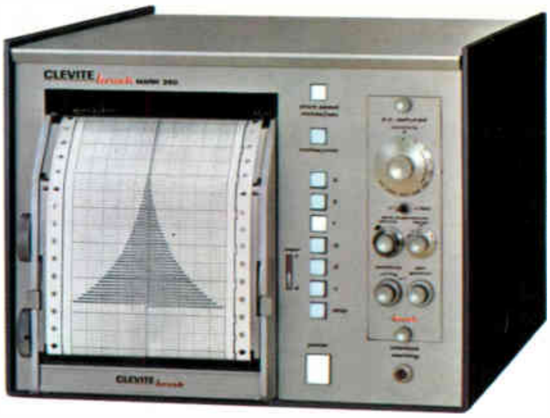
FIRST CLASS PERMIT 2472 CLEVELAND, OHIO, U.S.A.

CLEVITE CORPORATION
BRUSH INSTRUMENTS DIVISION
3631 PERKINS AVE.
CLEVELAND, OHIO 44114



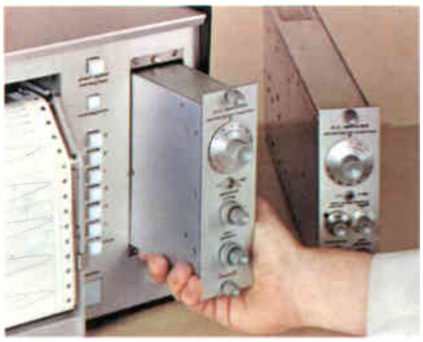
Meet the fastest, most accurate strip chart recorder on record: The new Brush Mark 250.

When you read about all the features you'll know why we call it the first recorder for the perfectionists of the world!

1 Unmatched frequency response. Flat to 10 cycles on full 4½" span! Useful response to 100 cycles. Nobody has a strip chart recorder in the same league.

2 Wide selection of signal conditioners. Choose from 21 interchangeable preamps. Use one today; plug in a different one when your recording requirements change.

3 Crisp, clean rectilinear writing. Patented, pressurized inking system puts smudge-proof trace *into* the paper not just on it.



4 Contactless, non-wearing feedback system. Same one used in our multi-channel Mark 200 recorders. (No slide wires!) Accuracy? Better than ½%!

5 Multiple chart speeds. Push-button choice of twelve . . . from 5 inches/second to 1/10 of an inch/minute (up to 8 days of continuous recording).

6 Portable or Rack mounting. And either way you get the exclusive new dual position writing table.

7 Removable chart paper magazine. Great for desk top record reviews. Man-sized manual winding knobs let you roll chart forward *and* back. Chart reloading is a cinch.

See what we mean? The Mark 250 is for the perfectionists of the world. Ask your Brush Sales Engineer for a demonstration. Or, write for chart sample and specifications. Clevite Corporation, Brush Instruments Division, 37th & Perkins, Cleveland, Ohio 44114.

Yes!
I'd like to know more about your new Mark 250.
☐ Please send chart sample and specifications.
☐ Please have your local Sales Engineer phone.

Name__________

Title__________

Company__________

Address__________

City__________ State__________ Zip__________

Get details fast! Send this card!

CLEVITE
brush INSTRUMENTS DIVISION

The Brush Mark 250
First recorder for perfectionists

 Circle 490 on reader service card

INNOVATION IS THE PULSE OF PROGRESS

In 1526, Philippus Paracelsus, a German alchemist and physician, defied the traditions of the medieval world by teaching that diseases were specific entities that could be cured by specific remedies. He made such substances as opium, mercury, lead, sulfur, iron, arsenic and copper sulfate a part of the pharmacopoeia. He popularized the use of tinctures and alcoholic extracts and introduced the therapeutic value of mineral baths. Many of these are still in common use. Thus, Paracelsus built the early foundations which led to the treatment of diseases by chemical means.

In 1957 Raychem pioneered a series of innovations in the field of radiation chemistry. Among the first was the production of heat-shrinkable plastic tubing for the insulation and protection of connections and terminations. Today this innovation is an accepted device in virtually every industry. Raychem leads the world in the types, properties and technology of heat-shrinkable tubings. Write for Raychem Bulletin 7000 — a comparative summary of types available and their uses.

Thermofit Kynar* is a product of Raychem Corporation's experience in the field of radiation chemistry. It is a heat-shrinkable tubing which is manufactured by exposing specially formulated polyvinylidene fluoride to massive doses of electron beam radiation, thus forming a crosslinked, three-dimensional gel network. The result is a clear, mechanically tough and semirigid tubing, which will not cold flow, does not burn, never melts, will not split, and which possesses a unique "elastic memory." Industry reference specifications are AMS 3632A and UL file E 35586.

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Circle 27 on reader service card

Electronics Review Volume 39 Number 18

Space electronics

Lunar traffic jam

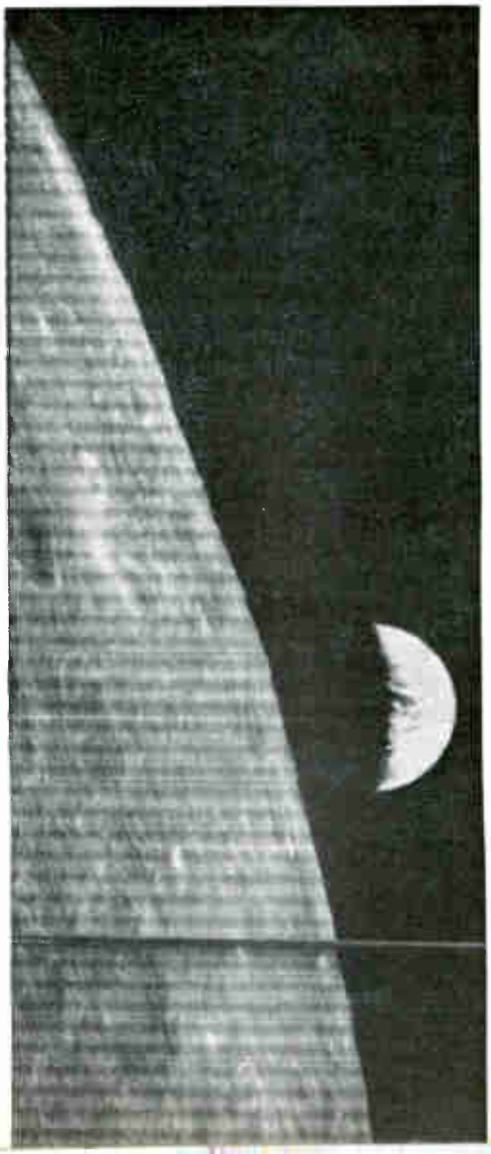
As Lunar Orbiter 1 winds up its photo-taking mission around the moon, officials at the National Aeronautics and Space Administration are preparing its stablemate, Surveyor 2, for its most ambitious mission to date in the double-barrel program to find the best sites for the first American astronauts to step on the moon. The one-eyed Lunar Orbiter, launched Aug. 10, made a major contribution by refining knowledge about the moon's gravity, but failed to take the high-resolution photos needed to verify Apollo landing sites.

The next Surveyor will have a hard act to follow. Surveyor 1 sent back 11,237 high-quality pictures after a perfect launch from Cape Kennedy May 30 and even survived the rigors of lunar night when the temperature fell to —250°F. The next Surveyor, scheduled for launch around Sept. 20, will duplicate the picture-taking assignment at a site in the middle of the moon but will attempt a far more difficult landing.

Landing straight. Benjamin Milwitzky, NASA's Surveyor program manager, explains that Surveyor 1 landed near the so-called vertical impact point on the west side of the moon. At this point, which is based on the complex celestial mechanics of the earth-moon system, a spacecraft launched directly from earth could land vertically. But NASA obviously doesn't want to be restricted to a single landing area when it sends the Apollo astronauts to the moon.

The next Surveyor is due to land farther east, around Sinus Medii (Central Bay) and thus make a sharper turn and still land in an upright position. Instead of approaching the moon at an angle of about 6° from the vertical as was the case with its predecessor, the next Surveyor initially will be 23° from vertical. The design limit is 45°.

All of this makes the mission far more difficult. Since the radar will not be looking directly down at the moon, it will have to sweep a larger area. This increases the range and weakens the returned signal accordingly. It also introduces more radar "noise" caused by sweeping over rough spots on the moon's surface. The correction maneuvers required of the spacecraft's propulsion systems are also made more complex. The small vernier rockets used to keep the craft pointed along the axis of its flight will have to expend more fuel.



Space brake. The main retromotor used to slow the craft to a landing speed it can survive also will have to do extra work. Milwitzky explains that as the Surveyor approaches the moon the lunar gravity takes over to make the craft fall straight down. The more the retromotors slow the craft, the greater is the effect of the moon's gravity. This is called a "gravity turn" in space jargon. In the case of Surveyor 2, the gravity turn will be much greater.

Five more Surveyor flights are planned after the next one. All the spacecraft are externally identical, although some may carry scientific instruments to gather more data on the moon. However, Milwitzky sees the program's prime job as calibrating sites for Apollo. He hopes to certify seven sites in the seven-flight program.

The next Lunar Orbiter, meanwhile, will be launched late this fall to do what its predecessor could not do: take photographs of potential Apollo landing sites with a resolution of a few yards. The first spacecraft in the five-flight series sent back medium-resolution photos, including the best pictures to date of the moon's dark side and the first picture of the earth, but the high-resolution camera system apparently was stymied by a spurious signal in the spacecraft that caused the shutter to trip prematurely. To compensate for this condition, officials at NASA's Langley Research Center, Hampton, Va., ordered the spacecraft to lower its orbit in an attempt to get a closer view of the moon.

Hospitable moon. The major accomplishment of Lunar Orbiter 1 was the discovery that the moon's gravitational field is not so unevenly distributed that it would disturb a spacecraft's orbit. As William H. Michael Jr. of Langley's Space Mechanics Division put it, "We seem to have a hospitable moon." This is vitally important for the Apollo mission since the command module must remain in a stable orbit around the moon with one astronaut aboard while the other two visit the surface.

Michael's calculations showed that the moon seems to bulge at the top and middle and be slightly depressed at the bottom and halfway between the middle and top. The irregularities are quite small: the average radius of 1,100 miles is only a quarter-mile greater at the top and a quarter-mile less at the bottom. The depression in the northern hemisphere is only an eighth of a mile as is the bulge around the lunar equator.

Russia too. Based on tracking data so accurate that the effects of the moon's gravity on the spacecraft velocity can be measured to within half an inch per second, Michael predicted the spacecraft would orbit for at least another five months before plunging into the moon. Even then the onboard propulsion system could be used to raise the orbit and keep the spacecraft alive, but this would further add to the traffic jam accumulating around the moon. In addition to the next Lunar Orbiter and Surveyor—both to be launched this year—the Soviet put its Luna 2 up there and may send other spacecraft before long.

Michael cautioned, however, that the data on the moon's gravity will need considerable refinement. The movements of dozens of spacecraft orbiting the earth over the past eight years have been accurately charted and there still exist some questions about the earth's gravity. Although a few days of tracking a single spacecraft can not be considered conclusive, he did say that "immediate prospects for the Apollo are comforting."

Apollo in November?

The near-perfect Apollo/Saturn 202 flight is setting the stage for the first orbital manned flight of the moon craft this year. Spacecraft manager Joseph Shea reported as satisfactory the performance of two electronic systems flown for the first time on an Aug. 25 ballistic flight—the S-band tracking system and the guidance system developed by the Massachusetts Institute of Technology.

George E. Mueller, head of the manned program at the National Aeronautics and Space Administration, is sticking to his earlier statements that the first manned Apollo flight is not officially set for this year although it has been widely rumored for around mid-November. He said the final decision will be made in November.

... Gemini in September

Also providing information necessary for future space flights will be the three-day Gemini 11 mission scheduled to begin Sept. 9. The astronauts will attempt to rendezvous with the Agena target vehicle on their first trip around the earth. They will also try to achieve the first automatic reentry using the onboard computer and inertial guidance system to feed commands into the attitude control and maneuver electronics system that controls the reentry thrusters. The crew will not touch the controls unless necessary.

Military electronics

Ground bugs

To the chagrin of Congress and the Pentagon, technical problems are plaguing the Army's transportable satellite communications ground terminals, including those needed in Vietnam.

Col. Mitchell Goldenthal, head of the Army's Satellite Communications Agency, told a Congressional group last month that the Hughes Aircraft Co.'s AN/MSC-46 terminals are lacking in these areas:

- Cryogenerator systems needed for cooling the parametric amplifier require major maintenance every 400 hours. Such work cannot be done in the field, so each system must be flown back to Hughes' plant in California for rejuvenation.
- The tracking systems have proved to be "unduly sensitive" and a Government-contractor team is touring the terminal sites to iron out the difficulties and provide additional training to personnel.
- The system's power supply, housed in cargo vans, is troubled by arcing because of high humidity. To solve this, air conditioning must be added.

Goldenthal told the House Military Operations subcommittee that the terminals will be debugged and operating properly by the end of the year. He said some of the technical problems result from the Army's decision not to include an engineering test model in the original contract, which is now nearing $23.1 million.

Repair woes. The colonel credited Hughes with making a "great effort . . . to adjudicate this (cryogenerator) problem." The company, he explained, is bearing the cost of flying the cryogenerators back to the United States for the required maintenance.

In the debugging operation, Hughes-built cryogenerator systems costing $30,000 are being replaced by a unit supplied by Arthur D. Little, Inc., of Cambridge, Mass., costing only $12,000. The Arthur D. Little unit can operate for 3,500 to 4,000 hours without major overhauling. But a weight penalty is being paid for the longer-running unit.

The Hughes terminal now weighs 123,000 pounds and includes a 40-foot parabolic antenna housed in an inflatable radome. Three vans are needed to support its operations. Delivery, which started late last year, will continue for some months. Six are in Hawaii, Ethiopia, the Philippines, West Germany, Fort Monmouth, N.J. (a trainer) and somewhere in Southeast Asia. Eight more are on order and will be installed as alternates. After that, no more MSC-46 terminals will be built.

Lighter model. Another type of ground terminal, developed by

Radiation, Inc., of Melbourne, Fla., the AN/TSC-54, will begin entering the inventory early next year, Goldenthal said. This is a lighter weight terminal for tactical forces with an 18-foot dish antenna.

The Army has ordered 13 of the Radiation systems, including an engineering test model. They will have an antenna not requiring a cryogenic cooling system.

The colonel reported that the tactical terminals are four months behind schedule and about 40% more expensive than anticipated.

He said the scheduling slip was caused in part by technical difficulties that were not further explained. Also, he said, subcontractors have been slow in delivering parts for the system. The first model is due in April, 1967; the original schedule called for delivery by this December. The price of the terminals is now set at $13.3 million, some $4 million more than anticipated.

Radiation, Inc., reports it has successfully tested the first model, bouncing signals off orbiting military satellites.

Outdoor advertising

A chattering Teletype last month printed the first commercial via a military communications satellite. The unlikely location of this event was the infield of Hollywood Park Racetrack in Los Angeles. The X-band message was transmitted from the satellite in its 18,200-nautical-mile orbit to a ground-based antenna only 6 feet in diameter.

Surprisingly enough, the customer—the Navy—and the builder, the Hughes Aircraft Co. in Fullerton, Calif., received last-minute permission from the Defense Communications Agency to interrupt acceptance tests on the new system to send the commercial. They performed this promotional spectacular before thousands of engineers attending the Western Electronic Show and Convention. It was a demonstration of the first model of a second-generation shipboard communications terminal, the AN/SSC-3.

Navy plug. There's no doubt that the Navy was anxious to show off its share of the three-service Initial Defense Communications Satellite Project, since the Air Force and Army have grabbed most of the mentions to date. The Wescon demonstration also helped engineers to learn more about the new shipboard terminal and just how well the military satellites were working, something the Defense Communications Agency has been rather coy about discussing recently.

The 11-line Teletype message was repeated several times with few errors.

Hughes, no slouch in publicizing its technical achievements, had hoped to use the Philco Corp. satellites for voice relay. But for some unexplained reason, the Pentagon's communication agency did not allow voice transmissions in the tests. [For details, see below].

Hughes project engineers say they can track and communicate with all seven of the Philco satellites, which were put into near-synchronous random orbits by a Titan-3C booster on June 16. With the 6-foot dish, the terminal can dig a signal out of the noise with

Titan 3C: unexpected source of trouble

The Pentagon's hopes for a successful launch of another group of communications satellites went up in flames on Aug 25. And so did the satellites. Eighty seconds after the big experimental Titan 3C roared off the pad, a rocket malfunction automatically caused the craft to destroy itself and its satellite package.

The fiery end of the Titan 3C is not without irony. For the past two months Pentagon officials have taken every opportunity to point with pride to their communications satellites, lofted into random orbits on June 16 [See related story on page 31]. All reports claimed an unqualified success—the seven Initial Defense Communications Satellites were flying high and healthy. It appears now these reports were inflated.

Last month, on the eve of the launch of a second series of Initial satellites, Air Force Gen. Ben I. Funk issued a terse announcement which disclosed that something was wrong with either the satellites or the ground stations. For some reason, a Pentagon spokesman explained, signals received from the 18,200-nautical-mile-high satellites were about 30% weaker than had been anticipated. This power loss reportedly was uncovered soon after the satellites were placed in orbit but the information was kept secret.

Because of the problem the Pentagon delayed the launch of the second series—hopefully until the power loss could be isolated and corrected. The Philco Corp., maker of the seven satellites, announced that its tests indicated that the craft weren't to blame. And the Hughes Aircraft Co., builder of the ground stations, after running some independent calibration tests, also disclaimed any responsibility—despite the rash of trouble that the military has been encountering with Hughes ground stations [See related story on page 30].

Nothing wrong. Finally, on Aug. 25, the Pentagon announced that it had a tentative answer: there was nothing wrong with either the satellites or the ground stations. The power loss, explained a Defense Communications Agency spokesman, was attributable to "free space loss"—attenuation that occurs when a signal travels a long distance through space. Apparently, pointed out the embarrassed spokesman, this signal loss wasn't considered when the power specifications were prepared.

Convinced that the problem had been isolated and that no changes were necessary on the satellites, the Pentagon ordered liftoff, a day behind schedule. And then the rocket blew up.

The next series of military satellites is now scheduled for launch early next year. But there's word that the Pentagon may push up the schedule to as early as eight weeks from now because it wants more and better communication links to South Vietnam.

LOS ANGELES, AUG. 22-26, 1966 -- THIS MESSAGE SENT AND
RECEIVED AT THE 1966 WESTERN ELECTRONICS SHOW AND CONVENTION,
IS AN EXAMPLE OF THE U.S. NAVY'S NEW "SPACE-AGE" VOICE. IT
WAS RELAYED THROUGH A MILITARY SATELLITE MORE THAN 18,000
MILES ABOVE THE EARTH'S EQUATOR, USING ONE OF THE NEW SEAGOING
SATELLITE COMMUNICATION TERMINALS BUILT FOR THE NAVY BY HUGHES
AIRCRAFT COMPANY, FULLERTON, CALIF. THE TERMINALS WILL
SUPPLEMENT EXISTING COMMUNICATIONS METHODS AND OFFER RELIABLE
LONG-RANGE VOICE AND TELETYPE COMMUNICATIONS UNAFFECTED BY
SOLAR AND ATMOSPHERIC DISTURBANCES.
U.S. NAVY SENDING ---------

Teletype message transmitted via the Initial Defense Communications Satellites to a Hughes Aircraft Co. 6-foot antenna at Wescon.

a level as low as −140 dbm (decibels above 1 milliwatt).

Smaller yet. The 6-foot parabolic antenna is the largest that can be operated on combat ships without interfering with other ship systems and "is about as small as we can go working with present satellites," says A.W. Ladd, Hughes project manager. However, with satellites currently being designed, which have higher effective radiated powers, shipboard antennas can go down to 3-foot diameters, Ladd explains. With minor modifications, the SSC-3 will also be able to work with the upcoming tactical satellite program, one Navy official notes.

Hughes is building seven of the SSC-3 terminals for the Navy. Two are research-and-development models (XN-1), but all will be installed shortly on ships for command-and-control communications, says Louis Johnson, assistant project manager for satellite communications, Naval Electronics System Command. The first ship will begin operating with one of the terminals in October.

The Navy is trying to get the money to build the terminals for a number of its ships. The SSC-3 is described as the future "workhorse of the Navy." Excluding research and development and installation, Johnson estimates that each SSC-3 will cost about $700,000.

The Navy became interested in the possibilities of communicating by satellite in 1962—years after the Army and the Air Force. While there were many problems, the first model, used with the Syncom and made basically from off-the-shelf hardware, did prove the feasibility of shipboard satellite terminals.

The SSC-2 used uncooled parametric amplifiers. Total system noise temperature for the S-band set was 180° K. The SSC-3 took a jump in frequency, to X-band, and used Peltier-cooled (thermoelectric) parametric amplifiers; total system noise temperature is 240° K.

On the mast. The SSC-3 will be mounted on a ship's mast. The Cassegrain feed puts out a 1.5° beam and the multimode, four-horn monopulse feed keeps total system losses to 0.1 db or less. First stages in the preamplifiers are three parametric amplifiers: one for error signal plus elevations, one for error signal plus azimuth and the last for sum channel. All have tunnel-diode second stages.

The set has both a frequency-modulation modem and a digital modem. The digital modem can be used with lower signal-to-noise ratios and is 5 db more efficient than the f-m unit. It can receive Teletype messages with the set's transmitter power at only 100 watts. A water-cooled klystron can produce 5 kilowatts, or 43 db of gain, for an output at the antenna feed of +67 dbm minimum.

The three-axis, gyro-stabilized pedestal has a tracking accuracy of 0.1° root-mean-square error and will operate in a 75-knot wind. Once the satellite is acquired, the SSC-3 tracks it automatically. The phase-lock receivers (for which Hughes is seeking patents) will lock on a zero-decibel signal-to-noise ratio signal.

Enough for now. Operating with the Initial satellites, the Hughes terminal can handle one duplex voice channel and two Teletype channels or 16 channels, "which is plenty for us," one Navy official says. However, the 6-foot shipboard terminal cannot communicate with a satellite at the same time one of the 40-foot Mark-1B satellite ground terminals — also made by Hughes—is on the air. Although the SSC-3 is only on one of the four channels, the Mark-1B is so powerful it overrides the shipboard set's signal.

The Navy concedes that it has a number of operational and technical problems to be worked out. It also wants more improvements in the shipboard set: reducing the antenna's weight and size, improving reliability and maintainability and integrating the control console and other equipment inside the ship.

Optoelectronics

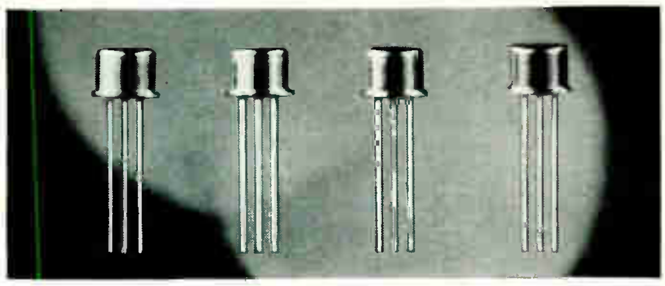
Photon finish

As an electronic material, silicon can be classified as a workhorse, performing a remarkable number of jobs reliably and steadily. With careful breeding, scientists at the Hewlett-Packard Co. in Palo Alto, Calif., have now produced a silicon photoconductor that's fast in the stretch, too. And Hewlett-Packard's entry—a photoconductor with a speed of response several orders of magnitude faster than present devices—may cause system designers to again put their money on optoelectronics, once touted as a sure winner.

About a decade ago, optoelectronics — combining solid-state light emitters and detectors in integrated structures to produce electronic functions—looked very promising. Optically coupled circuits and subsystems, it was said, could be produced with a high degree of input-output isolation, combined with ability to handle many signal channels in parallel. And the circuits could do anything conventional electronics could do—amplify, switch, store and perform logic operations.

Too slow. But the initial enthusiasm for optoelectronics soon dissipated when designers ran up against what seemed to be a fundamental limitation—lack of speed. The trouble was that the speed with which photodetectors respond to changes in light intensity de-

TranSitron THYRISTORS



Now...industry's lowest prices for premium-performance SCR's

Low cost TO-52 packaging provides military quality at commercial prices

Silicon Triode Thyristors

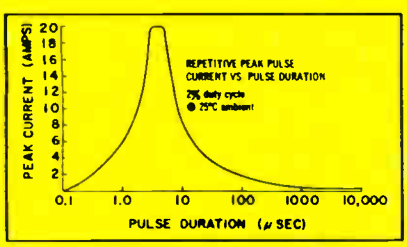
This Transitron family of premium, high-reliability, planar silicon controlled rectifiers is now available in hermetically-sealed TO-52 packages at the lowest prices in history.

Ideally suited to both commercial and military applications, the 2N4332 family features:

- **Blocking Voltages up to 250 volts**
- **Leakage Currents @25°C, less than 20 nano amps**
- **Leakage Currents @125°C, less than 50 micro-amps**
- **Low Holding Current—1.0 mA max. @ 25°C.**
- **Low Gate Triggering Current—10.0 micro-amps max. @ 25°C**

The low trigger current and voltage requirements make the series particularly useful for many high-performance switching applications.

In spite of the miniature package, these devices can effectively handle repetitive, high-peak pulse currents of low duration and duty cycle. They are designed to meet all of the rigid requirements of MIL-S-19500. Extensive temperature cycling, storage and operating life tests, as well as mechanical and hermetic seal tests, are included as a regular part of the manufacturing process to maintain military standards of quality.



The high pulse current capability of the 2N4332 family makes it ideal for commutating turn-off circuits and other capacitor discharge applications.

Typical applications include: Electroluminescent displays; timing and logic circuits; inverters; and squib firing, servo motor driving and phase control circuits.

TYPES AND MAXIMUM RATINGS

TYPE	VDRM/VRRM (@ 125°C)	TYPE	VDRM/VRRM (@ 125°C)
2N4332	30/30V	2N4335	150/150V
2N4333	60/60	2N4336	200/200
2N4334	100/100	2N4337	250/250

Gate Turn-off Triode Thyristors

Also available in hermetically-sealed TO-52 packages, at extremely low prices, is a new series of silicon planar Transwitches (2N4320/25). These units are ideal for use in industrial and military circuits requiring gate turn-off action.

The series offers anode currents to 250 mA, with a minimum gate turn-off beta of 5. Operating temperature range: —65°C to +125°C.

Reasonable quantities are available for off-the-shelf delivery, with fast action assured on large-quantity orders.

TYPES AND MAXIMUM RATINGS

TYPE	VDRM/VRRM (@ 125°C)
2N4320	30/30V
2N4321	60/60
2N4322	100/100
2N4323	150/150
2N4324	200/200
2N4325	250/250

Average Forward Current..............250 mA @ 75°C
One Cycle Surge (60 CPS).............5 Amps @ 75°C
Peak Gate Current for 8 msec.........100 mA @ 75°C
Peak Gate Power for 8 msec...........200 mW @ 75°C
Average Gate Power....................20 mW @ 75°C
Storage Temperature Range..........—65°C to +150°C
Operating Temperature Range........—65°C to +125°C

Light-Activated Triode Thyristors

Transitron's silicon planar Photoswitches are efficient, low-cost, light-sensitive devices for electro-optical applications. Contained in a miniature package (modified TO-18), the Photoswitch has been designed for critical control of electronic switching circuits such as counters, sorters, indexers, logic controls and card or tape readout.

It offers the design engineer the option of gate triggering (50 μa max.) or light activation (150 foot candles) or a combination of the two.

The TPS 20 Photoswitch family features:

- **Blocking Voltages up to 200V**
- **Low Leakage Current—100 μa max. @ 100°C**
- **Low Holding Current—1.0 mA max. @ 25°C**

TYPES AND MAXIMUM RATINGS

TYPE	VDRM/VRRM (@ 100°C)
TPS 20	25/25V
TPS 50	50/50
TPS 100	100/100
TPS 150	150/150
TPS 200	200/200

Average Forward Current..............200 mA @ 75°C
One Cycle Surge (60 CPS).............5 Amp. @ 75°C
Peak Gate Current for 8 msec..........250 mA @ 25°C
Average Gate Current..................25 mA @ 25°C
Reverse Gate Voltage.........................5 Volts
Reverse Gate Current..........................3 mA
Storage Temperature Range..........—65°C to +150°C
Operating Temperature Range........—65°C to +125°C

Send for this NEW SCR DATA, just off the press

Transitron
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Circle 33 on reader service card

pends on the level of illumination. The best available source of light, electroluminescent zinc sulfide, could only produce modest light levels, about four watts per square meter. As a result, the available photodetectors, cadmium sulfide and cadmium selenide, were too slow to compete with conventional electronic devices as circuit elements.

With the advent of efficient injection electroluminescent diodes, a light source became available that is more than 1,000 times brighter than zinc sulfide, equivalent to 6 kilowatts per square meter. Unfortunately, optoelectronics designers had not been able to take advantage of this high output level because there were no good photoconductors to match the characteristics of gallium arsenide light emitters. They could only choose between junction type photodetectors with limited gain, or high-gain CdS or CdSe, which have limited sensitivity at the wavelength of gallium arsenide emitters.

Teamwork. One of the early apostles of optoelectronics, E.E. Loebner of Hewlett-Packard — working with a colleague, T.J. Diesel, and with the help of Stanford University's Richard H. Bube, a photoconductor authority—has now increased the gain and speed of response of single-crystal silicon photoconductors by several orders of magnitude. The development of an efficient and fast silicon photoconductor is significant because the spectral and electrical characteristics of silicon are well matched with those of gallium arsenide injection diodes. Furthermore, silicon devices are compatible with integrated-circuit technology.

One factor that limits the response time of most photoconductors is the lifetime of the majority carriers in a material. A photoconductor is basically a light-sensitive resistor, whose electrical conductivity can be increased when exposed to light radiation. When the photoconductor absorbs light, electron-hole pairs are liberated in the material. These contribute to conductivity until captured by imperfections known as "traps," or by recombination. Photodetector responses to changes in light intensity depend greatly on free-carrier lifetime. For example, at low light levels response time in cadmium sulfide is 100 to 1,000 times greater than the lifetime.

Life expectancy. Loebner and his co-workers at Hewlett-Packard increased the electron lifetime in silicon by a process they call zinc counterdoping. They made photoconductors by diffusing zinc into n-type silicon single crystals containing arsenic donors. The ratio of arsenic to zinc is about 2 to 1. The result of this combination is highly negatively charged "capture" centers in the material. When incident photons release electron-hole pairs, these centers immediately capture the holes. The centers repel electrons and electron lifetime is increased. Lifetimes up to several hundred microseconds and response times not much greater than 3 or 4 times these have been observed at room temperature.

Photoconductor gain is limited by the onset of space-charge limited current, which occurs when the applied voltage gets too high. At this point, the photoconductor ceases to function. Because silicon has high conductivity, it can operate with higher voltages and therefore get high gain before space-charge limiting sets in. Measured gain of the zinc counterdoped photo detectors is greater than 10^6.

According to Loebner, the response speed of the new devices is expected to open up applications thus far closed to optoelectronics. The Hewlett-Packard group has already built some simple storage elements that have worked satisfactorily at excitation levels of 1½ to 2½ volts.

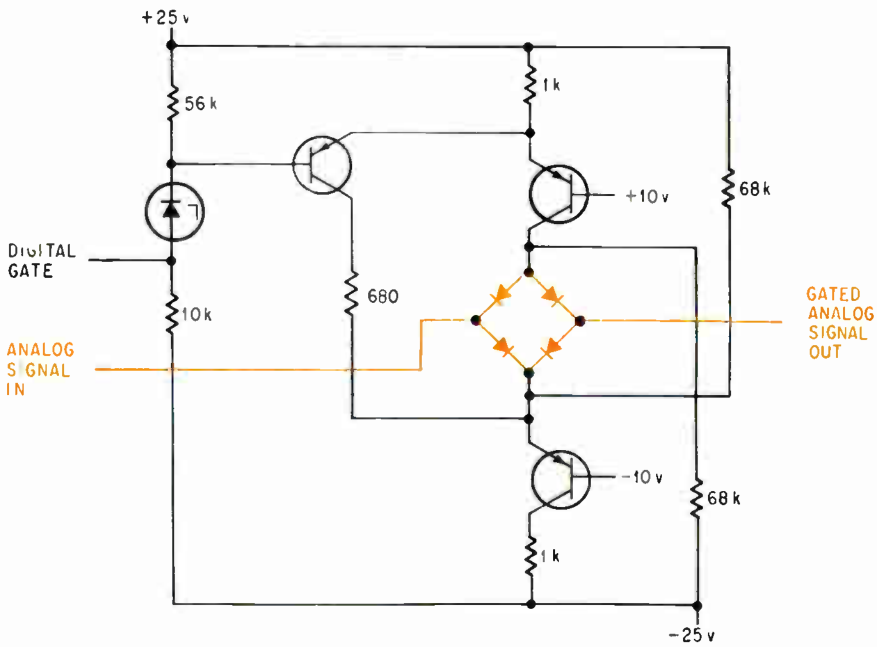
The work, sponsored in part by the Army Engineer Research and Development Laboratories, Fort Belvoir, Va., was reported last week at a conference on radiative processes in electronic materials held in Boston.

Computers

Circuit on display

Researchers at the University of Illinois are developing some unusual circuit techniques for storing and displaying analog information in a digital system—without a vast computer program, complex circuits or expensive cathode-ray tubes.

The project, under the direction



Digital-analog gate (bridge in color) passes an analog signal but is digitally controlled.

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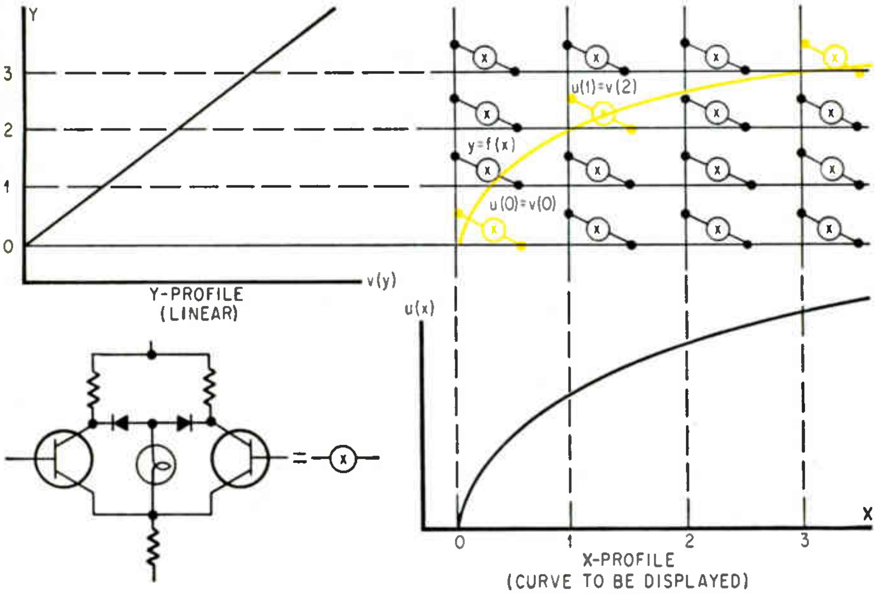


Paramosaic, a prototype of a digitally controlled display for analog quantities.

of W.J. Poppelbaum, professor of electrical engineering, is being conducted at the university's digital computer laboratory.

One technique, still under investigation, is the application of digital-analog circuits to graphical processing and display. For example, circuits such as the one sketched on page 34 can pass an analog signal when the digital gate is open, but when the gate is closed, the output floats.

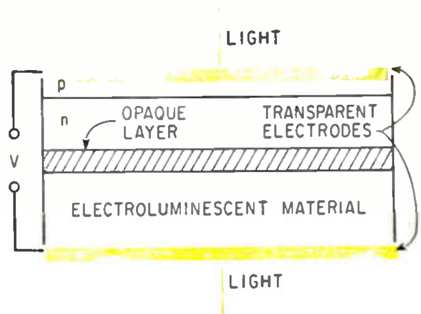
With these circuits, says Poppelbaum, graphical processing—of bubble chamber data, for instance—can be performed with accuracies of 0.1% or better and at megahertz speeds. The new approach is to do all the graphical processing in analog form, digitizing the data afterward if necessary. The usual procedure requires digitizing the analog data, processing it in a digital computer and then reconverting it to analog form for display. Processing in this context includes moving an image around on a screen or transmitting graphical data through a noisy channel to a remote receiver.

Other circuit examples include comparators—whose digital output indicates the equality of two analog inputs—amplifiers and out-of-range indicators that can inhibit the comparators.

One at a time. The circuits are used in what Poppelbaum calls a paramosaic—one form of which is a matrix of wires with a storage element at each intersection. The matrix is scanned, one storage element at a time, and the digital-analog gating circuit gates analog data to each storage element, such as the coordinates of a point on a curve.

Other digital-analog circuits in the paramosaic can shift the displayed image up, down, sideways, rotate it or change its size.

The lab built one prototype, a 32-by-32 paramosaic in which the storage elements are flip-flop circuits. A small light bulb connected to each storage element displays the stored data. Poppelbaum says a paramosaic made from an electroluminescent panel got much better resolution. It produced a semipermanent display more cheaply than possible with, say, storage cathode-ray tubes.



Electroluminescent panel, in cross section, from which a high-resolution paramosaic could be built.

The paramosaic looks like a sandwich; it's made of two transparent electrodes, an opaque layer, a layer of electroluminescent material and two layers of p and n material. A focused beam of light, controlled by analog-digital circuits, sweeps across the panel, tracing out a curve, for example. The resistance of the light-sensitive p-n junction drops sharply wherever the light strikes it because light generates hole-electron pairs. The resistance remains low because electrons are trapped and slowly released after the light beam passes.

Turn it off. Where the junction resistance is low, most of the bias voltage between the transparent electrodes appears across the electroluminescent material causing that spot to glow. The sheet of electroluminescent material, therefore, displays the path followed by the focused beam and retains the display until the bias voltage is removed.

Instrumentation

Look sharp

Air Force and space agency officials concede that, too often, satellites designed to observe the earth from afar simply don't "look" in the right direction and the expensive spacecraft spin around the earth without orientation. To provide better aim to these satellites, the military and the National Aeronautics and Space Administration settled on infrared sensing techniques to help orient the craft with the earth's horizon. The search now is for the best infrared spectral band to define the earth's rim.

The program is beginning to pay off. Studies so far indicate that the best band is in the far infrared—specifically the 14- to 16-micron region. Heat in this region is reflected by carbon dioxide. Hence the earth's atmosphere, which includes carbon dioxide, repels heat radiating from the sun. Since there is

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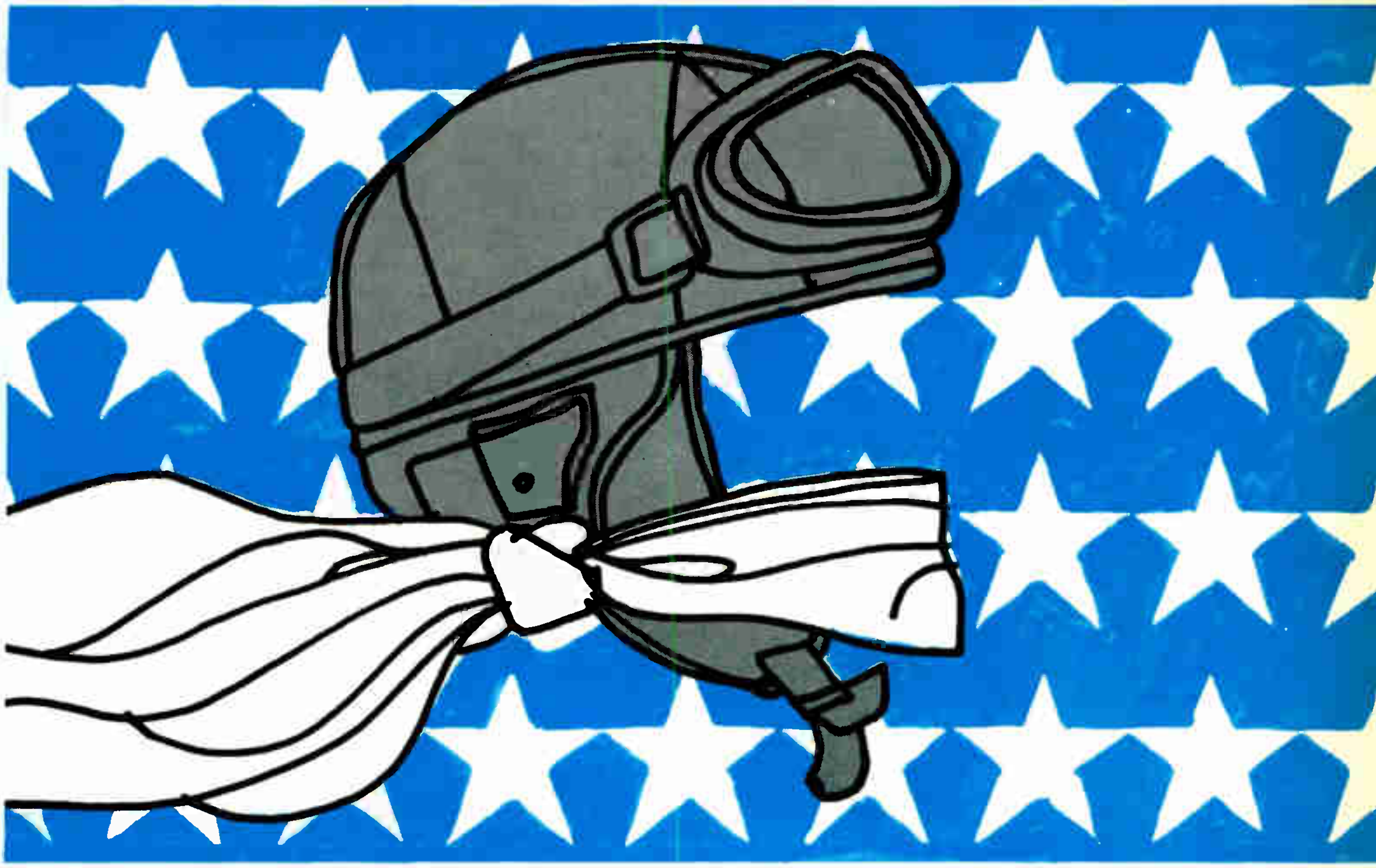

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Circle 37 on reader service card

more carbon dioxide near the earth's surface than at high altitudes, an infrared sensor detects more heat when it's pointed at the horizon than far above it.

Hide the horizon. The ideal approach would be to look at the earth in the visible spectrum but often clouds make this impossible. Various other spectral bands have been tried—some with disastrous results. The second Orbiting Geophysical Observatory (OGO), for example, tried to find the horizon in the 8- to 20-micron band. When its radiometer found some high-altitude cold clouds—which emit in the 10-micron region—the spacecraft thought it was looking at outer space and went out of control. The third OGO was modified to look at the horizon in the 12- to 22-micron band and that worked for a while. Other problems, however, made that test short-lived.

The research program proceeded on many fronts but some of the best data backing up the CO_2 band came from three sounding rocket experiments—two by the Air Force at White Sands Missile Range, N.M., and the first of NASA's two planned Project Scanner flights from Wallops Island, Va., Aug. 16. NASA plans its second flight at Wallops Island in November, and the Air Force has a program calling for another flight at White Sands and three at Fort Churchill, Canada. Augmenting this program are flights of the X-15 rocket research craft, which is equipped with a far-infrared radiometer.

Still a more ambitious attack on this problem is under study by NASA and the Scanner's prime contractor, Honeywell, Inc., of Minneapolis. The company received a $230,000 contract from NASA in March to determine first what additional data is needed and second whether more sophisticated techniques are feasible. The first phase could lead to orbiting experiments as part of the manned Saturn/Apollo applications program of a special-purpose unmanned spacecraft just for that purpose or "piggy-back" experiments on such spacecraft as the Orbiting Astronomical Observatory.

How sharp? For the moment, however, NASA's only approved program involves ballistic flights on sounding rockets. Jules Kanter, who runs the program in the electronics and control division of the agency's Office of Advanced Research & Technology, says the biggest question remaining is how good is the resolution. At best, present spacecraft systems give attitude reference to within about 1° of the vertical axis. An infrared radiometer looking through the 14- to 16-micron band detects a sudden drop of radiated heat between 15 and 30 miles. NASA hopes this can be translated into a vertical accuracy of 0.02°.

The November Scanner flight will gather data when the atmosphere in the Northern Hemisphere is coldest. August is the warmest month and if the temperature profiles are the same during both November and August, project officials will have at least a partial answer to the problem.

All the hardware, except the radiometer, for the November flight is at NASA's Langley Research Center, Va., which operates the $4.5-million project. The radiometer is being tested at the Santa Barbara, Calif., research center of the Hughes Aircraft Co., using infrared sensors supplied by the Barnes Engineering Co. Honeywell will integrate the equipment in addition to furnishing the spacecraft under its $2.2-million prime contract.

Water-vapor test. During the 13.5-minute flight from Wallops Island last month, a Trailblazer-2 vehicle rocketed the Scanner payload to an altitude of 380 miles. Data was telemetered in two wavelength bands: 14 to 16 microns and the 20- to 40-micron band that reflects heat radiated by water vapor. The guidance system on the spinning spacecraft used a telescope with an infrared sensor to measure returned heat energy and control a cold gas jet attitude-control system that kept the payload stabilized to within 2° of the vertical.

Still another flight is possible after November since Honeywell is under contract to deliver a third spacecraft in case the next one doesn't work. This craft could be flown next August to provide more data points on temperature profiles and confirm the findings of last month's shot.

Project Scanner payload designed to gather information on the earth's horizon to orient future satellites more precisely.

Manufacturing

Plastic bandwagon

Plastic packages have been such a success for transistors that integrated circuits are speeding down the same road—even though there seems to be serious doubt as to whether the plastic package will satisfy as many IC customers. The biggest question is reliability; there isn't enough data available. You can also get an argument as to whether plastic will save much money in the long run.

Still, every manufacturer of IC's —including the skeptics—is putting at least part of his line into plastic packages. They reason that the plastic transistor's feat of wiping

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TRW CAPACITORS

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out the Japanese cost advantage overnight was so spectacular that they have to gamble on a repeat performance with IC's.

Motorola, Inc., Texas Instruments Incorporated and the Signetics Corp., a division of the Corning Glass Works, are betting that plastics will be a big success. The Microelectronics division of the Philco Corp. is also heavily committed to plastic packaging. Philco's Eastern operation, in Lansdale, Pa., will use the transfer method of production. The General Electric Co., which developed one transfer method for transistors, will also use it for IC's; but GE does not seem to be as ready as the other four companies to make such sweeping claims.

On the other hand, the Semiconductor division of the Fairchild Camera & Instrument Corp. and the Radio Corp. of America are sticking to relatively primitive and inexpensive injection techniques.

Heat and humidity. The method of encapsulation is a matter of choice. Reliability almost seems to be a matter of opinion; everyone has figures to support his stand, and everyone's figures are different.

"I think you can meet military specifications," says Steve Levy, integrated circuit marketing manager for Motorola. And TI's George Berryman said in a paper presented at Wescon that two million hours of testing on transistors indicates that plastic packages can meet military specifications and are as reliable as their counterparts in metal cans.

Most data on reliability has come from transistor tests. Signetics, however, has deliberately made IC's with cavities in the plastic, then exposed them in a helium atmosphere and found that the leak rate was less than the 10^{-8} centimeters per second accepted as a hermetic standard. It has also tested some devices in a pressure cooker for 30 to 40 days before they broke down.

Says marketing manager George Didinger, "One large military customer has even suggested that we quit using glass." Signetics won't do that just yet, though by next year it expects plastic IC shipments to outstrip glass, because "not all our military customers feel that way. Most of them just don't believe that plastic is hermetic."

Levy says plastic packages will also dominate Motorola's shipments. The 23 devices, both diode transistor logic and resistor transistor logic, on which Motorola announced price reductions at Wescon, are rated from only 0° to 75° C, however, which is not up to military standards. Philco says it has tested devices at 125° C.

Skeptics. Ben Jacoby, IC marketing manager for RCA, says the cost advantages of up to 90% that some manufacturers are claiming may not hold up. RCA will soon introduce an all-ceramic dual in-line package with a welded seal that is at most 25% more expensive than plastic. "There's a real race to be run yet," Jacoby feels. The hermetically sealed ceramic package, he says, has not yet gone through a rigid cost-reduction program.

Fairchild's marketing boss, Don Valentine, says, "We will offer a ceramic, hermetically sealed dual in-line pack with both DTL and RTL for the same or better cost than anybody using molded epoxy." Fairchild expects to eliminate the expensive lead frame and 50% of the ceramic by taking the flip-chip approach. "That way we'll still have hermeticity, and we don't see plastics as being a penny cheaper," adds Valentine.

Advanced technology

Power from plasma

One of the problems plaguing spacecraft designers has been the plasma that's created when the craft reenters the atmosphere. A Sandia Corp. researcher now proposes to put the plasma to work by using it to generate current—and without adding weight or complex components. The plan is to separate the forward section of the nose cone from the rear section with an insulator connected to a conductor.

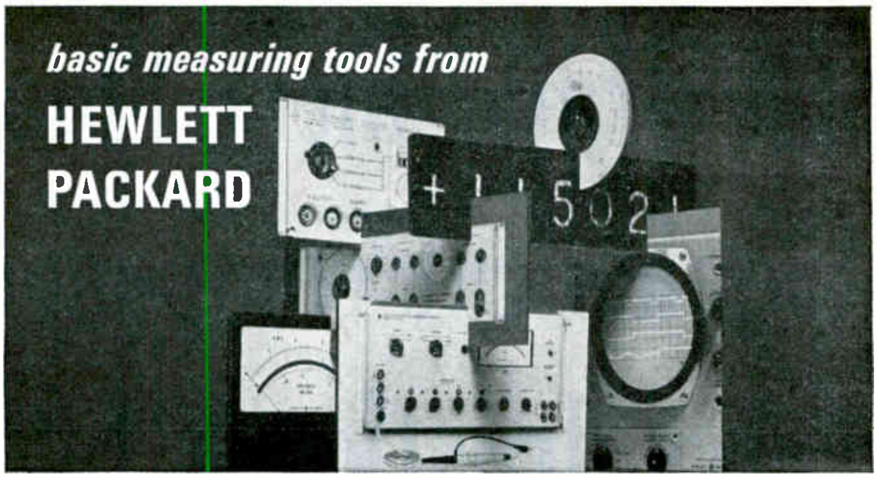
Hot spot. When a nose cone reenters the atmosphere at hypersonic velocities, the heat caused by friction ionizes the atmosphere. Around the front of the craft the cone emits a stream of electrons that flow through the surrounding ionized gases, or plasma, toward the rear of the vehicle. The rear section of the nose cone is cooler and collects some of the free electrons; hence the entire rear of the craft is negatively charged. The potential between the two sectrons causes a current flow. Current could be stored in either batteries or capacitors.

Continuous current would be generated as long as plasma is being created. The amount of power generated would depend on the nose cone's materials, size and shape, and the speed and temperatures reached during reentry.

The inventor of the generator, Keneel J. Touryan, supervisor of reentry studies at the Sandia laboratory in Albuquerque, N. M., says that a maximum of 2,000 watts could be generated continuously during reentry with a 3-foot-diameter nose cone.

Electronics notes

- **Another IC radio.** The Philco Corp. is the second company to announce a home radio receiver using integrated circuits. Its debut is set for October, about the same time as the General Electric Co.'s clock radio [Electronics, July 11, p. 40]. All the active circuits in Philco's a-m table model will be in two silicon flip chips soldered onto a 1- by 0.6-inch carrier board.
- **High field.** A superconducting solenoid generating 103,590 gauss in a two-inch bore is believed to be the highest field attained in a work area of that size. The solenoid was built by Magnion, Inc., of Burlington, Mass. Although it requires a liquid-helium environment, the device operates from a battery—in contrast to conventional magnets which require, for example, 50 kilowatts input and 10 tons of metal to produce 40,000 watts. The Magnion coil, made of niobium tin ribbon, has an outside diameter of 5.2 inches, and an active winding length of only 5.5 inches.



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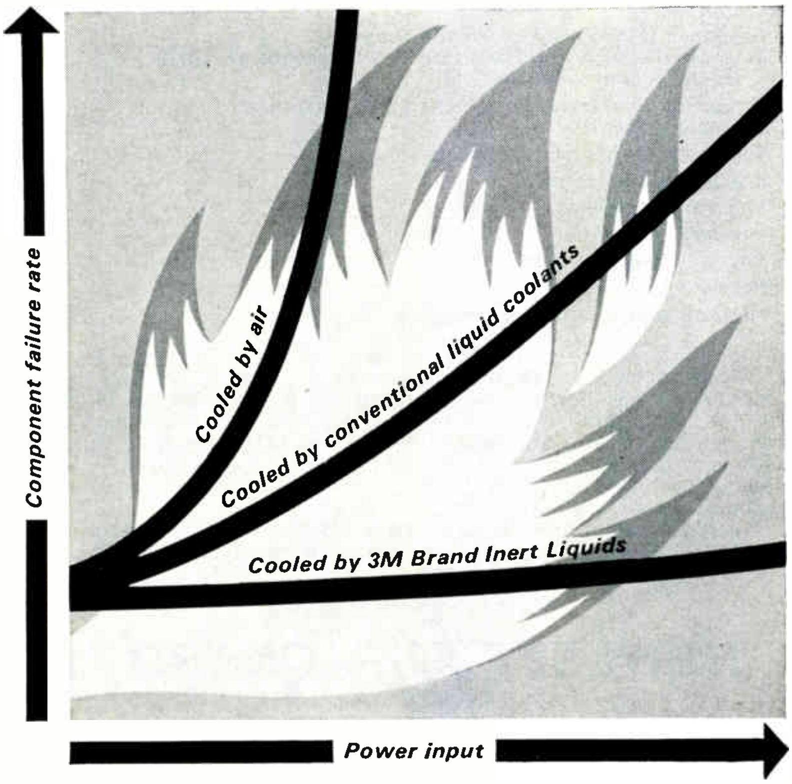

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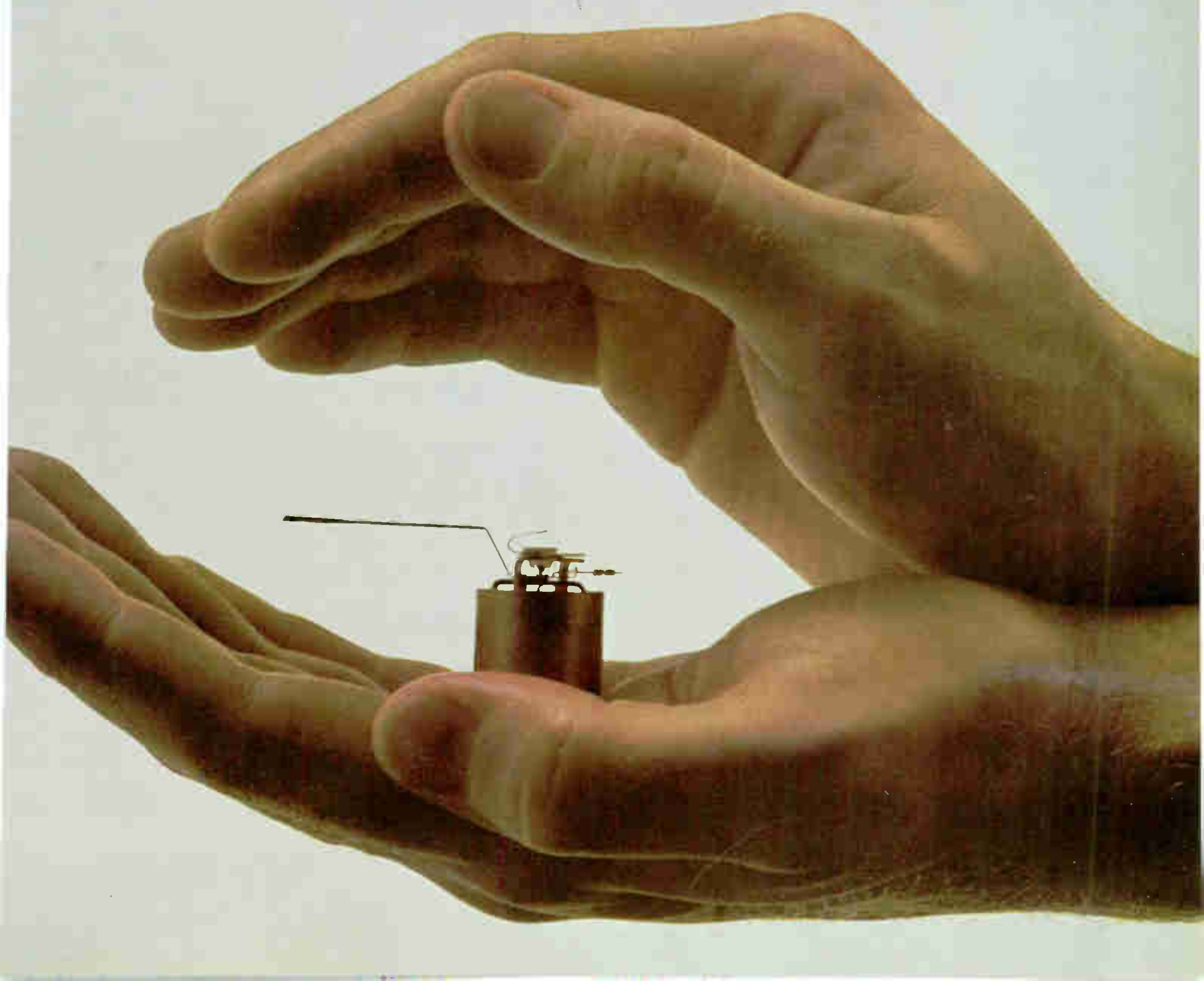

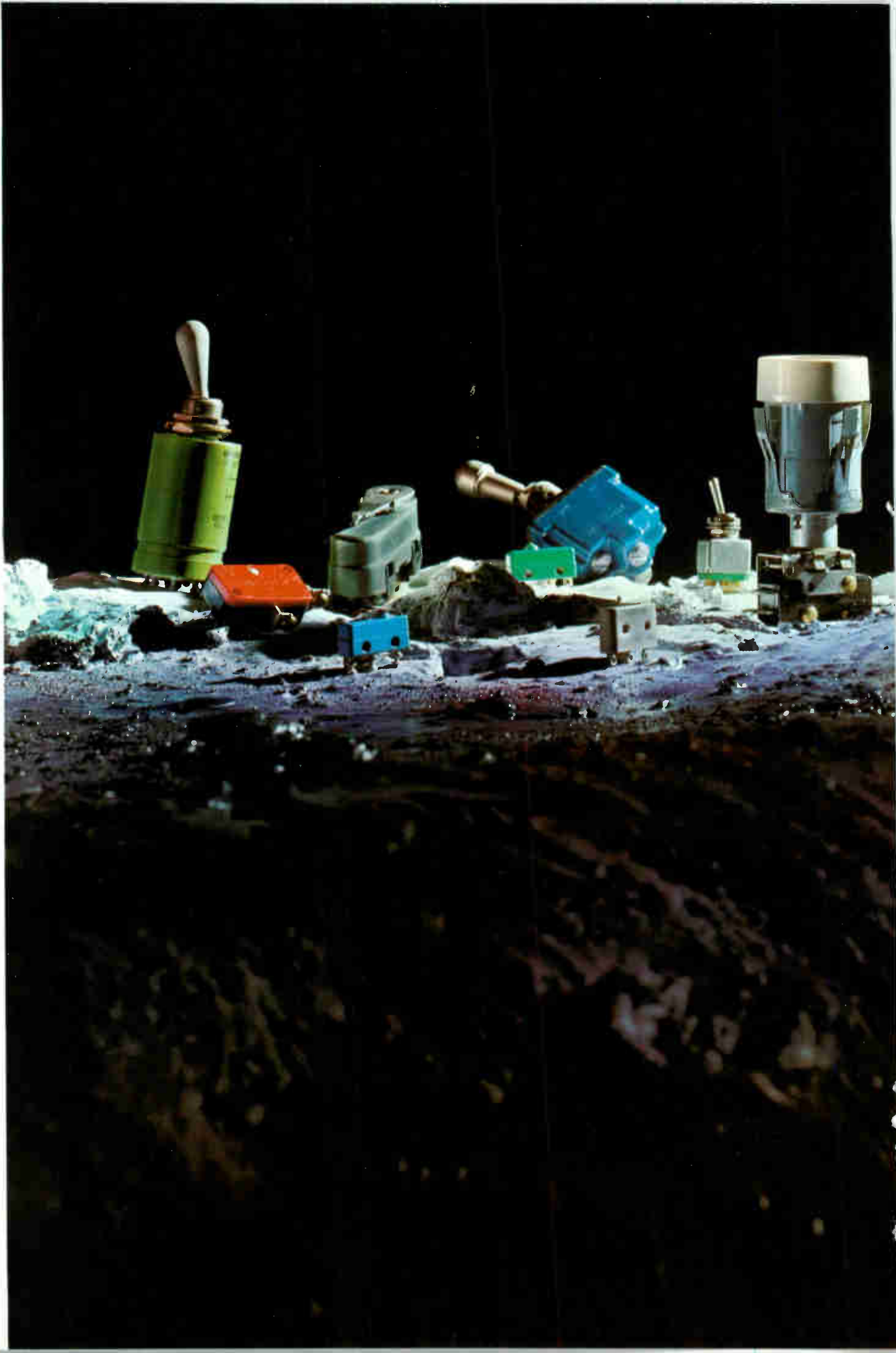

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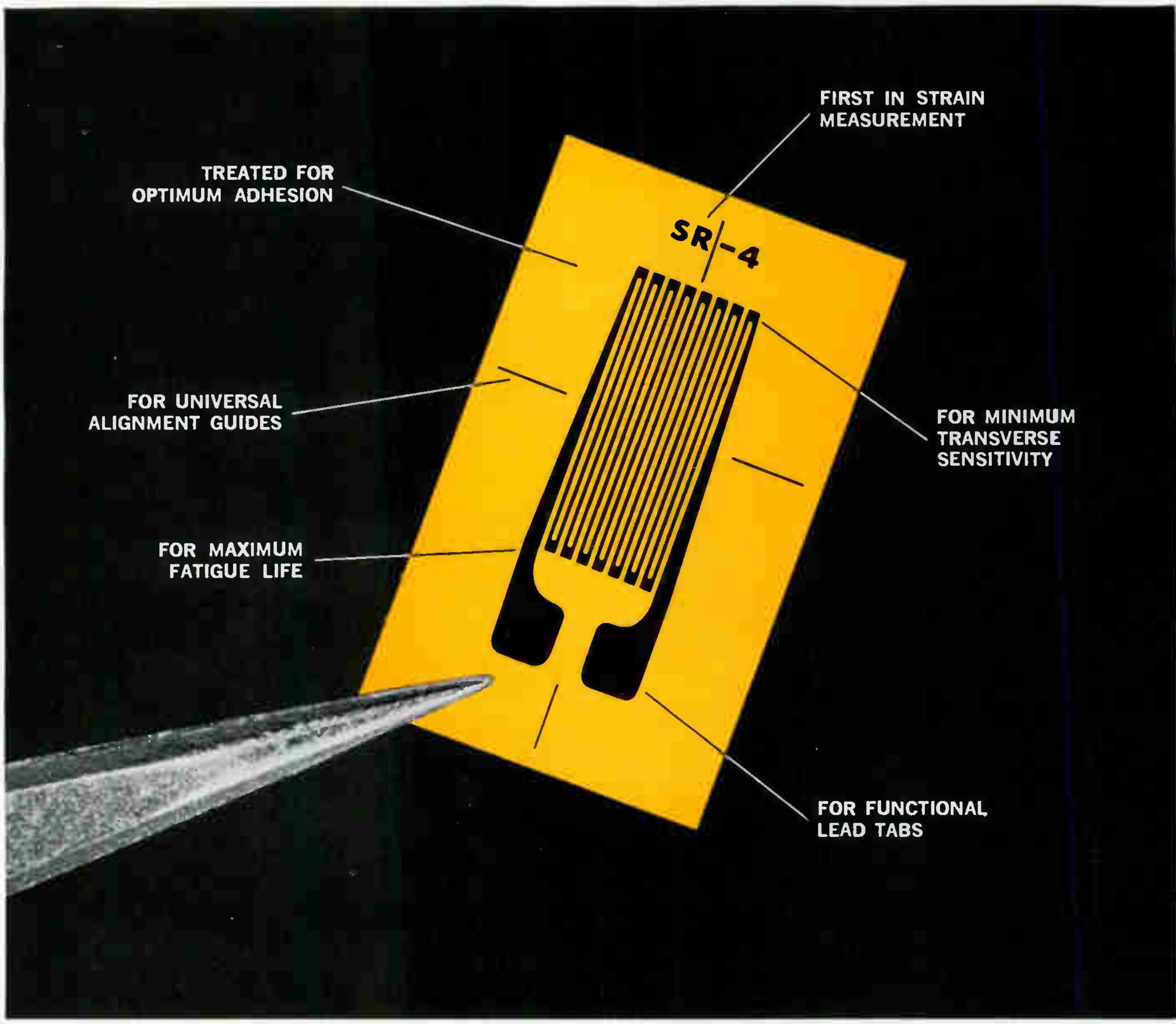

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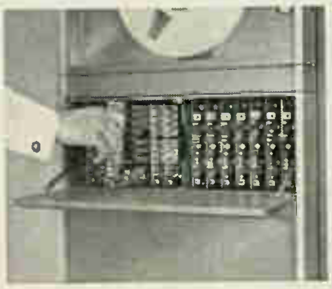

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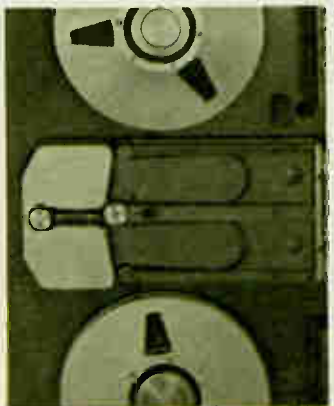
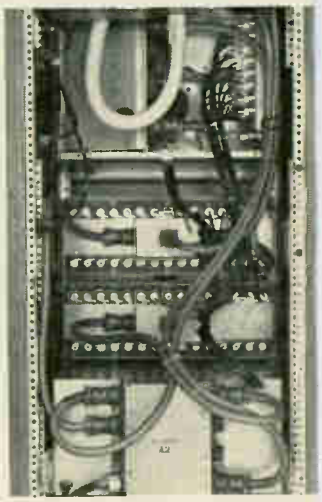


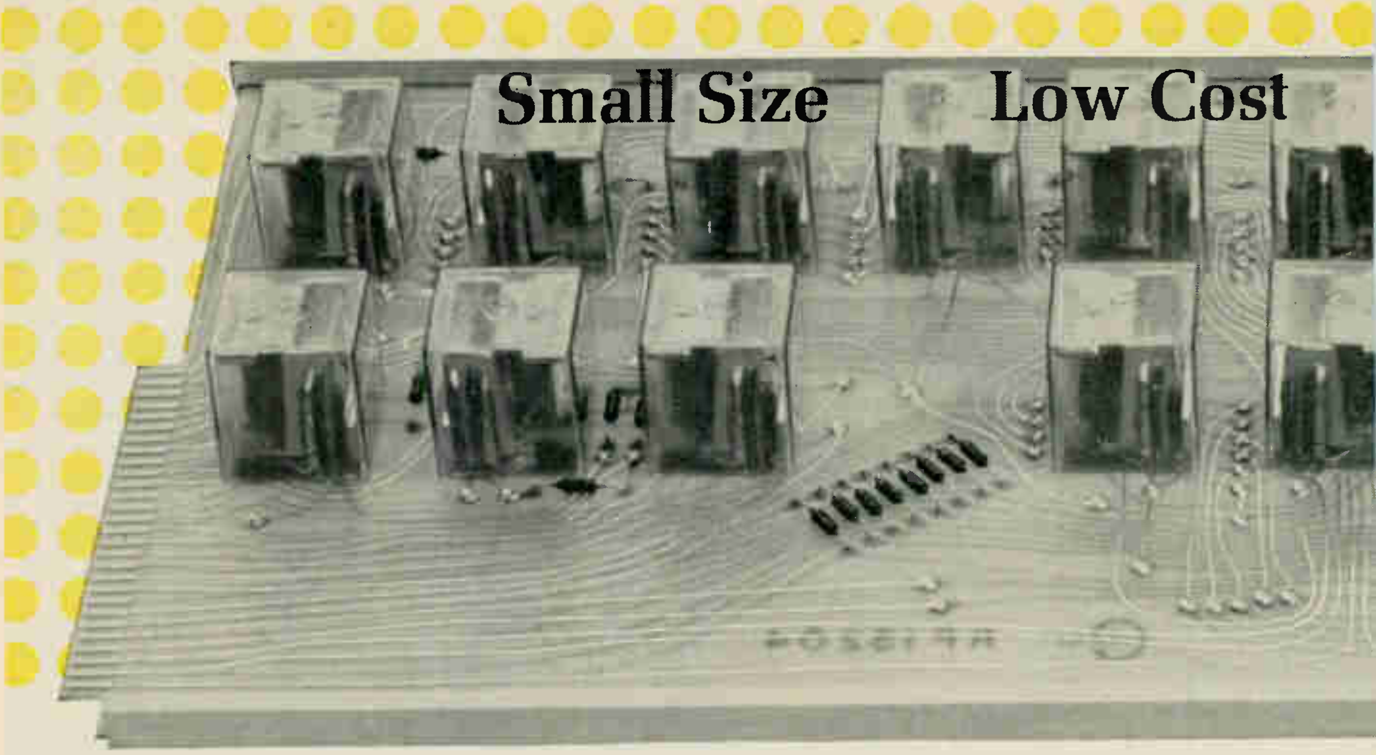
Advanced transport system features balanced tension direct drive. It eliminates belts, pulleys, gears, and pinchrollers and only the tape heads make contact with the oxide side of the tape.



Elimination of fixed rack harnesse means components are completely in dependent for optimum flexibility.

HONEYWELL IS WORLDWIDE • Sales and service offices in all principal cities of the world. Manufacturing in Brazil, Canada, France, Germany, Japan, Mexico, Netherlands, United Kingdom, United State

Circle 49 on reader service card



More Switching Capacity at Lower Cost...
for Millions of Operations

CLARE LB/LBP RELAYS

Check these CLARE LB/LBP features against your requirements:

- 6 Form C Contacts (Forms A, B and D also available)
- Small Size: 1.33 cubic inches
- Contact Rating: 2 amperes to low level
- Twin contacts for reliability
- Direct PCB, or plug-in mounting
- Long life operation

The new Type LB and LBP Relays are million-operation telephone type relays, offering extremely high quality performance at the lowest possible cost. They are ideal components for a variety of military, industrial and commercial applications, where limited space makes small size especially desirable. They provide wide application capability with a 6 form C contact arrangement. Contact forms A, B, and D are available if required. Twin contact construction provides two independent contact surfaces that assure greater contact reliability and performance. Must operate sensitivity for 6 form C is approximately 350 mw. Clear plastic cover with each LB and LBP relay; phenolic bottom plate also supplied with each LB relay.

Typical contact life ratings are: at 1.0 ampere, 28 vdc resistive, 10,000,000 operations; at 10 micro amperes, 10 millivolts, 250,000 operations with maximum contact resistance of 100 ohms.

Long Life Contact Versatility

Plug into wired chassis or printed circuit board

Type LBP Relay sockets offer choice of two terminal styles; elongated-hole solder type terminals for wired assemblies (shown in photo) or tab terminals (insert) for PCB mounting. Maximum height for plug-in wired assembly mounting, 1½ inches; for PCB mounting, 1¾ inches. Relay shown actual size.

Tab terminals for PCB mounting

Mount directly on printed circuit

Type LB Relay has tinned nickel silver terminals for direct PCB mounting. Volume: 1.33 cubic inches. Maximum mounted height, 1.24 inches. Relay shown actual size.

CONTACTS: Forms A, B, C or D. Up to 6 forms per relay

CONTACT LIFE: Mech.: 100,000,000 operations

Resistive Power Load (at 25°C):

Current (amperes)	Voltage	Life (operations)	Contact Form
1.0	28 vdc	10,000,000	C
2.0	28 vdc	100,000	C
.25	115 vac, 60 cps	50,000,000	C

Low Level Load (at 25°C):

Current	Voltage	Life (operations)	Contact Form
10 μa (closed circuit)	10 mv (open circuit)	250,000	C

(maximum contact resistance—100 ohms)

COILS

	Nominal Operating voltage	Resistance ± 10% @ 25) C
Single wound coils	5 to 100 vdc nominal	20 to 6550 ohms
Double wound coils (each coil)	4 to 75 vdc nominal	10/10 to 3275/3275 ohms

DIELECTRIC STRENGTH
500 vac rms, 60 cps
1000 vac as special

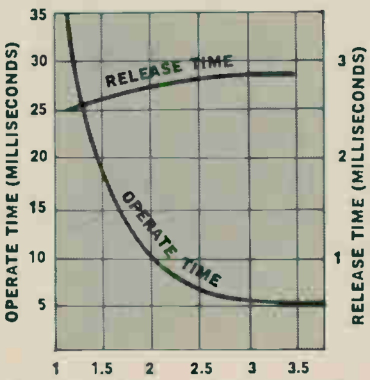
INSULATION RESISTANCE
500 K Megohms min.

SHOCK
OPERATING: 15g's 11 ms ½ sine wave, 10 usec max. contact chatter

VIBRATION
OPERATING: 10g's 5-2000 cps, 10 us max. contact chatter

SENSITIVITY: Approximately 350 milliwatts—6 Form C or 4C2D contacts.

TYPICAL OPERATE, RELEASE AND BOUNCE TIME



Contact Bounce
Normally open at operate 1.0 ms
Normally closed at release 3.0 ms

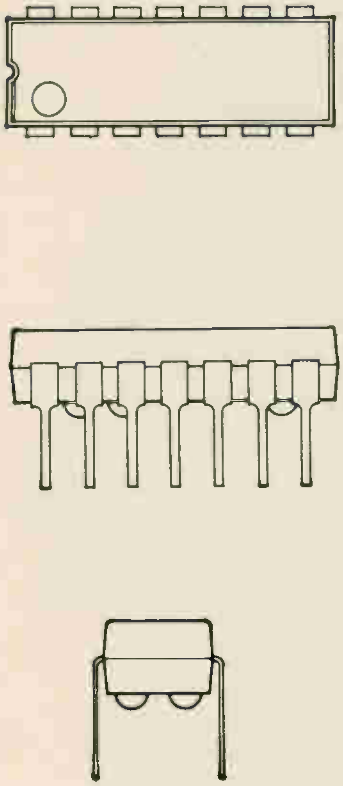
Notes
1. All values are typical
2. Switched battery voltage source
3. Coils not arc suppressed
4. Contact bounce not included in operate and release times.

NOTE—These specifications are condensed. For complete technical data see Data Sheet 552.

Address:
Group 09N5
C. P. CLARE & CO.
3101 Pratt Boulevard
Chicago, Illinois
60645

CLARE
relays and related control components

Circle 51 on reader service card



Now-
Motorola
830-Series
MDTL
Integrated Circuits
in PLASTIC!

ACTUAL SIZE

Here's the popular 830-series DTL integrated circuit complement in plastic packages at prices *from 30 to 60% lower than what you have been paying for metal!*

Offering the same wide range of circuit functions as previous metal and flat-packaged types, Motorola's new MC830P series, for operation from 0 to +75°C, provides an unusual opportunity for reducing production costs.

For example, the Motorola-designed Unibloc* plastic package, with dual in-line pin arrangement, offers great advantage for use in production assembly with automatic insertion equipment.

("Unibloc" is Motorola's trade name for its solid, single-piece pressure-molded package that offers unusual physical strength for internal leads and connections, plus improved heat transfer characteristics.)

Here are the new MDTL* circuit prices:

Circuit Function	Price† (100-999)
MC830P Dual 4-Input Gate	$2.70
MC831P Clocked Flip-Flop	3.25
MC832P Dual Buffer	3.00
MC833P Dual Expander	2.40
MC844P Dual Power Gate	3.00
MC845P Clocked Flip-Flop	3.25
MC846P Quad 2-Input Gate	3.25
MC848P Clocked Flip-Flop	3.25
MC862P Triple 3-Input Gate	3.00

†See your Motorola representative for even more substantial savings in larger quantities.

For complete details write to: Motorola Semiconductor Products Inc., Dept. TIC, Box 955, Phoenix, Arizona 85001.

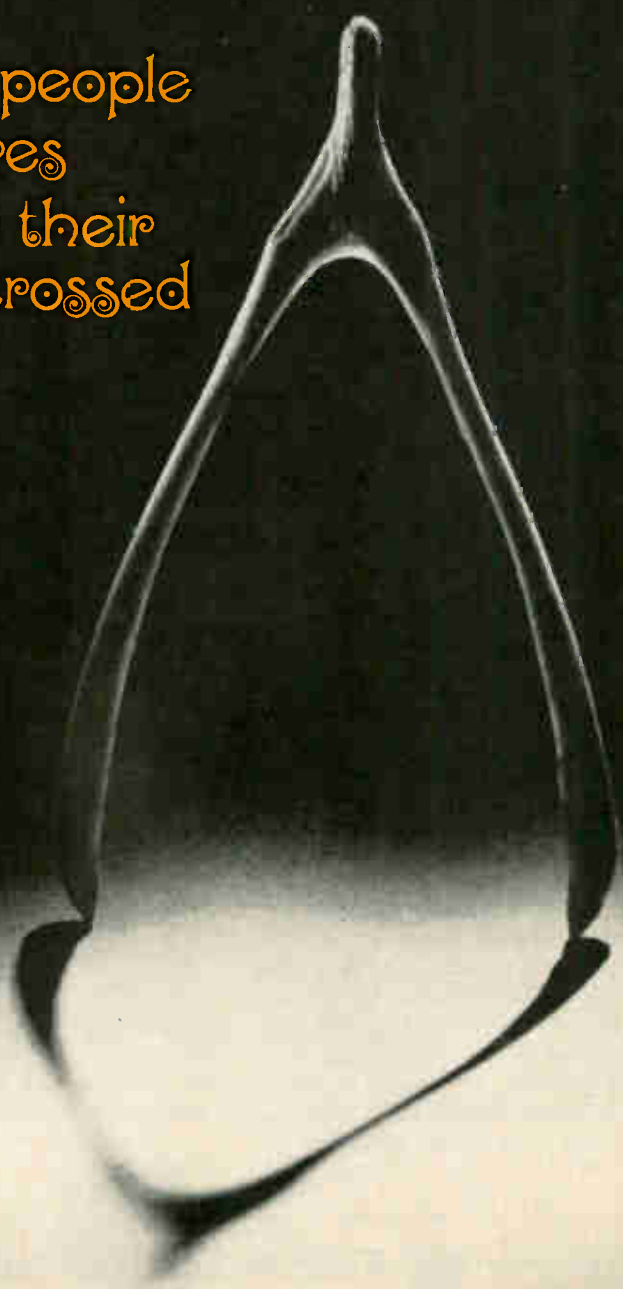
*Trademark of Motorola Inc.

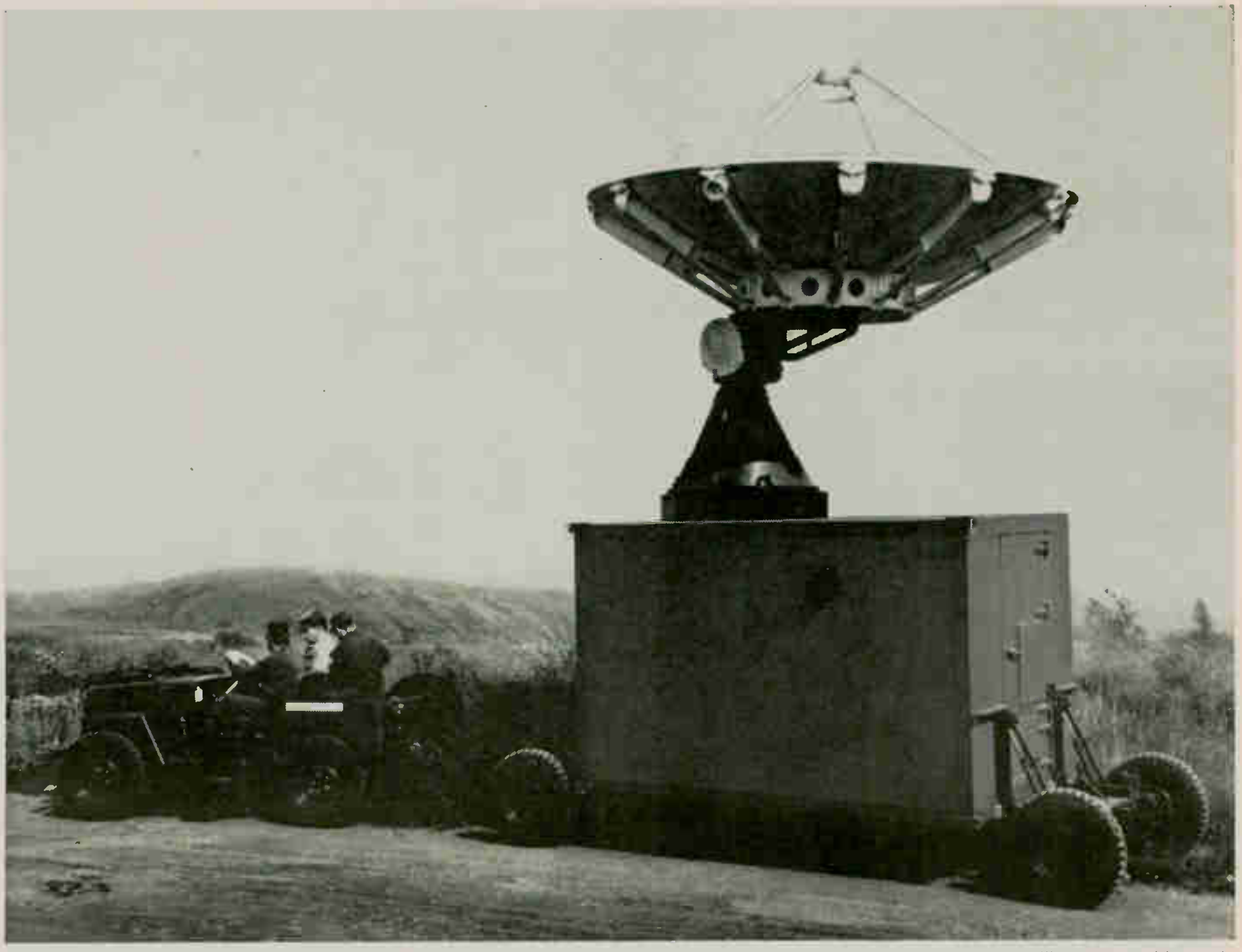
MOTOROLA Semiconductors

—where the priceless ingredient is care!

 Circle 52 on reader service card

Circle 53 on reader service card→





Sylvania's satellite communication terminal is one of the most mobile ground stations ever built. Weighing only two tons, it is readily transported by truck or helicopter. Three men can set it up in less than an hour When used with Syncom III, this terminal provides one duplex voice channel and 16 simultaneous teletype channels.

CUSTOM DESIGNED FOR MOBILITY
The power amplifier for the transmitter in the new Sylvania Comsat Ground Station is the air-cooled VA-881 — a specially designed 6.5 kW Varian klystron. Since the VA-881 operates without a liquid-to-air heat exchanger, it is lightweight and avoids the maintenance problems of leakage, plugged lines, and spillage.

VARIAN AIR-COOLED KLYSTRON POWERS SYLVANIA'S NEW COMSAT TERMINAL

Working hand-in-hand with America's leading satellite ground terminal designers, Varian has developed another new family of CW klystrons. These tubes have now advanced the state-of-the-art to: tuning ranges approaching 10%; bandwidths approaching 1%.

When you need a state-of-the-art klystron, call on Varian. Our scientists and engineers have the most thorough knowledge, capability, and technology in the entire microwave tube industry. Why not put this skill to work for you?

Palo Alto Tube Division, 611 Hansen Way, Palo Alto, California 94303. In Europe: Varian A. G., Zug, Switzerland. In Canada: Varian Associates of Canada, Ltd., Georgetown, Ontario.

varian

Circle 55 on reader service card

WHO SAYS YOU CAN'T AFFORD  PTICAL ENCODERS?

If you've suffered the friction, noise and wearout problems of brush encoders because optical encoders were out of your price range, suffer no more! Wayne-George announces a breakthrough in the price of optical encoders applicable to the low and intermediate resolution ranges. These new Wayne-George encoders offer resolution and accuracy to 10 binary digits per input shaft revolution in Natural Binary Code format or to 3 decimal digits per revolution in BCD Code format. The encoders feature self-contained, solid state electronics within a case diameter of 2.5 inches (smaller sizes coming soon). Operating life and MTBF exceed 30,000 hours. Prices? . . . You are in for a surprise ! . . Call or Write:

WAYNE-GEORGE CORPORATION

CHRISTINA STREET, NEWTON, MASSACHUSETTS 02161 TEL. (617) 969-7300

TWX 617-332-7637

Circle 57 on reader service card→

Our ferrite division can make that many toroids in a month. In sizes as small as 80 mils, with high temperature stability, inductance values within ± 5%, and in a wide range of ferrite materials to meet practically any pulsing speed. For example: for microsecond switching we can offer our Ferramic® 0-5, 0-6, and T-1 ferrites and for nanosecond switching there's our Ferramic H and Q-1 materials.

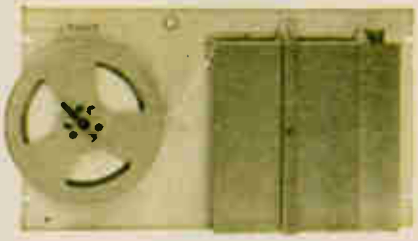
This materials capability plus our production capacity have made us the world's largest supplier of ferrite toroids for pulse transformers. But toroids are only a part of our business. In total we have eleven standard ferrite materials right now and will soon introduce a twelfth one. A brand new flat temperature-coefficient ferrite that will make circuit design news. We are equally big in other ferrites for digital applications such as square-loop (memory core) ferrites, recording head ferrites, and multiaperture devices.

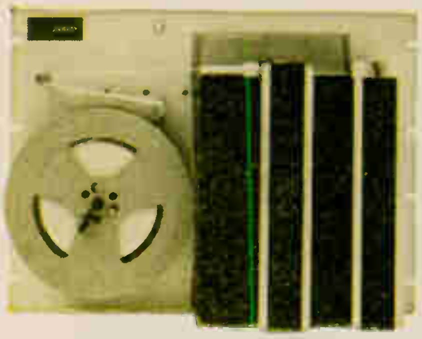
So whether you want 2 samples, an order of 10 million, or catalogs and technical literature, you can get immediate action by writing Mr. Ken Talbot, Manager of Sales, Indiana General Corporation, Electronics Division/Ferrites, Keasbey, New Jersey.

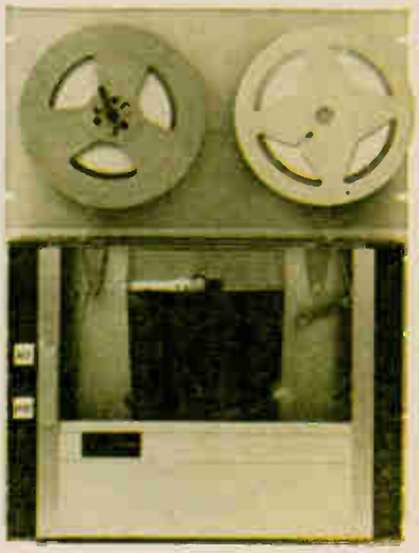
INDIANA GENERAL

Ten million pulse transformer cores is peanuts to Indiana General.

Our group.







A family of three perforators is just right when it satisfies about 99 percent of the applications. And these Tally perforators do.

Easily the best known perforator on the market today is the wonderfully reliable Tally 420 which operates at 60 characters per second. Some of our customers have operated this perforator up to 500 million cycles without overhaul.

Fastest perforator in the family is the Tally P-150, which, as you might guess, operates at 150 characters per second. Rounding out the line is our popular 120 character per second perforator, the P-120.

The Tally P-120 and P-150 offer a remarkable degree of sophistication. With the parity option they catch their own mistakes while working at maximum speed. Here's how it works. Parity contacts in the perforating mechanism allow interrogation during a punching cycle and before the tape is advanced to the next character. If an incorrect parity code is sensed, (1) tape advance is inhibited, (2) the code in error is overpunched with an all-hole delete code, (3) tape is advanced and the same character punched again. Clean accurate tapes are a virtual certainty.

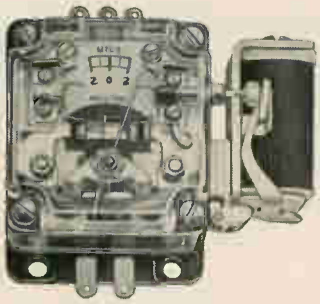
All Tally perforators accept paper, plastic, or foil tapes. They feature asynchronous operation so that punch commands can be accepted at any time interval up to maximum speed. Tally perforators handle 5 through 8 channels on any standard tape up to 1 inch without modification. Tally perforators have high quality die blocks and precision honed punch pins individually fitted for long life punching. All models offer integral reeling. All Tally perforators are available in 50/60 Hz, 115/230 vac models.

Options include bit echo verification, remote backup, end of tape, low tape, tape motion sensors, and teletypesetter configuration.

Write for more wisdom. Complete data on each and every member of the Tally group of perforated tape equipment is yours for the asking. For your information please address K. Crawford, Tally Corporation, 1310 Mercer Street, Seattle, Washington 98109. Phone: (206) MA 4-0760. TWX: (910) 444-2039. In the U.K. and Europe, address H. Ulijohn, Tally Europe, Ltd., Radnor House, 1272 London Road, London, S.W. 16, England. Phone POLlards 9199.

TALLY®

familiar faces from the world's broadest line of indicating relays

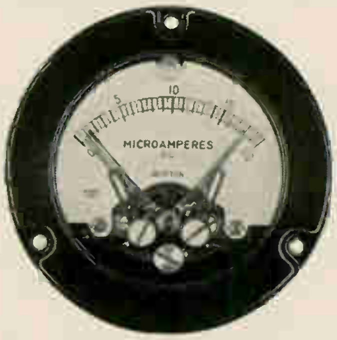


Model 813 Miniature—compact and lightweight; sensitive and Sensitrol (magnetic) contacts; single or double contact; ranges as low as 2-0-2 μa.

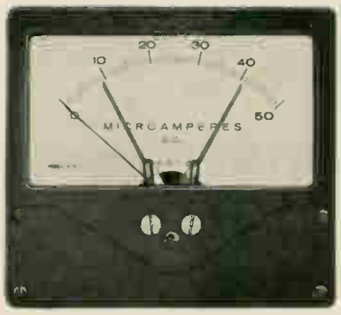
Model 1092 Sensitrol—low cost; all purpose; magnetically shielded; wide range adjustability; ideal for use in engineering breadboard circuits.

Model 705 Sensitrol—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—sealed; shielded; internal reset; solder terminals; single or double magnetic contact; ranges as low as 1-0-1 μa.

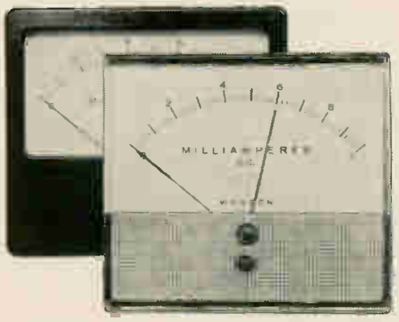


***Model 1097 Ruggedized 3½" Relay** —Load Current Contact Aiding type fully meets applicable portions of military ruggedized spec; sealed; long scale; shielded; solder terminals; single or double adjustable contacts.*



Model 1075 Photronic—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 1073 Mag Track—long scale; shielded; positive contact; combines Load Current Contact Aiding with magnetic attraction; self-contained reset; single or double adjustable contacts, ranges from 10 μa.

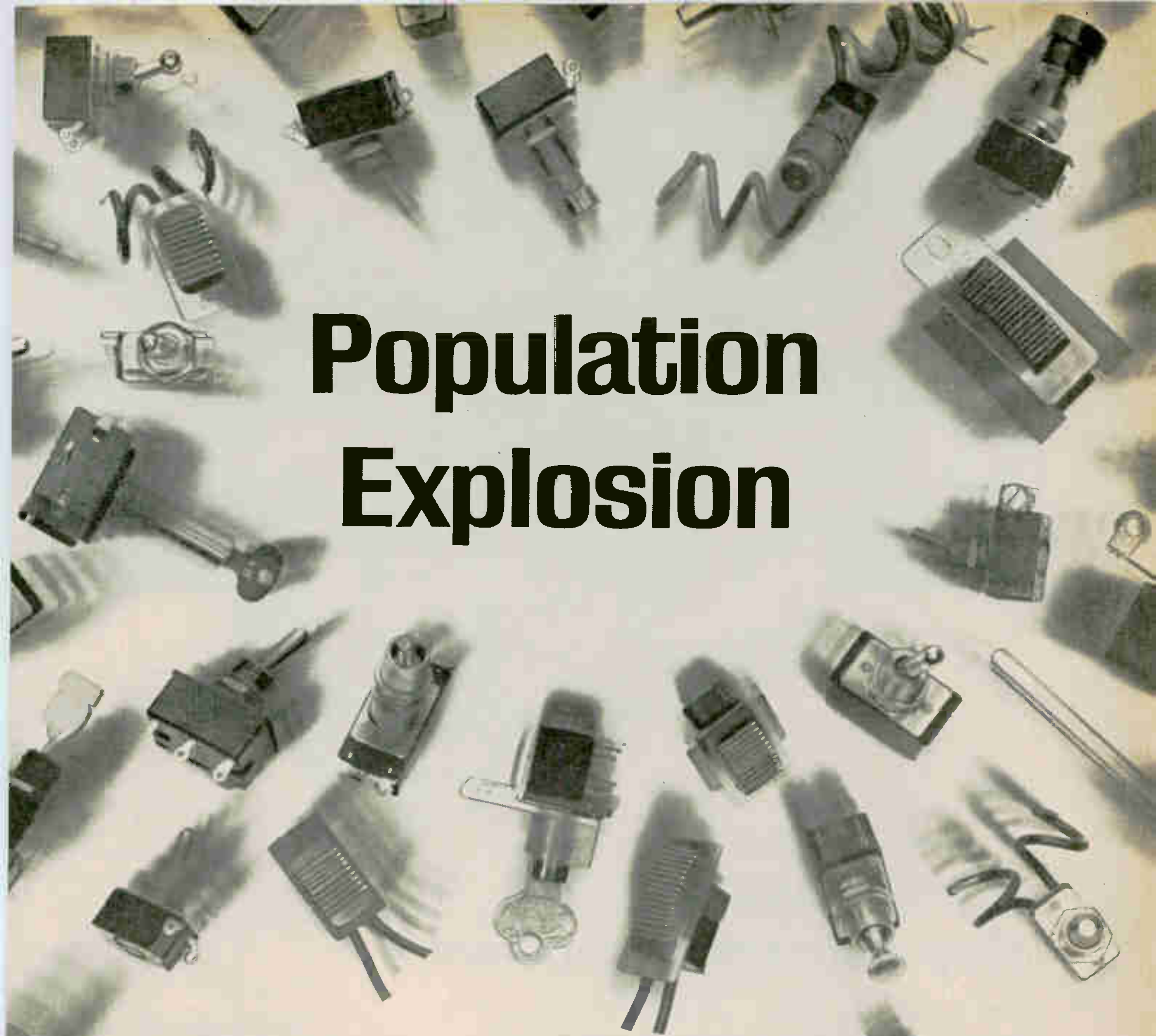


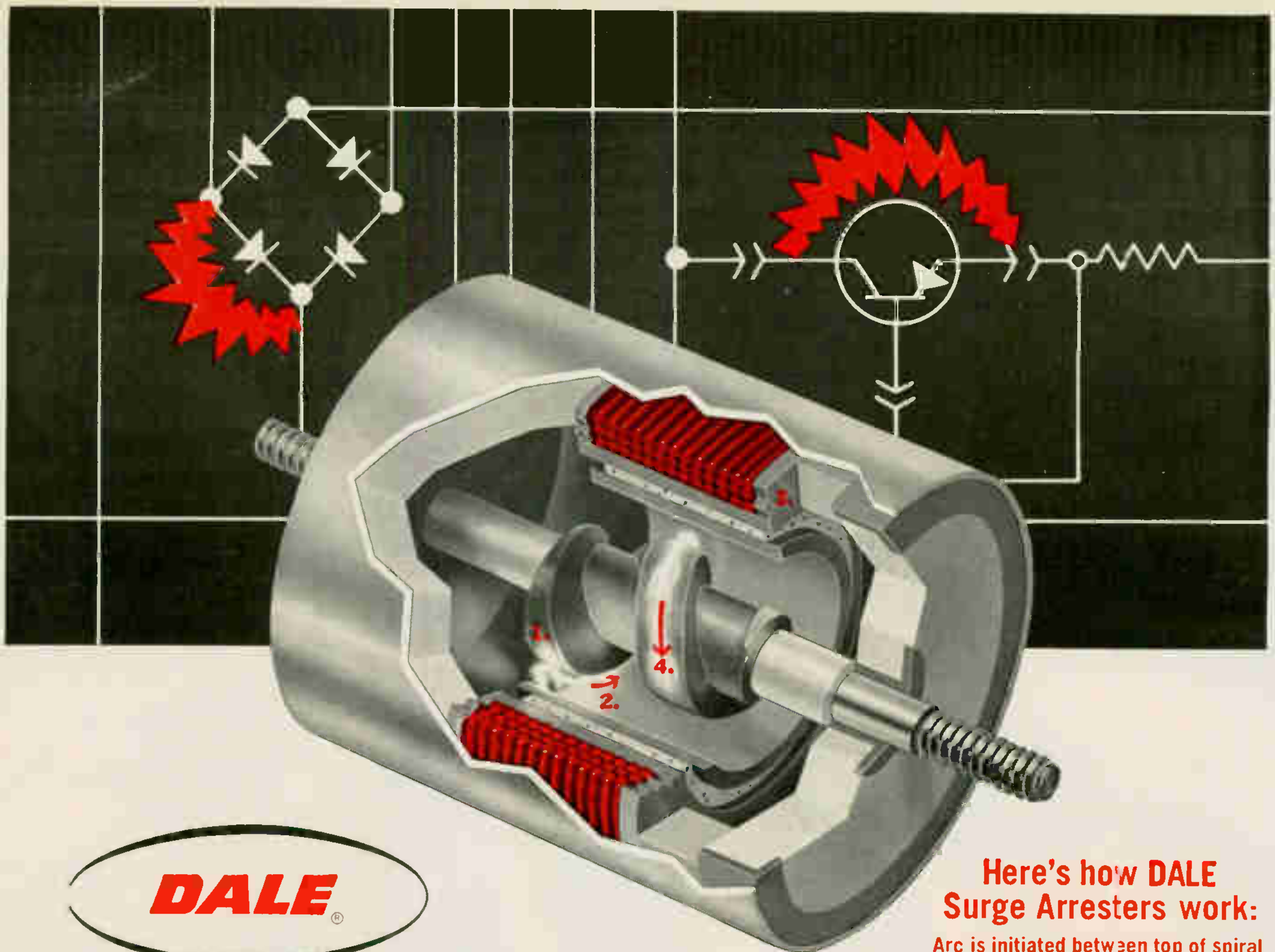
Model 1930/1940 Photronic—3½" and 4½" in either bakelite or plastic front; low cost; add-on power supply and solid state switching circuit; shielded; non-physical, adjustable contact.

Weston Instruments, Inc. • Newark Division • Newark, N.J. 07114

WESTON® *prime source for precision . . . since 1888*

Circle 61 on reader service card→





DALE®

SURGE ARRESTERS stop damaging transients!

Here's how DALE Surge Arresters work:

Arc is initiated between top of spiral electrode (1) and cylindrical electrode (2); Coil (3) is energized. Magnetic field produced by the coil causes spark to rotate down tapered spiral electrode, lengthening it to breaking point (4) before excess current is drawn.

Dale Surge Arresters deliver complete 2-way protection against transient over-voltages from any source.

1. Patented* design bypasses repeated surge voltages without damage to arrester or equipment attached. Pre-ionized atmosphere can be used to establish constant breakdown voltage level.

2. Surge-created arc is extinguished rapidly once normal voltages have been reached. This helps eliminate costly circuit interruptions caused when ordinary spark gaps draw excessive current which blows fuses and opens circuit breakers.

Check the areas where your circuits can utilize this complete transient voltage protection. Dale maintains complete transient voltage laboratory facilities to assist you with application engineering.

Covered by U.S. Patent No. 2,916,667

TWO TYPES AVAILABLE

LA8 Dustproof case. Will bypass 10 current surges rising to 15,000 amps peak in 5 microseconds and containing total charge of 21 coulombs with no damage to arrester or equipment attached and less than 20% change in original DC breakdown voltage. Spark gap arc-over voltage factory adjustable from 1500 to 4000 VDC ± 20%.

LA9 Hermetically sealed with soft solder. Will bypass approximately 100 current surges of 300 amps peak with 2 x 4 millisecond wave shape with no damage to arrester and equipment attached and less than 20% change in original DC breakdown voltage. Factory adjustable from 500 to 5000 VDC ± 20%. (10% tolerance available). Bypass capability derates below 1500 volts.

Both LA8 and LA9 have insulation resistance in excess of 1000 megohms and will not drop below 10 megohms during or after rated number of current surges.

For complete information write for new catalog on Surge and Aircraft Lightning Arresters or call DALE: 605-665-7887

DALE®

DALE ELECTRONICS, INC.
SIOUX DIVISION
100 Douglas Avenue, Yankton, South Dakota

SEE OUR SPECIFICATIONS IN VSMF THE MICROFILM CATALOG FILE

Washington Newsletter

September 5, 1966

Ship electronics: new emphasis on reliability

A combination of microelectronics, adaptive switching techniques and redundancy promises more reliability for the electronic equipment used on military ships. The Navy expects to put 85% of shipboard communications gear and 15% of radar equipment in the same category as other vessel subsystems, which have a mean-time-between-failure rate of two years. Planners are hinting at a big purchase of the new equipment within a couple of years for ships; designers of aircraft and tactical ground electronics also are showing interest.

The forecasts are based on work done for the Office of Naval Research by Motorola, Inc., and the Westinghouse Electric Corp., under contracts totaling over $600,000. Max Yoder, project manager of the study, said the Navy put the companies' transceivers through 7,000 hours of tests before the study was concluded and is extrapolating from these results a mean-time-between-failure rate for other equipment of 18,000 hours.

Congress cuts funds for Navy F-111B

The budget for the Navy's controversial F-111B interceptor took a drubbing in the final version of the 1967 defense appropriation bill that has cleared a joint Senate-House conference committee. Work on the Navy version of the all-purpose aircraft was reduced to the research-and-development level plus only $7.8 million for advance parts procurement.

But the bill, which now goes to a vote in both houses, where adoption is probable, preserves electronics R&D on the Navy plane.

Work on the Phoenix missile's fire-control system was given a specific go-ahead. The Hughes Aircraft Co. is prime contractor on the Phoenix; the Control Data Corp. and Univac division of the Sperry Rand Corp. are principal subcontractors.

Last month the House, in its original version of the bill, authorized the Navy to spend $159 million on its F-111B. The Navy had planned to put about $88 million of this into R&D and $71 million into advance parts procurement for an eventual prototype.

But when the bill got to the Senate, Sen. John L. McClellan (D., Ark.) tacked on amendments permitting R&D but prohibiting parts procurement and preventing the Pentagon from spending any of its nearly $400 million "discretionary funds" for procurement. The conference accepted all but $7.8 million of the cutback.

Taylor expected to be named head of ARPA division

Robert Taylor is expected to take over as director of information processing for the Defense Department's Advanced Research Projects Agency (ARPA). The information processing section is the focal point of the Pentagon's decisions on investments in new directions for computer technology. Taylor has been deputy to Ivan E. Sutherland, who left the agency this month for a Harvard University appointment as associate professor of electrical engineering. Sutherland will also continue research work in computer-aided graphics and design. His sketchpad project was one of the first in the field.

It is also reported that Lawrence G. Roberts of the Massachusetts Institute of Technology's Lincoln Laboratory will move to Washington as chief scientist for Taylor.

Washington Newsletter

Can't understand metric system, so Smith votes it down

Lame duck Rep. Howard W. Smith (D., Va.) for the second time in two years has killed a proposed study of United States adoption of the metric system—essentially because, he says, he doesn't understand it. Smith, defeated in the Virginia Democratic primary this year after 35 years in Congress, is chairman of the House Rules Committee, without whose approval bills seldom get to the House floor. Smith first deferred action last Sept. 9 on a study proposed by the chairman of the House Science Committee, George W. Miller (D., Calif.). At that time, Smith said: "I don't understand it, so it can't be very important." Last week after a belated request by Miller, Smith gave it another hearing. But when Miller was unable to translate 10 yards of cheesecloth at 10 cents a yard into metric units, Smith and the Rules Committee again turned thumbs down.

Electronics industry welcomes ease in copper squeeze

Pressure of tight copper supplies is easing for electronics and other industrial users. Imports of foreign copper are rising steadily and prices are close to domestic levels. Three factors contributed to the improved situation: a drop in demand by big foreign users, a switch to aluminum and other metals by U.S. users and an increase in supply in world markets. Indications are that defense production set-asides—a quota of excess production capacity—will soon become stabilized. The quota was increased two weeks ago.

Justice Department opposes copyright charge to CATV

The Justice Department, after some delay, has taken a strong stand against legislation that would subject community antenna television systems to copyright-law payments for programs they pluck off the airwaves and distribute to clients.

For some time the Administration has felt that forcing copyright payments on CATV operators would put most of them out of business. Now the Justice Department has put this feeling into words at hearings before a Senate Judiciary subcommittee. The Johnson family has interests in both CATV and broadcast stations.

Complicating the issue is a ruling in New York by a Federal judge that CATV systems already are subject to copyright payments for programs they pick off the air. That decision is being appealed.

Project no hole

Project Mohole, the ambitious plan to drill through the ocean bed to sample the earth's mantle, was cancelled indefinitely by a combination of budget cutting, increased Congressional impatience with big, esoteric research projects and an ill-timed political contribution. The Senate last week yielded to House pressure to delete $19 million from the fiscal 1967 budget for the $120-million long-term project.

The House opposition had strengthened when it was disclosed that the principal contractor, Brown & Root, Inc., of Houston had contributed $24,000 to a Presidential political fund. The disclosure coincided approximately with President Johnson's appeal to save the project, providing House opponents of the project with leverage. The National Science Foundation, which manages the project, estimates that it has paid out or has obligated $36 million for the stable deep-sea drilling platform and elaborate control mechanisms and drilling technology.

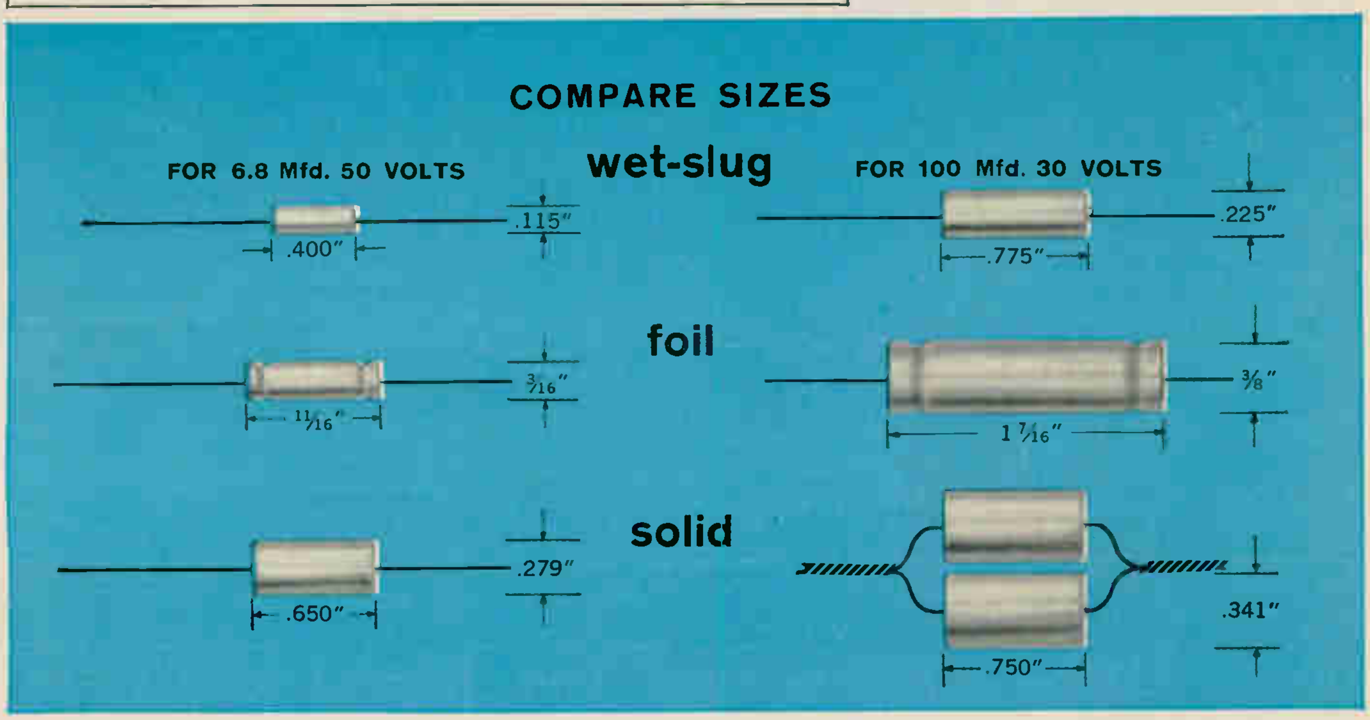
Why specify Mallory wet slug tantalum capacitors?

One reason:

☐ **lowest weight and smallest size per microfarad-volt**

Check these characteristics:

	Wet Slug Mallory MTP	Solid Mallory TAS
Mfd-volts/in³	178,000	37,200
Wt: grams/mfd-volt	0.00067	0.0024



Specify Mallory wet slug tantalum capacitors wherever you need lowest DC leakage, and proven freedom from catastrophic failure. Note: they don't need voltage derating. We'll help you by recommending the best type for your application.

And we'll recommend without bias, because we make a complete line of wet slug, solid and foil types. Write or call Mallory Capacitor Company, a division of P. R. Mallory & Co. Inc., Indianapolis, Indiana 46206.

50th ANNIVERSARY

MALLORY

Circle 65 on reader service card

What's so special about <u>this</u> Thermal Writing Recorder?

PREAMPLIFIER PLUG-IN MODULES

Just about everything.

This is CEC's new DG 5510 – the most advanced, versatile and reliable direct-writing instrument yet perfected.

The basic 5510 recorder is a solid-state, eight-channel, self-contained unit with driver amplifiers and power supply capable of accepting a broad selection of high-level signals.

Specific advantages include . . .

Electrical Signal Limiting assures that the stylus motor and writing assembly cannot be damaged by transient or other high-level signals which may occur. Each analog channel is provided with electrical signal limiting built into the driver amplifiers, adjustable to 115% of full-scale deflection.

Varying ac and dc signals, having a wide dynamic range, can be precisely conditioned by the proper choice of the Type 1-500 series preamplifiers available: the 1-510 Attenuator, 1-511 Medium Gain, and 1-512 Medium-Low Gain Preamplifiers.

Solid-state driver amplifiers provide compensation and damping to the stylus motors throughout the entire operating limits to assure constant instrument accuracy.

A heated writing stylus traveling over a "knife edge" produces exceptionally sharp contrast rectilinear traces when used with CEC DataTrace® thermal-sensitive paper.

Accessibility and ease of maintenance are significant advantages of the recorder assembly. It comes with 3-position rack slides and mounts into a standard 19" rack.

Applications include the military, aerospace and industry in general.

The complete DG 5510 System consists of the following:

One Type 5-510 Basic Recorder.
One Type 1-051 Preamplifier Mounting Case.
One Type 17-050 Mobile Console Cabinet.
Eight Type 1-500 Preamplifiers, (specify type desired).

Features:

- Solid-state electronics.
- Designed for operator convenience.
- Immediate readout.
- Interchangeable plug-in preamplifiers.
- Sensitivity – 25 mv to 500 volts full scale.
- Rectilinear recording without ink.
- Frequency response – dc to 150 Hz.
- Calibrated zero suppression ±100 volts max.
- Automatically adjusted trace contrast.

BASIC RECORDER

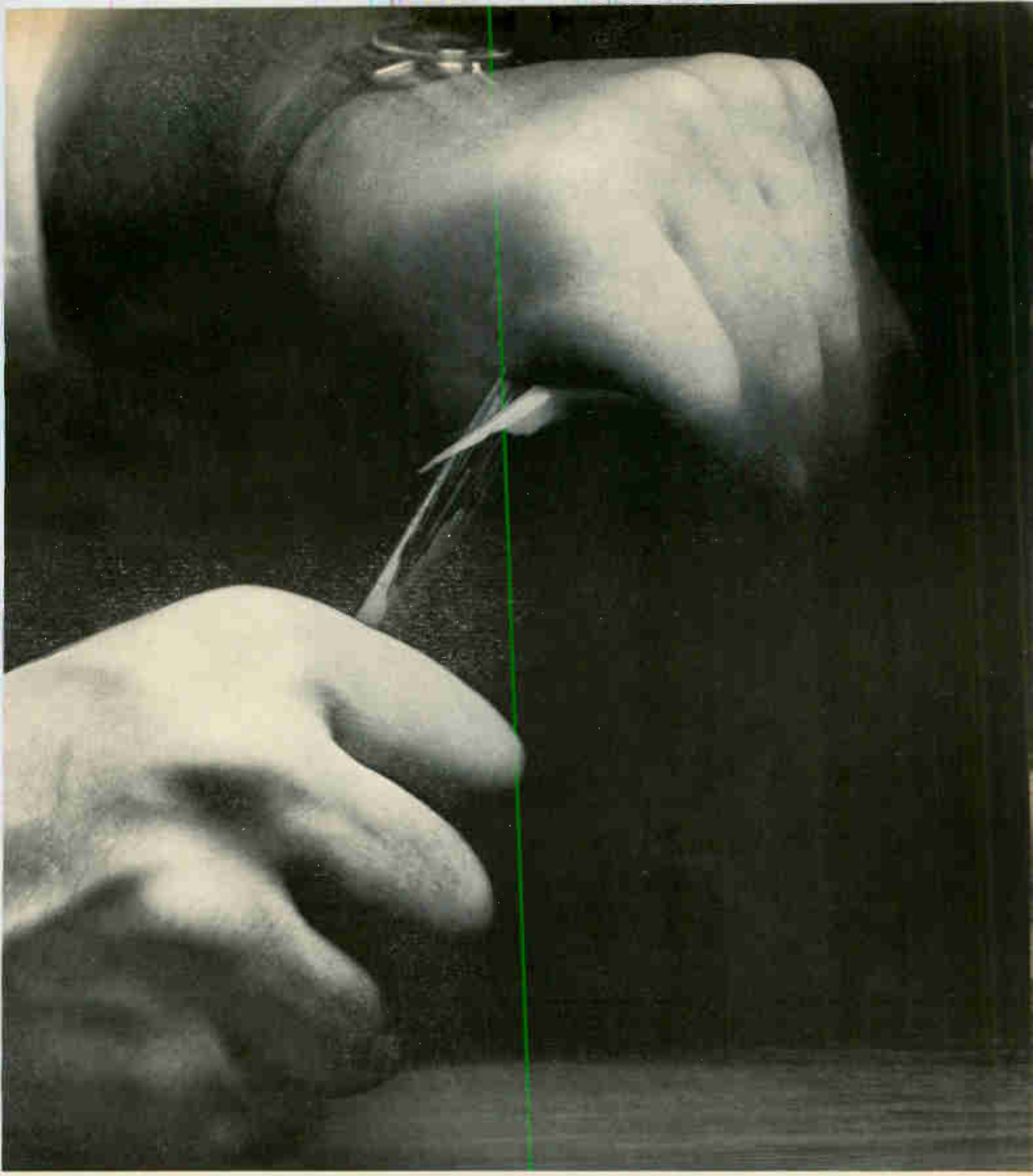
- Twelve-speed pushbutton chart drive.
- Modular design with built-in driver amplifiers and power supply.
- Timing marker and pushbutton event marker integral to basic recorder.
- Zero adjust integral to the basic recorder provides full-scale position adjustment.

Accessories:

- Remote-control panel.
- Interchannel bipolar event markers (max. of seven available).
- Driver amplifiers for bipolar event markers. (For low-level event signals.)
- Slow-speed conversion kit–provides mm/min. chart speeds in addition to standard mm/sec. chart drive.
- Polarity reversal switching. Factory option.
- Six-channel, 50 mm width per channel. Factory option.
- Paper supply and take-up, 1000-ft. roll. Factory option.
- Power supply for 50 Hz and nonstandard voltages available.

For complete information about the advanced new DG 5510 System, call or write for CEC Bulletin 5510-X13.

CEC
Data Instruments Division
CONSOLIDATED ELECTRODYNAMICS
A SUBSIDIARY OF BELL & HOWELL/PASADENA, CALIF. 91109
INTERNATIONAL SUBSIDIARIES: WOKING, SURREY, ENGLAND AND FRIEDBERG (HESSEN), W. GERMANY



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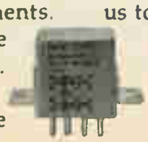

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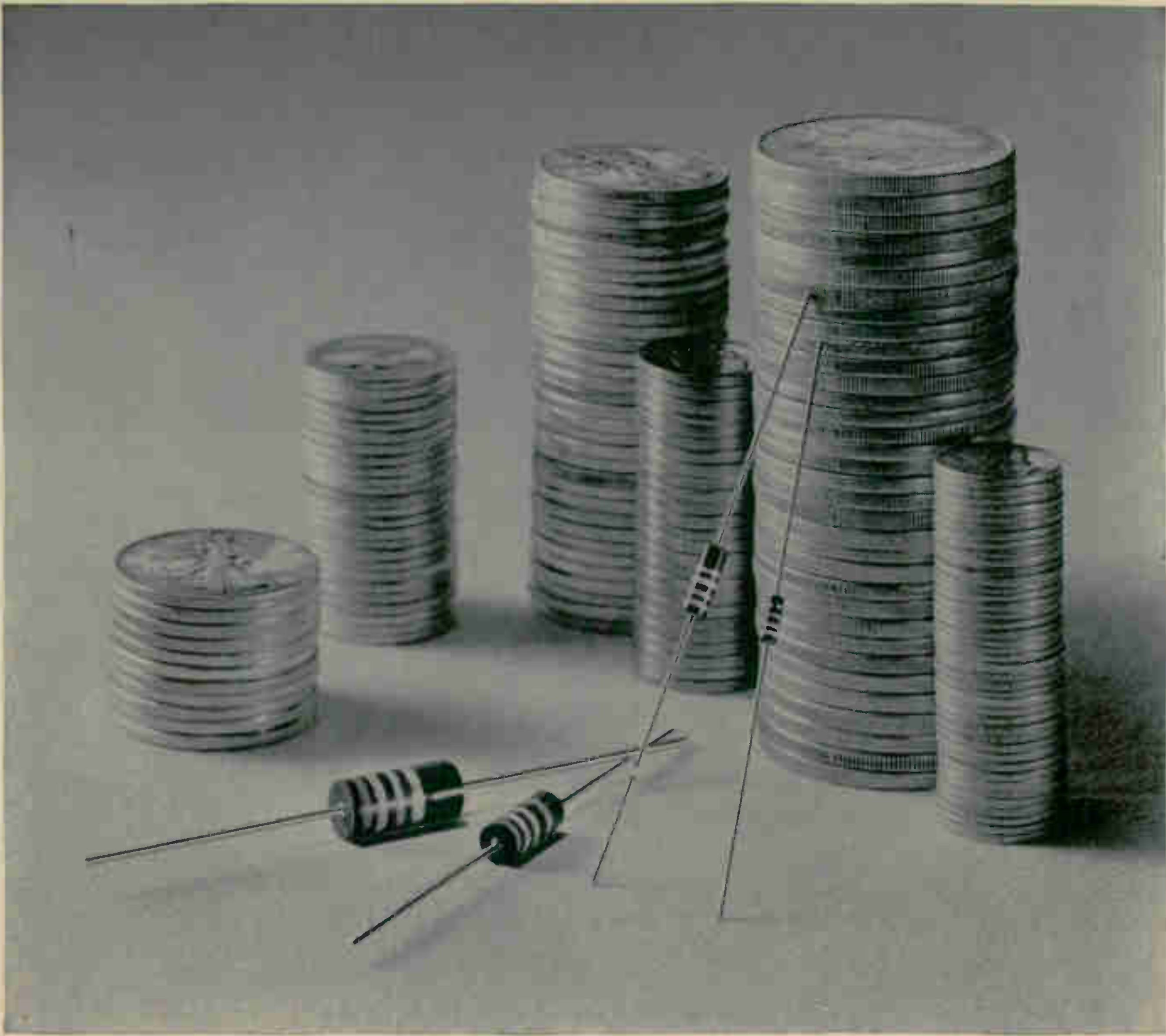

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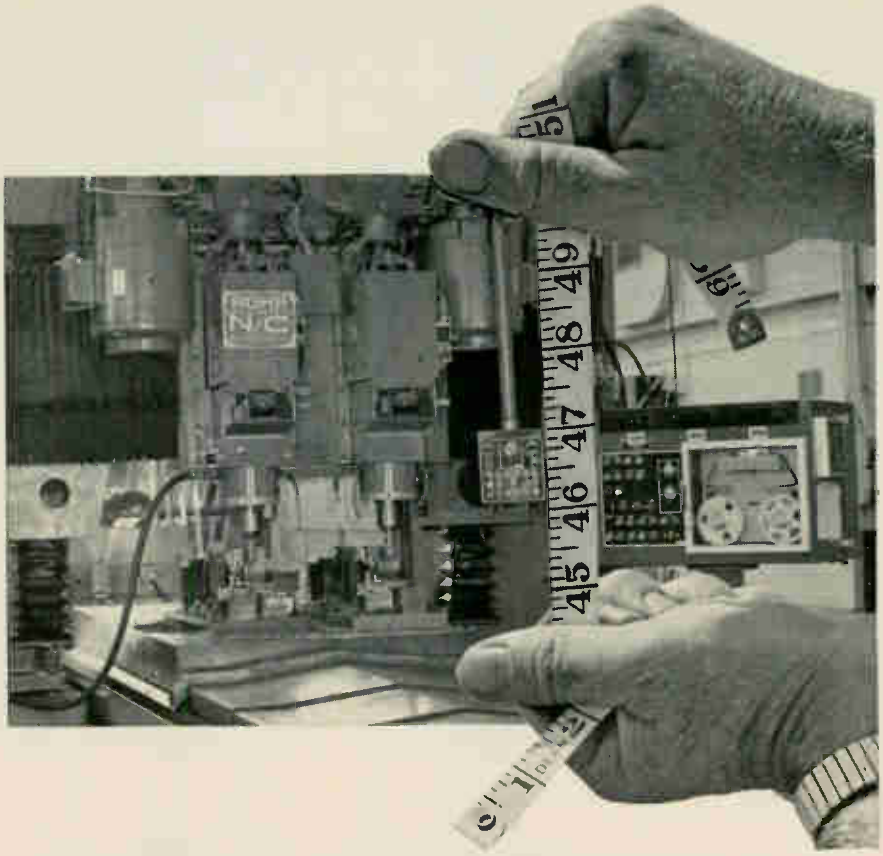

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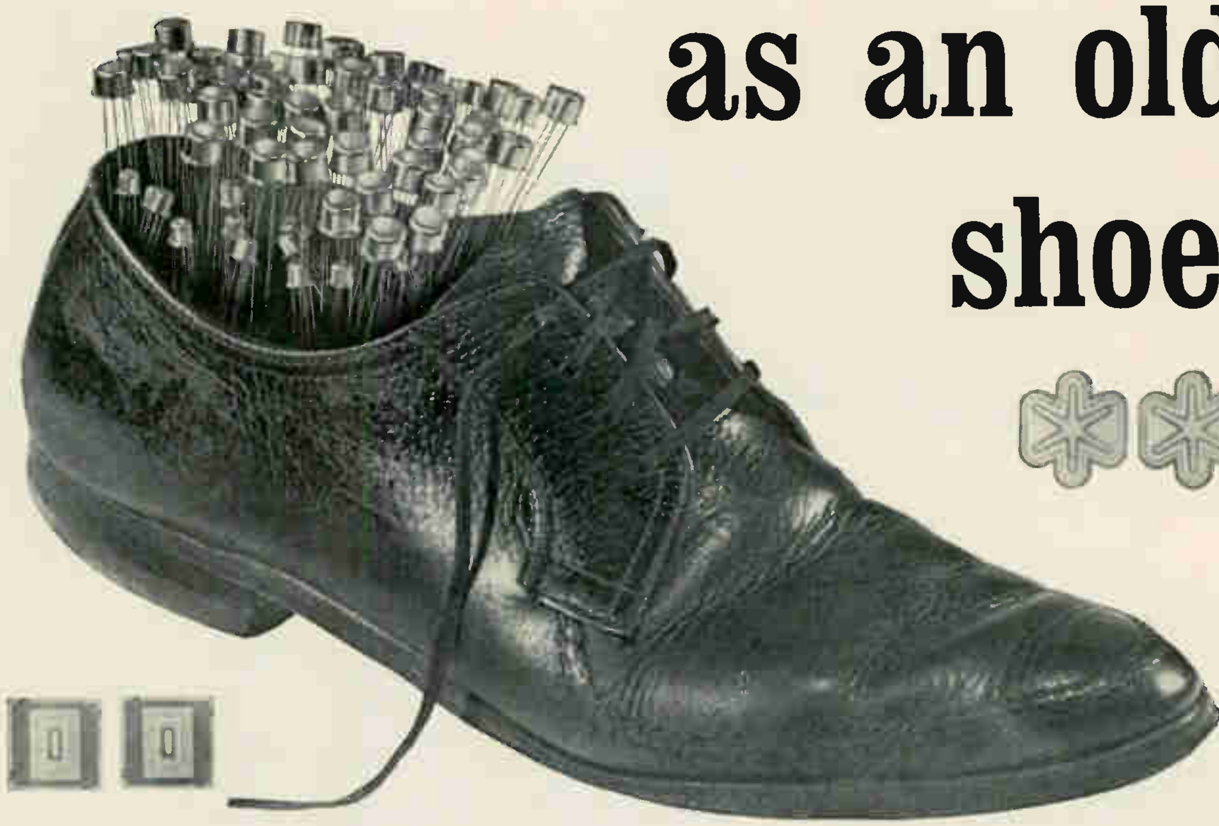

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2N3946 2N3947	2N3250-50A 2N3251-51A	Complementary high performance BOX for low level switch and amplifier applications.
2N3252 2N3253	2N3467 2N3468	Complementary high performance SNOWFLAKES for high level switching applications.
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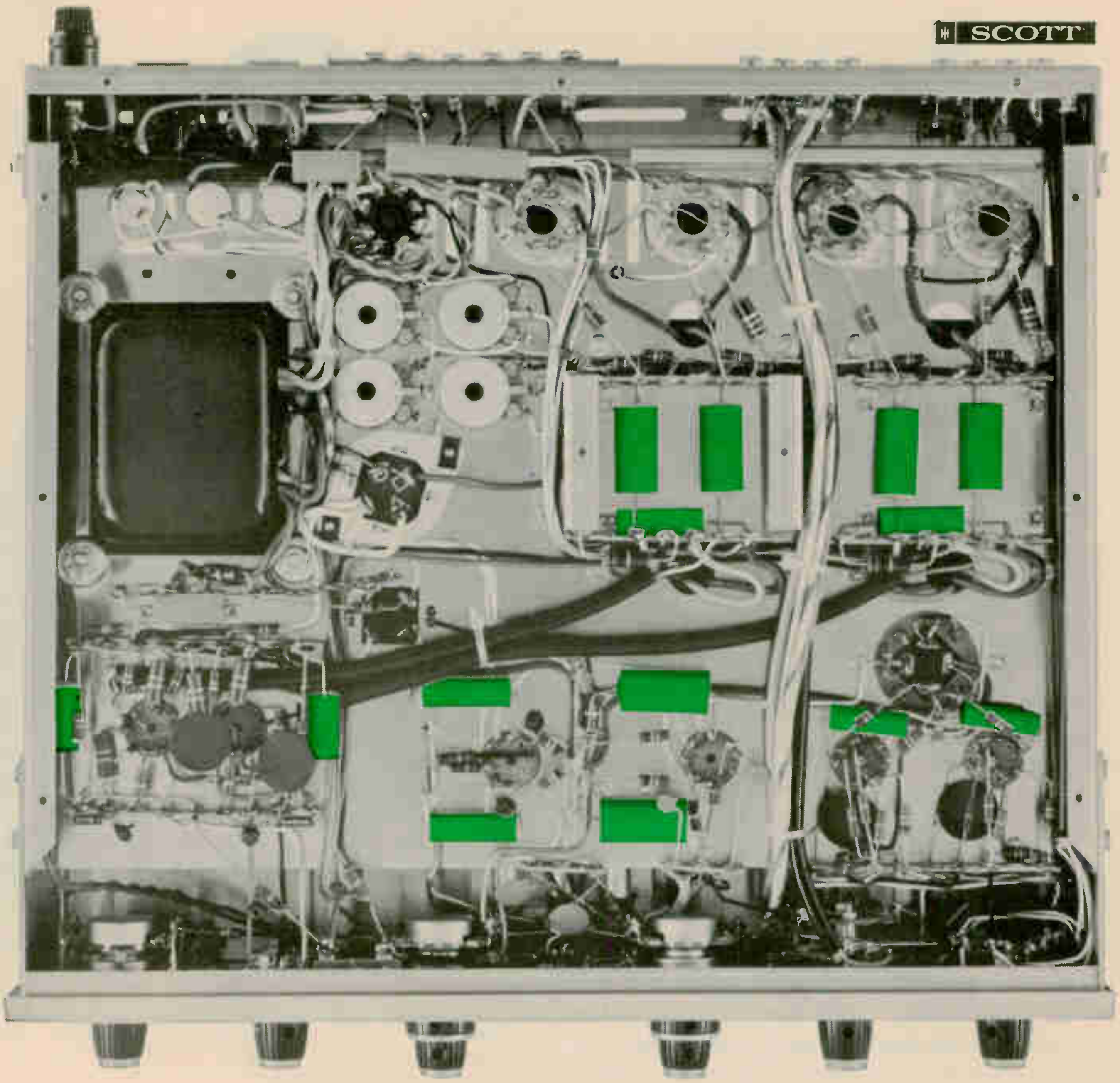

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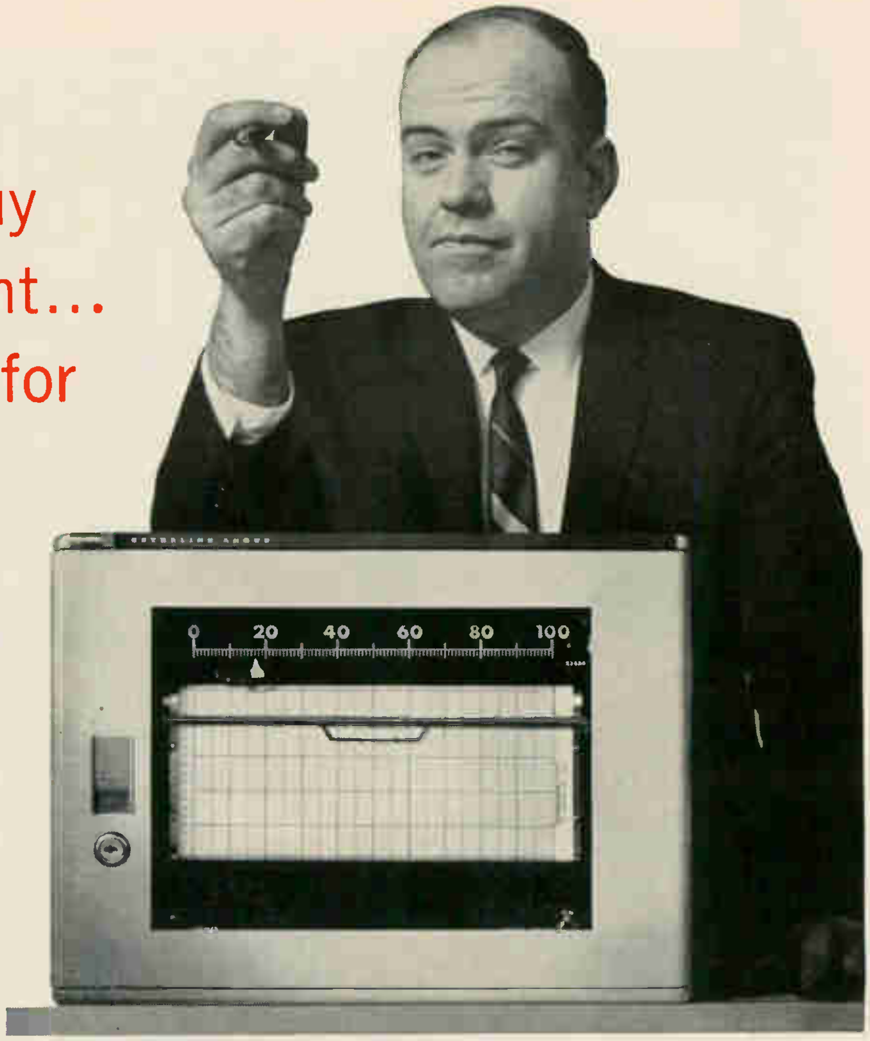

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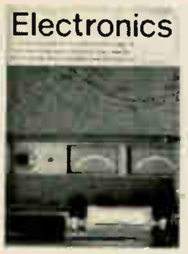
Technical Articles

Scattering parameters speed design of h-f transistor circuits page 78



As microwave systems go solid state, engineers have learned they need new design techniques to take advantage of the characteristics of new high-frequency transistors. One such technique involves the measuring of so-called scattering parameters and plotting their values on a Smith chart to synthesize the desired transistor circuit. For the cover, photographer Norton Pearl superimposed on a Smith chart a Hewlett-Packard vector voltmeter, which is measuring s-parameters of the transistor shown mounted in a special fixture.

Sense amplifier fits any memory: page 89

Though integrated circuits have won wide acceptance in computer design, mostly they have been used in the logic portion. A new design, however, makes a sense amplifier of microcircuits so it will be compatible with the microelectronics of processors. In addition, this general-purpose design works in any computer with a coincident current memory.

Divic gives answers to complex navigation questions: page 105

A special algorithm and a unique combination of digital and differential processing techniques have been devised for this small computer, whose size has been shrunk by the use of integrated circuits. The effect is to combine the speed of a digital differential analyzer with the flexibility of a general-purpose machine.

Pumping new life into ruby lasers: page 115

Two bars to using the ruby laser in industrial applications have been their short life that makes them uneconomic and slow repetition rates. Now, a device with a new resonator design and a low-cost mercury flashtube for pumping promises at last to make the laser a production tool in commercial micromachining processes.

Coming September 19

- An introduction to computer-aided design
- Glass as a design material
- Pulse-code modulation for telephone transmission

Design theory

Scattering parameters speed design of high-frequency transistor circuits

At frequencies above 100 Mhz scattering parameters are easily measured and provide information difficult to obtain with conventional techniques that use h, y or z parameters

By Fritz Weinert

Hewlett-Packard Co., Palo Alto, Calif.

Performance of transistors at high frequencies has so improved that they are now found in all solid-state microwave equipment. But operating transistors at high frequencies has meant design problems:

- Manufacturers' high-frequency performance data is frequently incomplete or not in proper form.
- Values of h, y or z parameters, ordinarily used in circuit design at lower frequencies, can't be measured accurately above 100 megahertz because establishing the required short and open circuit conditions is difficult. Also, a short circuit frequently causes the transistor to oscillate under test.

These problems are yielding to a technique that uses scattering or s parameters to characterize the high-frequency performance of transistors. Scattering parameters can make the designer's job easier.

- They are derived from power ratios, and consequently provide a convenient method for measuring circuit losses.
- They provide a physical basis for understanding what is happening in the transistor, without need for an understanding of device physics.
- They are easy to measure because they are based on reflection characteristics rather than short- or open-circuit parameters.

The author

Fritz K. Weinert, who joined the technical staff of Hewlett-Packard in 1964, is project leader in the network analysis section of the microwave laboratory. He holds patents and has published papers on pulse circuits, tapered-line transformers, digital-tuned circuits and shielding systems.

Like other methods that use h, y or z parameters, the scattering-parameter technique does not require a suitable equivalent circuit to represent the transistor device. It is based on the assumption that the transistor is a two-port network—and its terminal behavior is defined in terms of four parameters, s_{11}, s_{12}, s_{21} and s_{22}, called s or scattering parameters.

Since four independent parameters completely define any two-port at any one frequency, it is possible to convert from one known set of parameters to another. At frequencies above 100 Mhz, however, it becomes increasingly difficult to measure the h, y or z parameters. At these frequencies it is difficult to obtain well defined short and open circuits and short circuits frequently cause the device to oscillate. However, s parameters may be measured directly up to a frequency of 1 gigahertz. Once obtained, it is easy to convert the s parameters into any of the h, y or z terms by means of tables.

Suggested measuring systems

To measure scattering parameters, the unknown transistor is terminated at both ports by pure resistances. Several measuring systems of this kind have been proposed. They have these advantages:

- Parasitic oscillations are minimized because of the broadband nature of the transistor terminations.
- Transistor measurements can be taken remotely whenever transmission lines connect the semiconductor to the source and load—especially when the line has the same characteristic impedance as the source and load respectively.
- Swept-frequency measurements are possible instead of point-by-point methods. Theoretical work shows scattering parameters can simplify design.

Scattering-parameter definitions

To measure and define scattering parameters the two-port device, or transistor, is terminated at both ports by a pure resistance of value Z_0, called the reference impedance. Then the scattering parameters are defined by s_{11}, s_{12}, s_{21} and s_{22}. Their physical meaning is derived from the two-port network shown in first figure below.

Two sets of parameters, (a_1, b_1) and (a_2, b_2), represent the incident and reflected waves for the two-port network at terminals 1-1′ and 2-2′ respectively. Equations 1a through 1d define them.

$$a_1 = \frac{1}{2}\left(\frac{V_1}{\sqrt{Z_0}} + \sqrt{Z_0}\, I_1\right) \qquad (1a)$$

$$b_1 = \frac{1}{2}\left(\frac{V_1}{\sqrt{Z_0}} - \sqrt{Z_0}\, I_1\right) \qquad (1b)$$

$$a_2 = \frac{1}{2}\left(\frac{V_2}{\sqrt{Z_0}} + \sqrt{Z_0}\, I_2\right) \qquad (1c)$$

$$b_2 = \frac{1}{2}\left(\frac{V_2}{\sqrt{Z_0}} - \sqrt{Z_0}\, I_2\right) \qquad (1d)$$

The scattering parameters for the two-port network are given by equation 2.

$$\begin{aligned} b_1 &= s_{11}\, a_1 + s_{12}\, a_2 \\ b_2 &= s_{21}\, a_1 + s_{22}\, a_2 \end{aligned} \qquad (2)$$

In matrix form the set of equations of 2 becomes

$$\begin{bmatrix} b_1 \\ b_2 \end{bmatrix} = \begin{bmatrix} s_{11} & s_{12} \\ s_{21} & s_{22} \end{bmatrix} \begin{bmatrix} a_1 \\ a_2 \end{bmatrix} \qquad (3)$$

where the matrix

$$[s] = \begin{bmatrix} s_{11} & s_{12} \\ s_{21} & s_{22} \end{bmatrix} \qquad (4)$$

is called the scattering matrix of the two-port network. Therefore the scattering parameters of the two-port network can be expressed in terms of the incident and reflected parameters as:

$$s_{11} = \left.\frac{b_1}{a_1}\right|_{a_2 = 0} \qquad s_{12} = \left.\frac{b_1}{a_2}\right|_{a_1 = 0}$$

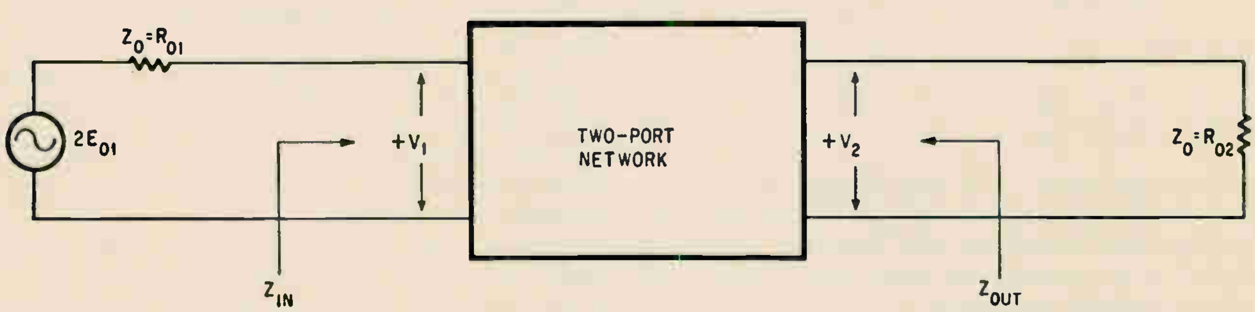
$$s_{21} = \left.\frac{b_2}{a_1}\right|_{a_2 = 0} \qquad s_{22} = \left.\frac{b_2}{a_2}\right|_{a_1 = 0} \qquad (5)$$

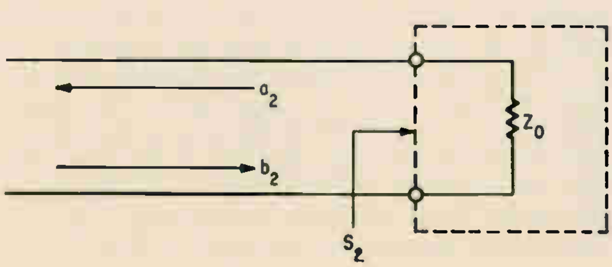
In equation 5, the parameter s_{11} is called the input reflection coefficient; s_{21} is the forward transmission coefficient; s_{12} is the reverse transmission coefficient; and s_{22} is the output reflection coefficient. All four scattering parameters are expressed as ratios of reflected to incident parameters.

Physical meaning of parameters

The implications of setting the incident parameters a_1 and a_2 at zero help explain the physical

Scattering parameters are defined by this representation of a two-port network. Two sets of incident and reflected parameters (a_1, b_1) and (a_2, b_2) appear at terminals 1-1′ and 2-2′ respectively.





By setting a_2 equal to zero the s_{11} parameter can be found. The Z_0 resistor is thought of as a one-port network. The condition $a_2 = 0$ implies that the reference impedance R_{02} is set equal to the load impedance Z_0. By connecting a voltage source, 2 E_{01}, with the source impedance, Z_0, parameter s_{21} can be found using equation 5.

meaning of these scattering parameters.

By setting $a_2 = 0$, expressions for s_{11} and s_{22} can be found. The terminating section of the two-port network is at bottom of page 79 with the parameters a_2 and b_2 of the 2-2′ port. If the load resistor Z_0 is thought of as a one-port network with a scattering parameter

$$s_2 = \frac{Z_0 - R_{02}}{Z_0 + R_{02}} \qquad (6)$$

where R_{02} is the reference impedance of port 2, then a_2 and b_2 are related by

$$a_2 = s_2 b_2 \qquad (7)$$

When the reference impedance R_{02} is set equal to the local impedance Z_0, then s_2 becomes

$$s_2 = \frac{Z_0 - Z_0}{Z_0 + Z_0} = 0 \qquad (8)$$

so that $a_2 = 0$ under this condition. Similarly, when $a_1 = 0$, the reference impedance of port 1 is equal to the terminating impedance; that is, $R_{01} = Z_0$. The conditions $a_1 = 0$ and $a_2 = 0$ merely imply that the reference impedances R_{01} and R_{02} are chosen to be equal to the terminating resistors Z_0.

In the relationship between the driving-point impedances at ports 1 and 2 and the reflection coefficients s_{11} and s_{22}, the driving-point impedances can be denoted by:

$$Z_{in} = \frac{V_1}{I_1}; \qquad Z_{out} = \frac{V_2}{I_2} \qquad (9)$$

From the relationship

$$s_{11} = \left.\frac{b_1}{a_1}\right|_{a_2 = 0}$$

$$s_{11} = \frac{\frac{1}{2}\left[(V_1/\sqrt{Z_0}) - \sqrt{Z_0}\, I_1\right]}{\frac{1}{2}\left[(V_1/\sqrt{Z_0}) + \sqrt{Z_0}\, I_1\right]} \qquad (10)$$

which reduces to

$$s_{11} = \frac{Z_{in} - Z_0}{Z_{in} + Z_0} \qquad (11)$$

Similarly,

$$s_{22} = \frac{Z_{out} - Z_0}{Z_{out} + Z_0} \qquad (12)$$

These expressions show that if the reference impedance at a given port is chosen to equal the ports driving-point impedance, the reflection coefficient will be zero, provided the other port is terminated in its reference impedance.

In the equation

$$s_{21} = \left.\frac{b_2}{a_1}\right|_{a_2 = 0}$$

the condition $a_2 = 0$ implies that the reference impedance R_{02} is set equal to the load impedance R_2, center figure page 79. If a voltage source 2 E_{01} is connected with a source impedance $R_{01} = Z_0$, a_1 can be expressed as:

$$a_1 = \frac{E_{01}}{\sqrt{Z_0}} \qquad (13)$$

Since $a_2 = 0$, then

$$a_2 = 0 = \frac{1}{2}\left(\frac{V_2}{\sqrt{Z_0}} + \sqrt{Z_0}\, I_2\right)$$

from which

$$\frac{V_2}{\sqrt{Z_0}} = -\sqrt{Z_0}\, I_2$$

Consequently,

$$b_2 = \frac{1}{2}\left(\frac{V_2}{\sqrt{Z_0}} - \sqrt{Z_0}\, I_2\right) = \frac{V_2}{\sqrt{Z_0}}$$

Finally, the forward transmission coefficient is expressed as:

$$s_{21} = \frac{V_2}{E_{01}} \qquad (14)$$

Similarly, when port 1 is terminated in $R_{01} = Z_0$ and when a voltage source 2 E_{02} with source impedance Z_0 is connected to port 2,

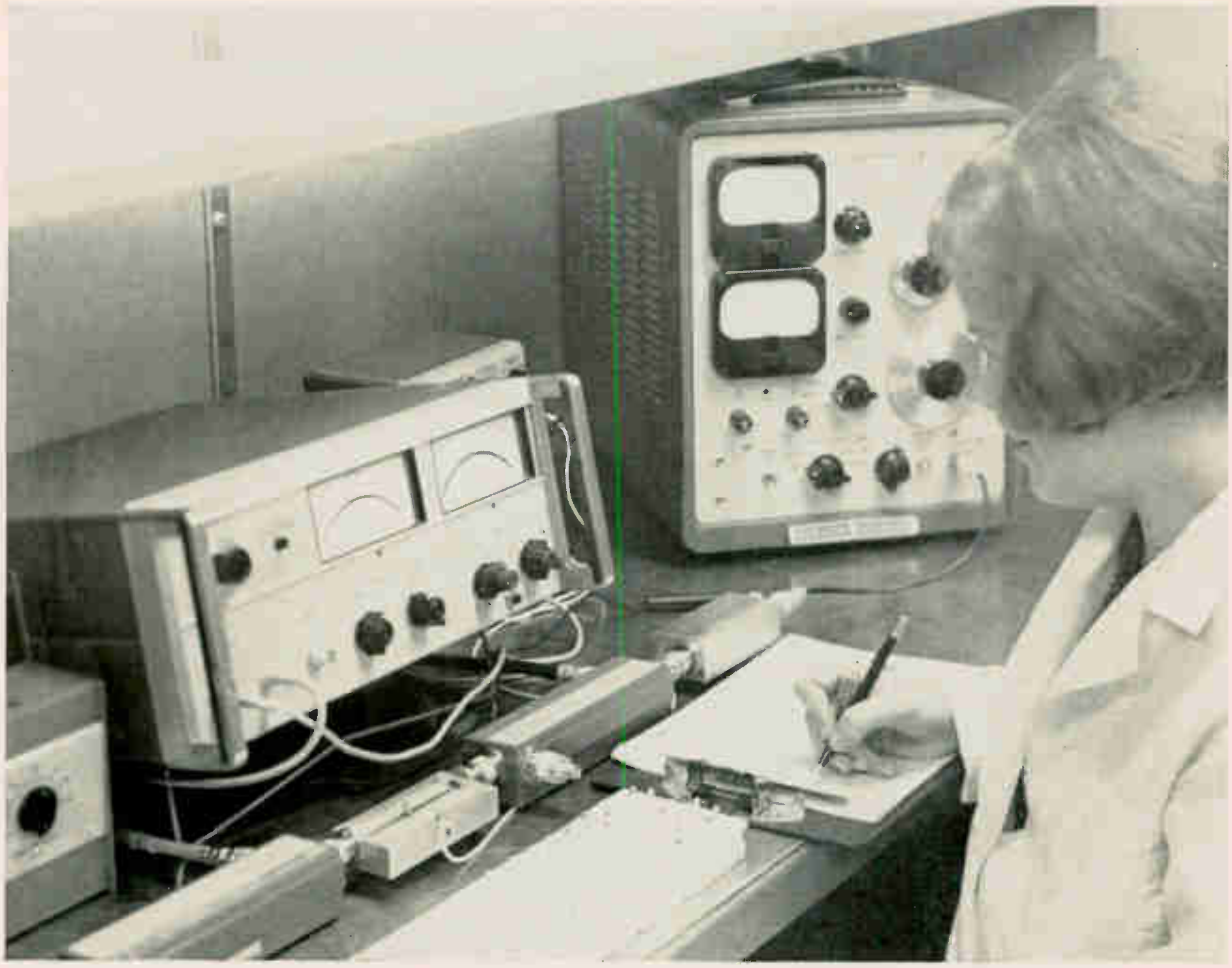
$$s_{12} = \frac{V_1}{E_{02}} \qquad (15)$$

Both s_{12} and s_{21} have the dimensions of a voltage-ratio transfer function. And if $R_{01} = R_{02}$, then s_{12} and s_{21} are simple voltage ratios. For a passive reciprocal network, $s_{21} = s_{12}$.

Scattering parameters s_{11} and s_{22} are reflection coefficients. They can be measured directly by means of slotted lines, directional couplers, voltage-standing-wave ratios and impedance bridges. Scattering parameters s_{12} and s_{21} are voltage transducer gains. All the parameters are frequency-dependent, dimensionless complex numbers. At any one frequency all four parameters must be known to describe the two-port device completely.

There are several advantages for letting $R_{01} = R_{02} = Z_0$.

- The s_{11} and s_{22} parameters are power reflection coefficients that are difficult to measure under normal loading. However, if $R_{01} = R_{02} = Z_0$, the parameters become equal to voltage reflection coefficients and can be measured directly with available test equipment.
- The s_{12} and s_{21} are square roots of the transducer power gain, the ratio of power absorbed in the load over the source power available. But for $R_{01} = R_{02} = Z_0$, they become a voltage ratio and can be measured with a vector voltmeter.
- The actual measurement can be taken at a distance from the input or output ports. The measured scattering parameter is the same as the parameter existing at the actual location of the particular port. Measurement is achieved by connecting input and output ports to source and load by means of transmission lines having the same impedance, Z_0,



25°C	100 Mhz	300 Mhz	100°C	100 Mhz	300 Mhz
s_{11}	0.62 < −44.0°	0.305 < −81.0°	s_{11}	0.690 < −40°	0.372 < −71°
s_{12}	0.0115 < +75.0°	0.024 < +93.0°	s_{12}	0.0125 < +76.0°	0.0254 < +89.5°
s_{21}	9.0 < +130°	3.85 < +91.0°	s_{21}	8.30 < +133.0°	3.82 < +94.0°
s_{22}	0.955 < −6.0°	0.860 < −14.0°	s_{22}	0.955 < −6.0°	0.880 < −15.0°

25°C	590 Mhz	1,000 Mhz	100°C	500 Mhz	1,000 Mhz
s_{11}	0.238 < −119.0°	0.207 < +175.0°	s_{11}	0.260 < −96.0°	0.196 < +175.0°
s_{12}	0.0385 < +110.0°	0.178 < +110.0°	s_{12}	0.0435 < +100.0°	0.165 < +103.0°
s_{21}	2.19 < +66.0°	1.30 < +33.0°	s_{21}	2.36 < +69.5°	1.36 < +35.0°
s_{22}	0.830 < −26.0°	0.838 < −49.5°	s_{22}	0.820 < −28.0°	0.850 < −53.0°

Scattering parameters can be measured directly using the Hewlett-Packard 8405A vector voltmeter. It covers the frequency range of 1 to 1,000 megahertz and determines s_{21} and s_{12} by measuring ratios of voltages and phase difference between the input and output ports. Operator at Texas Instruments Incorporated measures s-parameter data for TI's 2N3571 transistor series. Values for $V_{CE} = 10$ volts; $I_c = 5$ milliamperes.

as the source and load. In this way compensation can be made for added cable length.

- Transistors can be placed in reversible fixtures to measure the reverse parameters s_{22} and s_{12} with the equipment used to measure s_{11} and s_{21}.

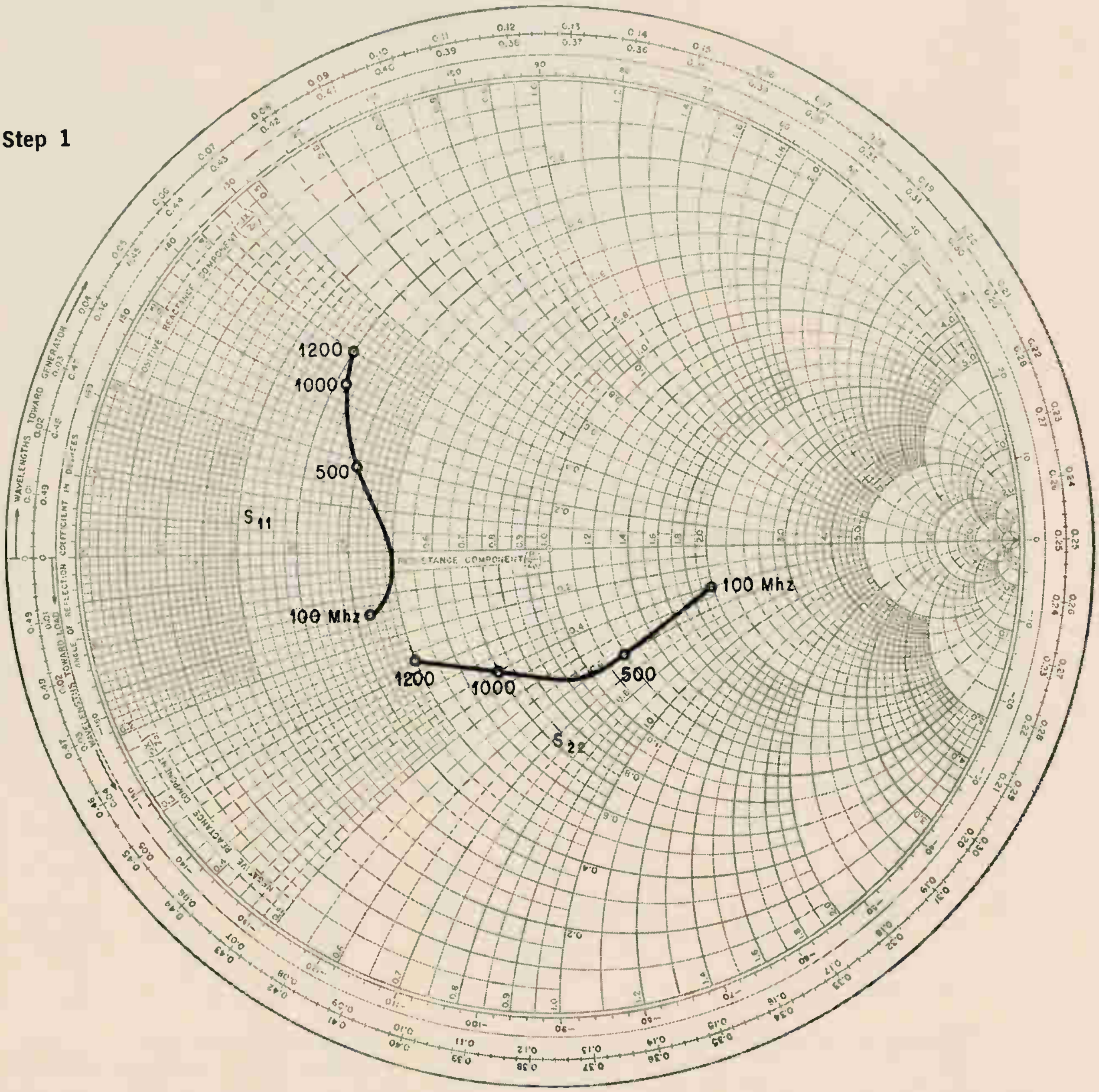
The Hewlett-Packard Co.'s 8405A vector voltmeter measures s parameters. It covers the frequency range of 1 to 1,000 megahertz and determines s_{21} and s_{12} by measuring voltage ratios and phase differences between the input and output ports directly on two meters, as shown above. A dual-directional coupler samples incident and reflected voltages to measure the magnitude and phase of the reflection coefficient.

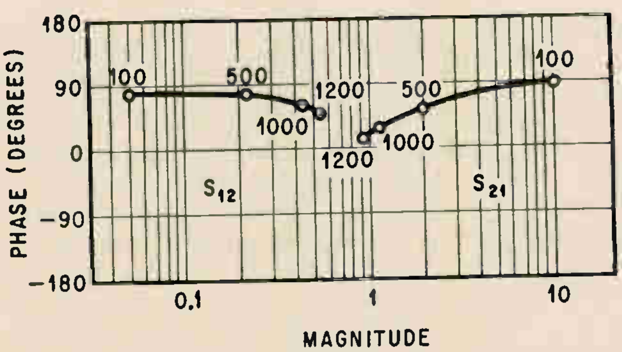
To perform measurements at a distance, the setup on page 86 is convenient. The generator and the load are the only points accessible for measurement. Any suitable test equipment, such as a vector voltmeter, directional coupler or slotted line can be connected. In measuring the s_{21} parameter as shown in the schematic, the measured vector quantity V_2/E_o is the voltage transducer gain or forward gain scattering parameter of the two-port and cables of length L_1 and L_2. The scattering parameter s_{21} of the two-port itself is the same vector V_2/E_o but turned by an angle of $360° (L_1 + L_2)/\lambda$ in a counterclockwise direction.

Plotting s_{11} in the complex plane shows the conditions for measuring s_{11}. Measured vector r_1 is the reflection coefficient of the two-port plus

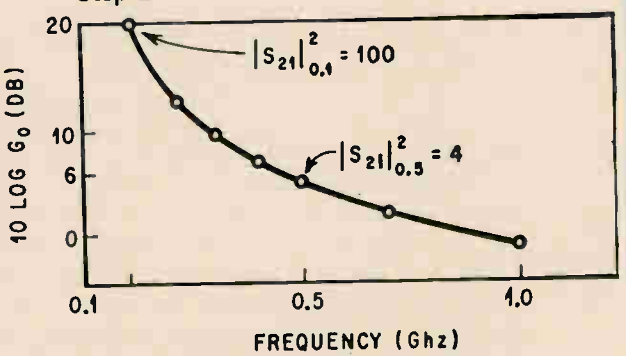
Amplifier design with unilateral s parameters

Step 1





Step 2



From the measured data transducer power gain is plotted as decibels versus frequency. From the plot an amplifier of constant gain is designed. Smith chart is used to plot the scattering parameters.

To design an amplifier stage, a source and load impedance combination must be found that gives the gain desired. Synthesis can be accomplished in three stages.

Step 1

The vector voltmeter measures the scattering parameters over the frequency range desired.

Step 2

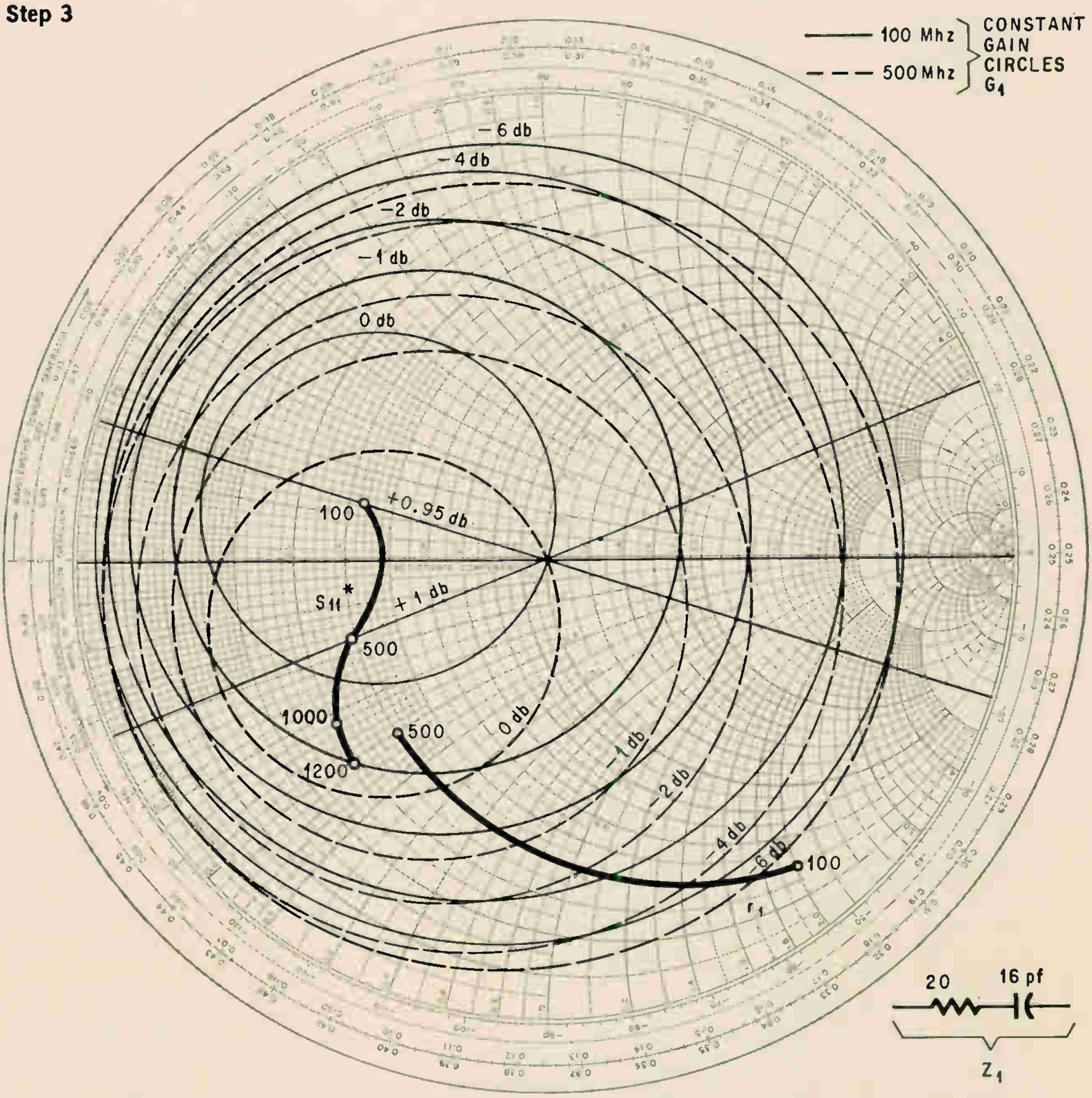
Transducer power gain is plotted versus frequency using equation 19 and the measured data from step 1. This determines the frequency response of the uncompensated transistor network so that a constant-gain amplifier can be designed.

Step 3

Source and load impedances must be selected to provide the proper compensation of a constant power gain from 100 to 500 Mhz. Such a constant-gain amplifier is designed according to the following:

- Plot $s_{11}°$ on the Smith chart. The magnitude of $s_{11}°$ is the linear distance measured from the center of the Smith chart. Radius from the center of the chart to any point on the locus of s_{11} represents a reflection coefficient r. The value of r can therefore be determined at any frequency by drawing a line from the origin of the chart to a value of $s_{11}°$ at the frequency of

Step 3



Source impedance is found by inspecting the input plane for realizable source loci that give proper gain. Phase angle is read on the peripheral scale "angle of reflection coefficient in degrees."

interest. The value of r is scaled proportionately with a maximum value of 1.0 at the periphery of the chart. The phase angle is read on the peripheral scale "angle of reflection coefficient in degrees." Constant-gain circles are plotted using equations 24 and 25 for G_1. These correspond to values of 0, −1, −2, −4 and −6 decibels for $s_{11}°$ at 100 and 500 Mhz. Construction procedure is shown on page 83.

▪ Constant-gain circles for $s_{22}°$ at 100 and 500 Mhz are constructed similarly to that below.

▪ The gain G_0 drops from 20 db at 100 Mhz to 6 db at 500 Mhz, a net reduction of 14 db. It is desirable to find source and load impedances that will flatten this slope over this frequency range. For this case it is accomplished by choosing a value of r_1 and r_2 on the constant-gain circle at 100 Mhz, each corresponding to a loss of −7 db. If this value of r_1 and r_2 falls on circles of 0-db gain at 500 Mhz, the over-all gain will be:

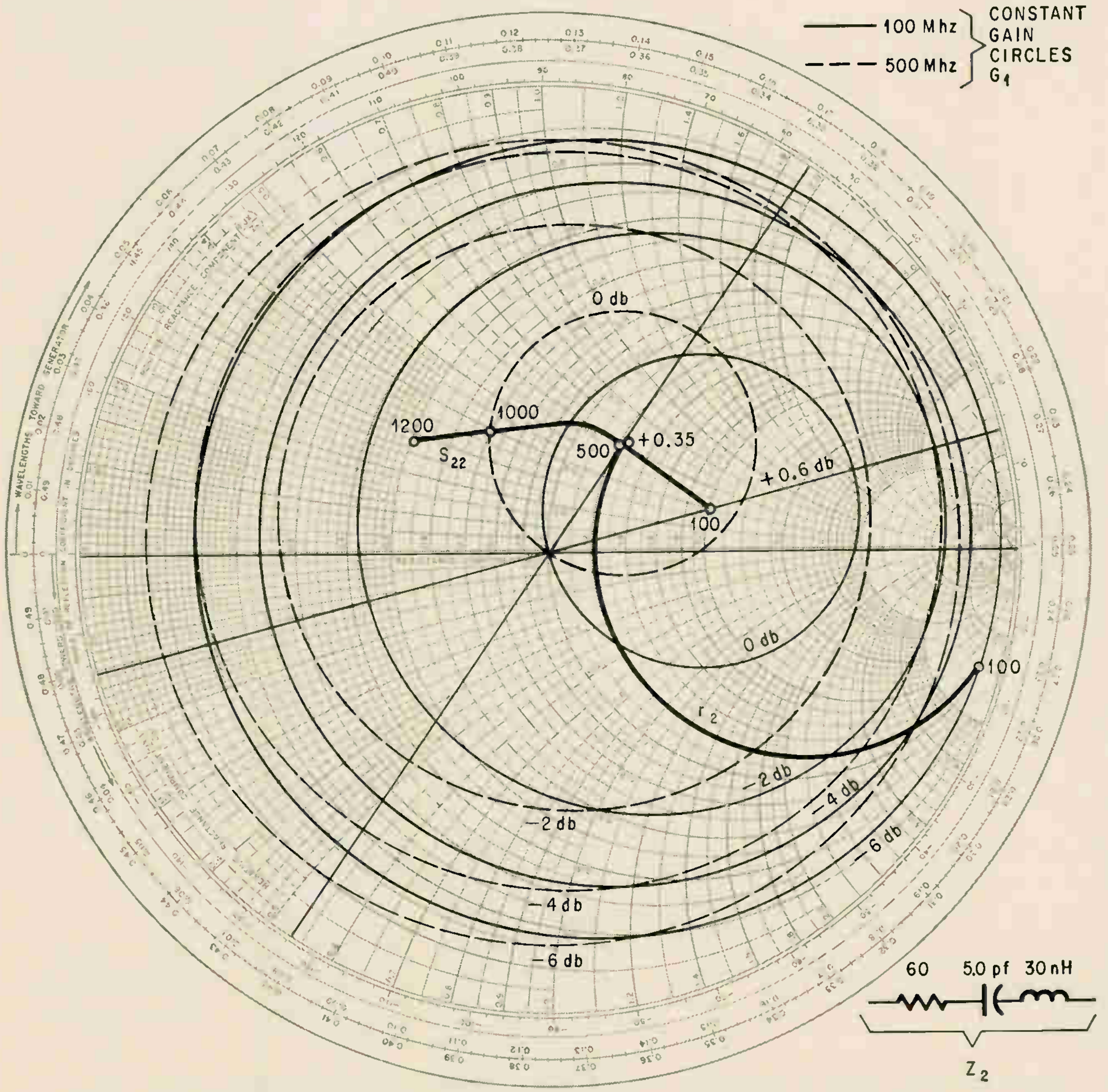
At 100 Mhz,

$$G_T(db) = G_0 + G_1 + G_2 = 20 - 7 - 7 = +6 \text{ db}$$

At 500 Mhz,

$$G_T(db) = 6 + 0 + 0 = +6 \text{ db}$$

▪ A source impedance of 20 ohms resistance in series with 16 picofarads of capacitance is chosen. Its value is equal to 50 (0.4 − j2) ohms at 100 Mhz. This point crosses the r_1 locus at about the −7 db constant-gain circle of G_1 as illustrated on page 83. At 500 Mhz this impedance combination equals 50 (0.4 — j0.4) ohms and is located at approximately the +0.5 db constant-gain circle. The selection of source impedance is an iterative process of inspection of



Load impedance is found by inspecting the output plane for loci that give proper gain.

the input r_1 plane on the Smith chart. The impedance values at various frequencies between 100 and 500 Mhz are tried until an impedance that corresponds to an approximate constant—gain circle necessary for constant power gain across the band is found.

- At the output port a G_2 of −6 db at 100 Mhz and +0.35 db at 500 Mhz is obtained by selecting a load impedance of 60 ohms in series with 5 pf and 30 nanohenries.
- The gain is:

At 100 Mhz,

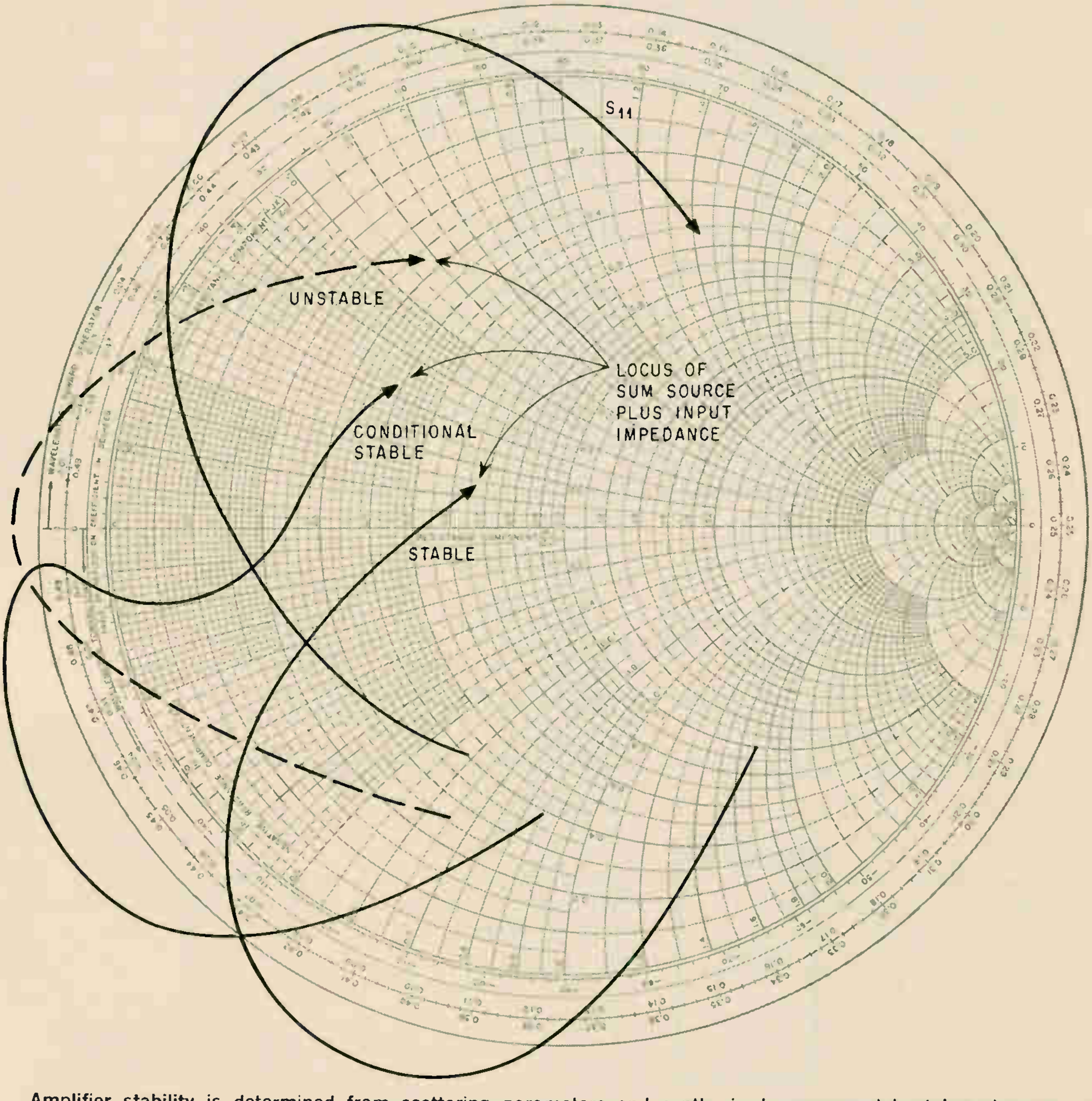
$$G_T(\text{db}) = G_0 + G_1 + G_2 = 20 - 7 - 6 = +7 \text{ db}$$

At 500 Mhz,

$$6 + 0.5 + 0.35 = +6.85 \text{ db}$$

Thus the 14-db variation from 100 to 500 Mhz is reduced to 0.15 db by selecting the proper source and load impedances.

Stability criterion. Important in the design of amplifiers is stability, or resistance to oscillation. Stability is determined for the unilateral case from the measured s parameters and the synthesized source and load impedances. Oscillations are only possible if either the input or the output port, or both, have negative resistances. This occurs if s_{11} or s_{22} are greater than unity. However, even with negative resistances the amplifier might be stable. The condition for stability is that the locus of the sum of input plus source impedance, or output plus load impedance, does not include zero impedance from frequencies zero to infinity [shown in figure below]. The technique is similar to Nyquist's feedback stability criterion and has been derived directly from it.



Amplifier stability is determined from scattering parameters and synthesized source and load impedances.

input cable L_1 (the length of the output cable has no influence). The scattering parameter s_{11} of the two-port is the same vector r_1 but turned at an angle 720° L_1/λ in a counterclockwise direction.

Using the Smith chart

Many circuit designs require that the impedance of the port characterized by s_{11} or the reflection coefficient r be known. Since the s parameters are in units of reflection coefficient, they can be plotted directly on a Smith chart and easily manipulated to establish optimum gain with matching networks. The relationship between reflection coefficient r and the impedance R is

$$r = \frac{R - Z_0}{R + Z_0} \qquad (16)$$

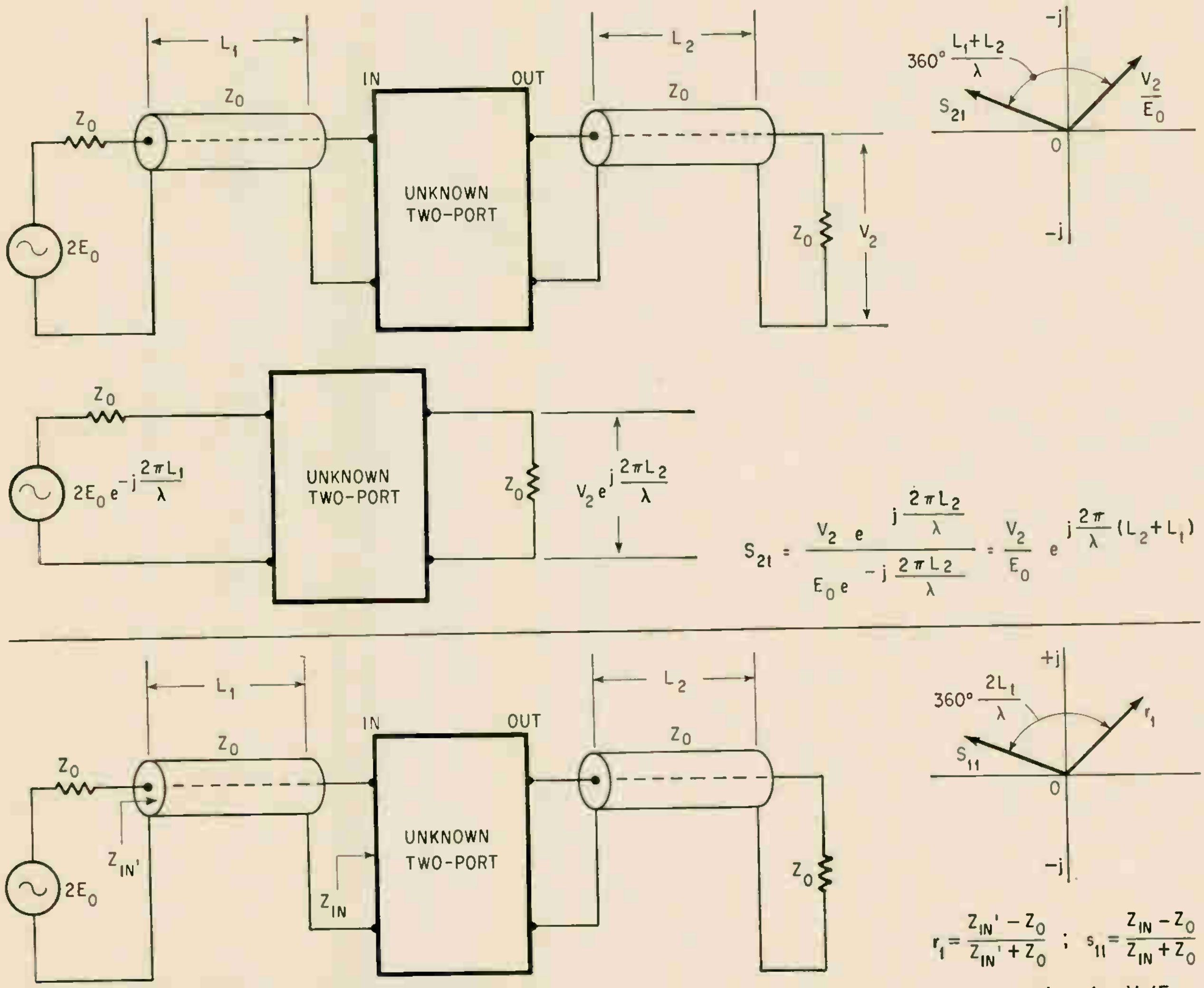
The Smith chart plots rectangular impedance coordinates in the reflection coefficient plane. When the s_{11} or s_{22} parameter is plotted on a Smith chart, the real and imaginary part of the impedance may be read directly.

It is also possible to chart equation 1 on polar coordinates showing the magnitude and phase of the impedance R in the complex reflection coefficient plane. Such a plot is termed the Charter chart. Both charts are limited to impedances having positive resistances, $|r_1| < 1$. When measuring transistor parameters, impedances with negative resistances are sometimes found. Then, extended charts can be used.

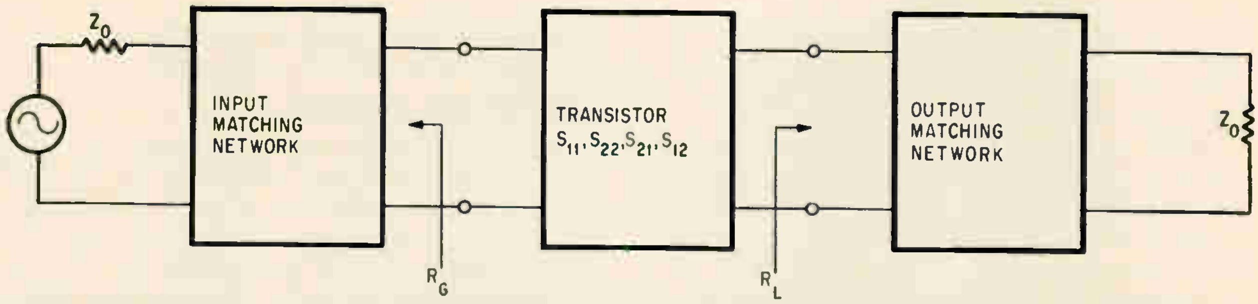
Using a parameter in amplifier design

Measurement of a device's s parameters provides data on input and output impedance and forward and reverse gain. In measuring, a device is inserted between known impedances, usually 50 ohms. In practice it may be desirable to achieve higher gain by changing source or load impedances or both.

An amplifier stage may now be designed in two steps. First, source and load impedances must be found that give the desired gain. Then the impedances must be synthesized, usually as matching networks between a fixed impedance source or between the load and the device [see block diagram top of p. 87].



S parameters can be measured remotely. Top test setup is for measuring s_{21}; bottom, for s_{11}. Measured vector V_2/E_0 is the voltage transducer gain of the two-port and cables L_1 and L_2. The measured vector r_1 is the reflection coefficient of the two-port plus input cable $L_1 + L_2$. Appropriate vectors for r_1 and s parameters are plotted.



To design an amplifier stage, source and load impedances are found to give the gain desired. Then impedances are synthesized, usually as matching networks between a fixed impedance source or the load and the device. When using s parameters to design a transistor amplifier, it is advantageous to distinguish between a simplified or unilateral design for times when s_{12} can be neglected and when it must be used.

When designing a transistor amplifier with the aid of s parameters, it is advantageous to distinguish between a simplified or unilateral design for instances where the reverse-transmission parameter s_{12} can be neglected and the more general case in which s_{21} must be shown. The unilateral design is much simpler and is, for many applications, sufficient.

Unilateral-circuit definitions

Transducer power gain is defined as the ratio of amplifier output power to available source power.

$$G_T = \frac{I_2^2 . R_{e2}}{\dfrac{E_0^2}{4R_{e1}}} \qquad (17)$$

For the unilateral circuit G_T is expressed in terms of the scattering parameters s_{11}, s_{21} and s_{12} with $s_{12} = 0$.

$$G_T = G_0 . G_1 . G_2 \qquad (18)$$

where:

$G_0 = |s_{21}|^2$ = transducer power gain for $R_1 = Z_0 = R_2$ (19)

$$G_1 = \frac{\left|1 - |r_1|^2\right|}{|1 - r_1 s_{11}|^2} \qquad (20)$$

= power gain contribution from change of source impedance from Z_0 to R_1

$$r_1 = \frac{R_1 - Z_0}{R_1 + Z_0} \qquad (21)$$

= reflection coefficient of source impedance with respect to Z_0

$$G_2 = \frac{\left|1 - |r_2|^2\right|}{|1 - r_2 s_{22}|^2} \qquad (22)$$

= power gain contribution from change of load impedance from Z_0 to R_2

$$r_2 = \frac{R_2 - Z_0}{R_2 + Z_0} \qquad (23)$$

= reflection coefficient of load impedance with respect to Z_0

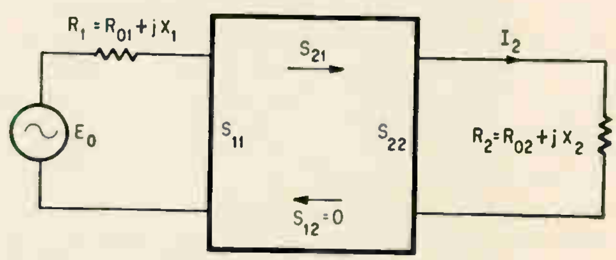
In designing an amplifier stage the graphical procedure shown at the bottom is helpful. The measured values of parameter s_{11} and its complex conjugate s_{11}^* are plotted on the Smith chart together with radius distances. Center of the constant-gain circles located on the line through s_{11}^* and the origin at a distance

$$r_{01} = \frac{G_1}{G_{1\,max}}\left[\frac{|s_{11}|}{1 - |s_{11}|^2 (1 - G_1/G_{1\,max})}\right] \qquad (24)$$

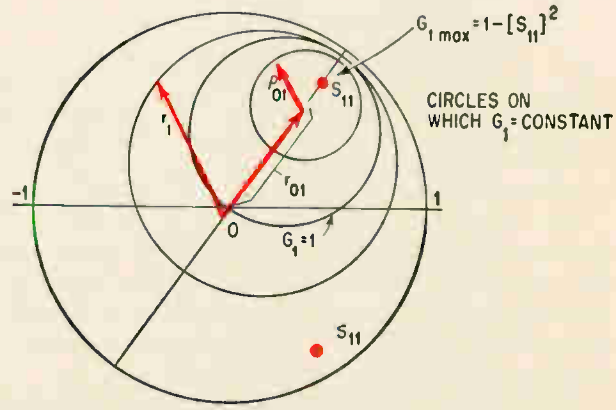
The radius of circles on which G_1 is constant is

$$\rho_{01} = \frac{\sqrt{1 - G_1/G_{1\,max}}\,(1 - |s_{11}|^2)}{1 - |s_{11}|^2 (1 - G_1/G_{1\,max})} \qquad (25)$$

If the source reflection coefficient r_1 is made equal



The two-port network is terminated at the ports by impedances containing resistance and reactance. Expressions for the transducer power gain can then be derived in terms of the scattering parameters.



A graphical plot helps in design of an amplifier stage. Here the measured parameters s_{11} and s_{11}^* are plotted on a Smith chart. The upper point is s_{11}^*.

to s_{11}^*, then the generator is matched to the load and the gain becomes maximum (G_{1max}). Constant-gain circles can be constructed, as shown, in 1- or 2-decibel increments or whatever is practical using equations 9 and 10.

If the source impedance R_1 or its reflection coefficient is plotted, the gain contribution G_1 is read directly from the gain circles. The same method is used to determine G_2 by plotting s_{22}, s_{22}^*, constant-gain circles and r_2.

Examples for the design procedure are given in greater detail in Transistor Parameter Measurements, Hewlett-Packard Application Note 77-1. The procedure is outlined in "Amplifier design with unilateral s parameters," beginning on page 82.

Measuring s parameters

S-parameter measurements of small-signal transistors require fairly sensitive measuring equipment. The input signal often cannot exceed 10 millivolts root mean square. On the other hand, wide frequency ranges are required as well as fast and easy operation. Recent advantages in measuring equipment have provided a fast and accurate measuring system. It is based on the use of a newly developed instrument, the H-P sampling vector voltmeter 8405A [see photo p. 81], and couplers.

The vector voltmeter covers a frequency range of 1 to 1,000 Mhz, a voltage measurement range of 100 microvolts full scale and a phase range of ±180° with 0.1° resolution. It is tuned automatically by means of a phase-locked loop.

Directional couplers are used to measure reflection coefficients and impedances. A directional coupler consists of a pair of parallel transmission lines that exhibit a magnetic and electric coupling between them. One, called the main line, is connected to the generator and load to be measured. Measurement is taken at the output of the other, called the auxiliary line. Both lines are built to have a well defined characteristic impedance; 50 ohms is usual. The voltage coupled into the auxiliary line consists of components proportional to the voltage and current in the main line. The coupling is arranged so that both components are equal in magnitude when the load impedance equals the characteristic impedance of the line.

Directional couplers using two auxiliary lines in reverse orientation are called dual-directional couplers. A feature of the unit is a movable reference plane; the point where the physical measurement is taken can be moved along the line connecting the coupler with the unknown load. A line stretcher is connected to the output of the first auxiliary line.

The reference plane is set closer to the transistor package than the minimum lead length used with the transistor. Additional lead length is then considered part of the matching networks. The influence of lead length is also measured by changing the location of the reference plane.

Measurement of s_{11} parameter is made when the instrument is switched to one of two positions. The quotient V_B/V_A equals the magnitude of s_{11}. Its phase is read directly on the 8405A meter. When switched to the alternate position, the s_{21} parameter is read directly from the same ratio.

Accuracy and limitations

When measuring small-signal scattering parameters, a-c levels beyond which the device is considered linear must not be exceeded. In a grounded-emitter or grounded-base configuration, input voltage is limited to about 10 millivolts rms maximum (when measuring s_{11} and s_{21}). Much higher voltages can be applied when measuring s_{22} and s_{12} parameters. In uncertain cases linearity is checked by taking the same measurements at a sampling of several different levels.

The system shown is inherently broadband. Frequency is not necessarily limited by the published range of the dual directional couplers. The coupling factor K falls off inversely with frequency below the low-frequency limit of a coupler. The factor K does not appear in the result as long as it is the same for each auxiliary port. Since construction of couplers guarantees this to a high degree, measurements can be made at lower frequencies than are specified for the coupler.

The system's measurement accuracy depends on the accuracy of the vector voltmeter and the couplers. Although it is possible to short circuit the reference planes of the transistors at each frequency, it is not desirable for fast measurements. Hence, broadband tracking of all auxiliary arms of the couplers and tracking of both channels of the vector voltmeter are important. Tracking errors are within about 0.5 db of magnitude and ±3° of phase over wide frequency bands. Accuracy of measuring impedances expressed by s_{11} and s_{22} degrade for resistances and impedances having a high reactive component. This is because s_{11} or s_{22} are very close to unity. These cases are usually confined to lower frequencies.

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Sense amplifier fits any memory

General-purpose amplifier attaches to most coincident-current memories without redesigning; it has adjustable threshold, good noise rejection and it drives any standard logic gate with positive or negative output

By Brant Johnson
Sylvania Electric Products, Inc., Woburn, Mass.

A new sense amplifier will simplify the memory designer's job and enable computer makers to produce less costly machines. In the past when a memory was designed, a sense amplifier was designed to go with it. The new general-purpose amplifier can be used in most coincident-current computer memories.

Sylvania Electric Products, Inc., a subsidiary of General Telephone and Electronics Corp., developed the sense amplifier at its Woburn, Mass. laboratories. It attaches to most coincident-current memories without the need for custom design work. It accepts any threshold levels over a wide range of temperatures, rejects noise, drives standard logic gates with either a positive or negative output and works with high- or low-speed memories.

The sense amplifier is an integrated circuit, which makes possible a computer built entirely of integrated circuits. Up to now most sense amplifiers were made of discrete components. The sense amplifier [see photo on page 90] has a bandwidth of 10 megahertz and drifts only 22 microvolts per degree centigrade.

Most sense amplifiers are designed specifically for the particular memory with which they will be used. This is necessary because the threshold level varies from application to application, because of the presence and severity of noise and because the requirements of logic circuits may vary.

The new circuit was designed to be compatible with Sylvania's universal high-level (SUHL) logic family, [Electronics, April 19, 1965, p. 166] for use with Sylvania's MSP-24 microcircuit computer [Electronics, October 18, 1965, p. 72].

What's a sense amplifier?

When data is taken from a coincident-current ferrite-core memory, it comes out as electrical pulses on a group of wires—one wire for each bit in the word. Ordinarily the presence of a pulse indicates a 1 bit, and the absence of a pulse at the proper time indicates a 0 bit. The sense amplifier accepts these pulses, rejects noise pulses, shapes the signal, amplifies it and drives logic circuits through which data is transferred to the computer's memory data register.

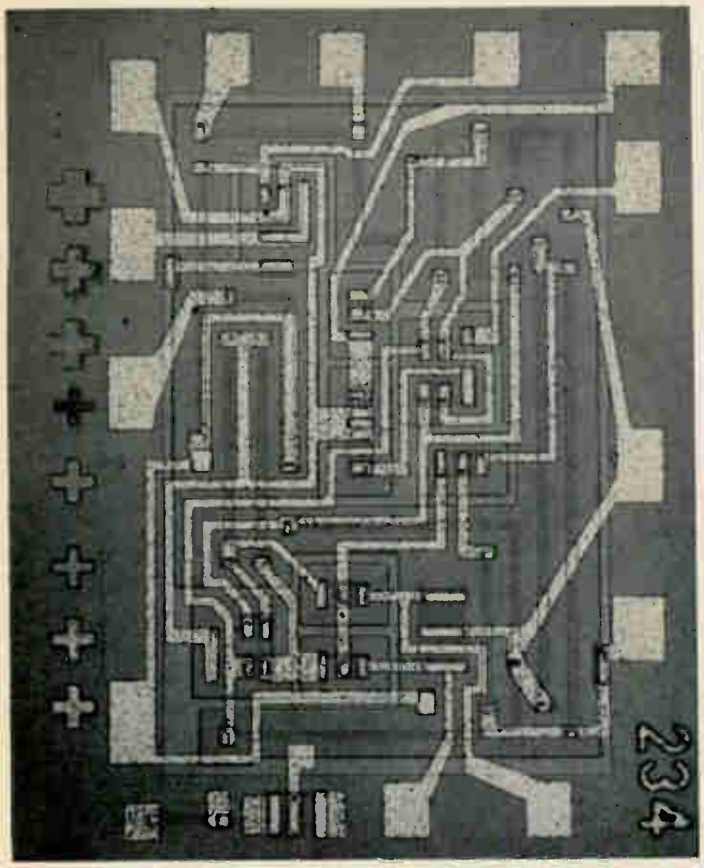
The sense amplifier is a differential amplifier whose two inputs are connected to the two ends of the sense winding [see panel on p. 91]. The input to the amplifier is sometimes positive, sometimes negative and always noisy. The amplifier must therefore accept both positive and negative pulses, but produce a uniform output that is always of the same polarity.

Two kinds of noise

Common-mode noise and differential noise complicate the task of signal detection. Common-mode noise—that is, noise that appears equally at both amplifier inputs—is caused by inductive coupling from the relatively large currents that write information into the memory, across the closely spaced wires on which the cores are strung. Differential noise arises from fully selected cores that do not switch because they are already in the 0 state and from half-selected cores. The zigzag routing of the sense line partly cancels differential noise; with this routing half the cores are sensed in one direction and half in the other. Nevertheless, the signal-to-

The author

Brant Johnson is a design engineer in the integrated circuits department of Sylvania's semiconductor division. Besides the sense amplifier described here, he has designed a wideband amplifier that Sylvania produces and has worked with digital IC's and with memories.



Sense amplifier on monolithic silicon chip 40 mils square can be used in most coincident-current memories.

noise ratio on the sense line is low. For example, a 64-by-64 bit memory plane made of 20-mil cores that require an 875-milliampere write current and produce a 35-millivolt pulse when they switch can generate differential noise greater than 10 millivolts and common-mode noise of 1 volt or more.

A sense amplifier must reject differential signals below a fixed threshold level. Usually the threshold level is optimized for a particular memory; it depends on the size of the core. Such an amplifier may be unreliable in another memory system. If, for example, the signal-to-threshold ratio is too low, a valid 1 bit may be read as a 0. Conversely, a high signal-to-threshold ratio may permit noise to be detected so that a 0 is read as a 1. Therefore, a sense amplifier to be used with a variety of memory systems must have a variable threshold control. The threshold voltage of a sense amplifier must be well defined, because the degree of uncertainty in the threshold limits the accurate setting of the amplifier's threshold level to the minimum output pulse expected from the core. With poor threshold definition, the threshold voltage must be set lower than desired, decreasing the degree of noise protection.

Sense amplifiers must reject common-mode noise several volts in amplitude, yet be sensitive enough to detect small differential voltages of either polarity. Therefore the sense amplifier's input stage normally consists of a differential amplifier fed by a current source. The supply voltages and bias levels for the input stage must be chosen so that the collector-base junctions of all transistors are strongly reverse biased—enough to keep the transistors in their active region even in the presence of several volts of common-mode noise. The Sylvania circuit rejects up to 5½ volts of common-mode noise.

Unlike most others, the Sylvania sense amplifier does not include an internal strobe circuit—a circuit that blocks passage of signals through the amplifier except during a short time interval when the proper signal is expected. The strobe usually follows detection and amplification and precedes wave shaping. With the Sylvania amplifier, more precise strobing is possible with an external gate circuit at the output, where the signal is a pulse with well defined amplitude and duration. Strobing at the output is preferable because it avoids loading of the amplifier analog section and improves frequency response.

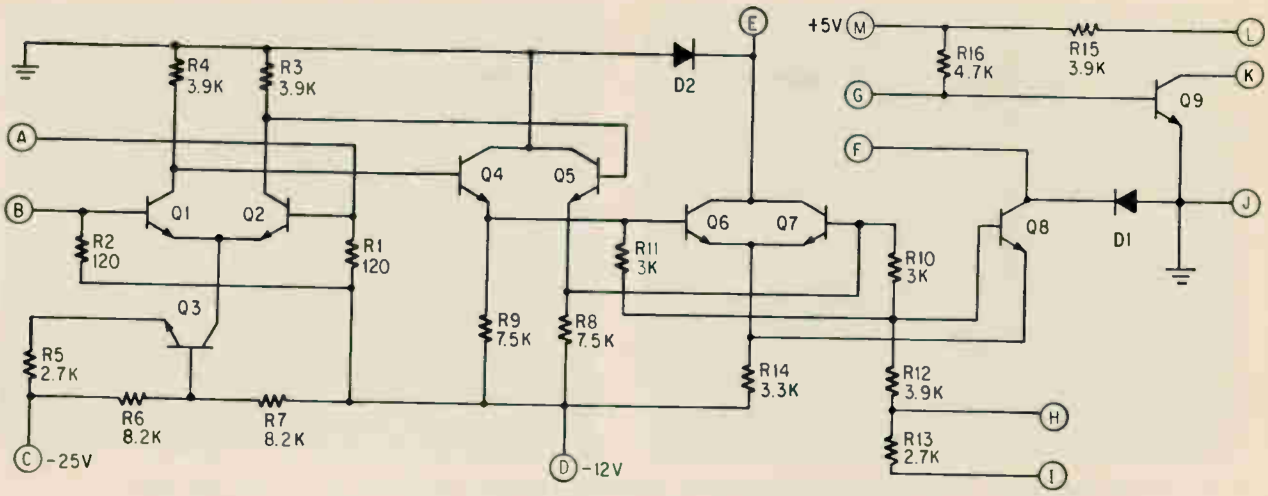
Circuit details

Sylvania's monolithic sense amplifier is a silicon integrated circuit, diagramed on the opposite page. Its input is through pins A and B to transistors Q_1 and Q_2 connected as a differential pair. Transistor Q_3 supplies a constant current to the pair. The two resistors connected to the bases of Q_1 and Q_2 provide a low input impedance, approximately matching the input impedance of the amplifier to the output impedance of the sense winding, and thereby reducing reflections.

The output of the first stage passes through the emitter-follower transistors Q_4 and Q_5, which isolate the input stage from the rest of the circuit. The isolation helps preserve the gain of the input stage by reducing the loading effect of the following stages. The negative voltage at the emitters of Q_4 and Q_5 is connected to ground (or to an alternative voltage—see below) through the voltage divider network R_{10}, R_{11}, R_{12} and R_{13}, and establishes a less negative voltage at the base of transistor Q_8. This voltage remains constant regardless of the presence of a signal; therefore Q_8 operates as a grounded-base amplifier, with its base at a fixed negative voltage instead of at ground.

The emitters of Q_6, Q_7 and Q_8 are all electrically common and are approximately 0.75 volt more negative than the base of Q_8. But that base is more positive than the bases of Q_6 and Q_7, considerably more so than 0.75 volt, because of the voltage divider. Therefore Q_6 and Q_7 are reverse biased and do not conduct.

When the amplifier is quiescent, pins A and B are at the same potential, a few volts below ground. The differential pair Q_1 and Q_2 conduct. A small current passes through Q_8 and R_{14} to the −12 volt power supply. If a voltage appears between pins A and B, one of the input transistors—say Q_1—will conduct less and the other will conduct more. The collector of Q_1 becomes more positive, and this level is transmitted through Q_4 to the base of



Adjustable threshold and choice of positive or negative output pulse are features of this general-purpose sense amplifier. The threshold is established by the connection of pin H or I to ground or to a positive or negative voltage, directly or through a resistance; thus there are three ways to adjust it. For a negative output pulse, pins F and G are connected together; for a positive output pulse, pins E and G are connected.

Q_6, which turns on (if the input signal is large enough). A signal of reversed polarity between A and B will pass through Q_2 and Q_5 and will turn on Q_7. This passes additional current through R_{14}, raising the potential at the three common emitters and turning off Q_8.

Positive or negative

If pins F and G are connected together, and E is disconnected, the current through Q_8 passes from the +5 volt power supply through resistor R_{16}. Transistor Q_9 does not conduct. When Q_8 turns off, this current is diverted into the base of Q_9, which then becomes saturated. Its current flows through a connection between pins L and K; when it turns on, the voltage at K decreases sharply and a negative output signal is generated.

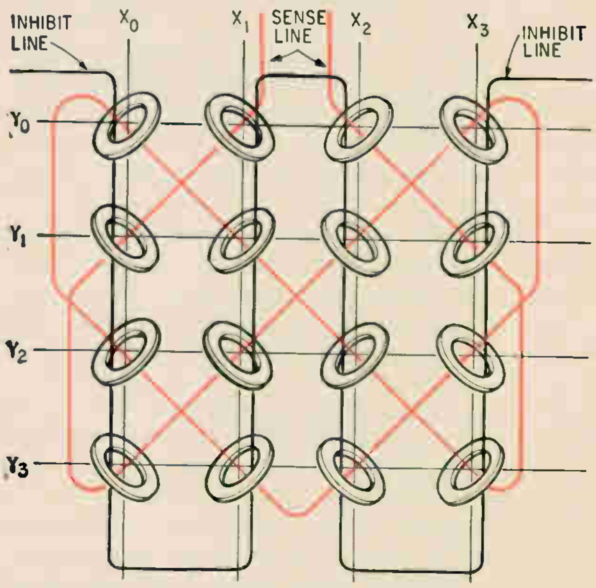
On the other hand, if pins E and G are connected, and F is disconnected, the current through Q_8 comes through the diode D_1. There is no diversion

Memory windings

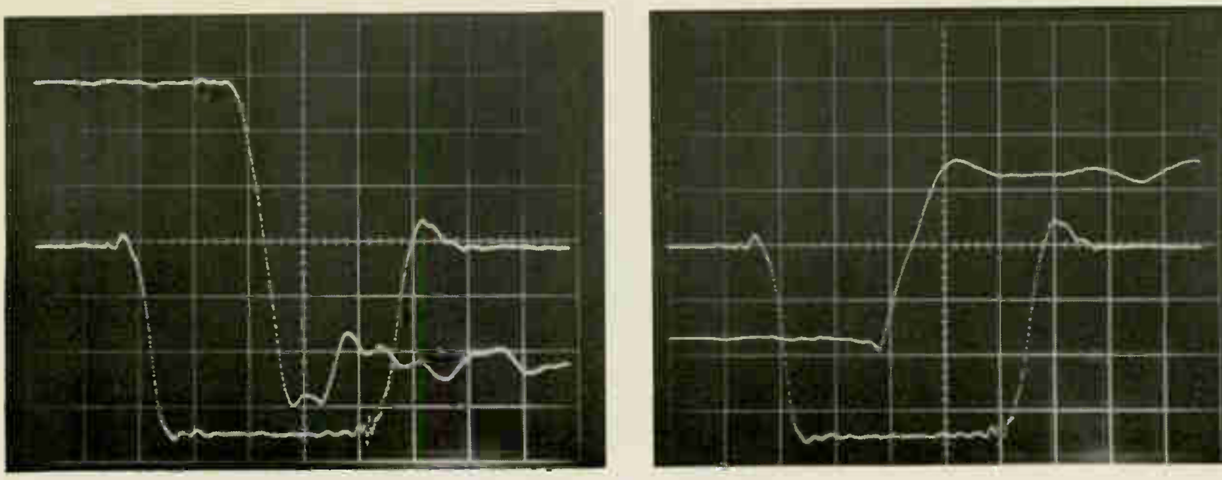
The diagram at the right identifies the various windings ordinarily used in a coincident-current memory. Half-select currents, too small to switch the magnetization state of the ferrite cores alone, pass through one x and one y winding. The total or full-select current flowing through the two wires is large enough to switch the one core through which both wires pass. The direction of the current forces the core into the 0 state; if it is already in that state, then it does not switch and no output pulse is generated. But if the core was previously in the 1 state, then it switches to 0; the change in magnetization generates a pulse in the sense winding; this winding passes through all cores in the plane.

The inhibit winding controls the writing of new data into the memory. Half-select currents pass through the x and y windings in the opposite direction to that for reading, so that a single core tends to switch into the 1 state. If that core is intended to remain in the 0 state, an opposing current passing through the inhibit winding insures that it does not switch.

Coincident-current memories are made of a stack of planes like the one in the diagram. Typical sizes are from 32-by-32 up to 100-by-100, wired in a pattern similar to the 4-by-4 in the diagram. All the x windings are connected in series and so are all the y windings. A current on one x and one y



winding therefore selects a single core in each plane; if the planes are horizontal, the selected cores will be in a vertical column through the stack. Each plane corresponds to one bit in a word, and contains one bit of every word in the memory. Each plane has its own individual sense winding and inhibit winding passing through every core in the plane.



A 17-millivolt input pulse 100 nanoseconds wide (left) produces a negative output pulse less than 60 nanoseconds later. A similar pulse (right) can produce a positive output pulse with a similar propagation delay.

of Q_9's base current, so that Q_9 is normally saturated. When a signal turns on either Q_6 or Q_7, the base current is diverted from transistor Q_9 to the collector of Q_6 or Q_7; Q_9 cuts off, the voltage at K increases sharply and a positive output signal is generated.

When the sense amplifier is one of a group operating from a single memory stack, pins L and K are connected on each amplifier. But when several stacks are operated individually, each feeding information into a single processors, the outputs from the various stacks must pass through an OR gate. (One can also visualize other situations where outputs of several sense amplifiers must pass through an OR gate.) The easiest way to combine the outputs of several amplifiers (provided the outputs are negative) is to omit the connection between pins L and K on all but one amplifier and then connect all the pins K on all the amplifiers with the first logic circuit in the data path of the processor. Then when any one transistor Q_9 turns on, the common connection becomes negative and acts like a negative-input OR gate.

The number of amplifiers that can be operated in parallel this way depends on the parallel resistance of all the output transistors in the cutoff state, the capacitance of the interconnecting wires and other system factors. Amplifiers of this design connected for positive outputs cannot be operated in parallel; their output transistors are normally saturated, and cutting off one of them will not cause the common connection to become positive because the remaining transistors will hold it down.

The photographs shown above are oscilloscope traces of the amplifier's performance for positive and negative outputs. Both photos show an input pulse 100 nanoseconds wide and 17 millivolts high. In each case the amplifier reaches its output level in less than 60 nanoseconds. The trailing edge of the output is not shown in the photos; its delay and transition time can be different, depending on the circuit driven by the amplifier and on the distributed capacitance along the wire that connects the amplifier with its driven circuit.

Adjusting the threshold

The reverse bias on transistors Q_6 and Q_7 controls the threshold voltage of the amplifier. Several different ways to adjust the threshold level are available. The description of circuit operation assumed that pin I was connected to ground. But if either pin H or pin I is connected to ground, or to some positive or negative voltage, directly or through a resistance connected in series or in parallel with R_{13}, the bias on the two transistors and hence the threshold level will be affected.

Including the effects of a resistor R_x and a threshold-controlling voltage V_x, either of which can be zero, the voltages at the emitters of Q_6 and Q_7 are:

$$V_{eQ_6} = (V_{eQ_4} - V_x)\left[1 - \frac{\frac{1}{2}R_{11}}{\frac{1}{2}R_{11} + R_{12} + R_{13} + R_x}\right] - V_{beQ_8}$$

$$V_{eQ_7} = (V_{eQ_5} - V_x)\left[1 - \frac{\frac{1}{2}R_{10}}{\frac{1}{2}R_{10} + R_{12} + R_{13} + R_x}\right] - V_{beQ_8}$$

The two expressions are identical except for the components involved. The term V_{beQ8} is the base-to-emitter voltage drop on the transistor Q_8; all other voltages are measured to ground. Since the bases of Q_6 and Q_7 are connected directly to the emitters of Q_4 and Q_5,

$$V_{eQ_4} = V_{bQ_6} \quad \text{and} \quad V_{eQ_5} = V_{bQ_7}$$

Then the reverse bias on Q_6 and Q_7 is:

$$V_{bQ_6} - V_{eQ_6} = V_x + \frac{(V_{bQ_6} - V_x)\,(\frac{1}{2}R_{11})}{(\frac{1}{2}R_{11}) + R_{12} + R_{13} + R_x} + V_{beQ_8}$$

$$V_{bQ_7} - V_{eQ_7} = V_x + \frac{(V_{bQ_7} - V_x)\,(\frac{1}{2}R_{10})}{\frac{1}{2}R_{10} + R_{12} + R_{13} + R_x} + V_{beQ_8}$$

To forward bias either Q_6 or Q_7, a positive signal voltage that exceeds the reverse bias by the base-to-emitter voltage or more must be delivered to the base. The three transistors Q_6, Q_7 and Q_8 are nominally identical, and therefore have equal base-to-emitter voltage drops. Thus the required signal voltage is the middle term in either of the previous pair of equations. This voltage divided by the single-ended gain of the input stage (about 50) defines the threshold voltage of the amplifier. The effects of R_x and V_x on the threshold voltage are shown in the graphs at the right.

Symmetric response

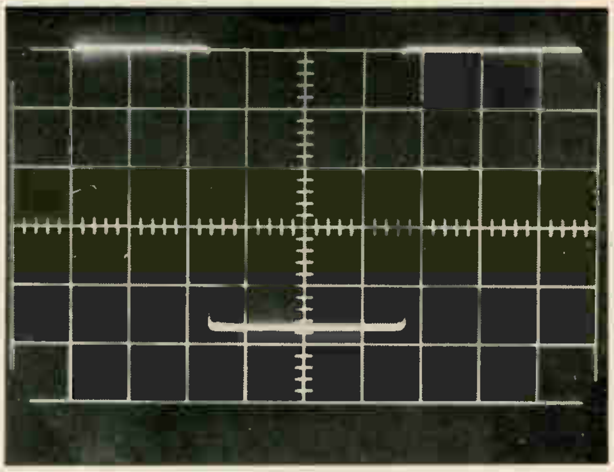
The voltage transfer characteristic shown in the photo at the right is the amplifier's output plotted against an input of an a-c voltage with an amplitude of 80 millivolts peak to peak. Pin I was connected directly to ground for this test. The photo shows that the amplifier's 17-millivolt threshold level is highly symmetric—that is, the amplifier responds in the same way to positive and negative signals of equal amplitude. To obtain this symmetry or low offset, the two input transistors should have the same base-to-emitter voltage drop—within ½%—when conducting, and the collector resistors must match within two or three percent. The matching of the resistors is less critical than that of the voltage drops, because their value has less effect on threshold level.

The Sylvania sense amplifier has a threshold whose uncertainty is very low. Less than 1 millivolt increment in the input voltage causes output to change from a logic 1 to a logic 0 or vice versa. This low uncertainty may be attributed to the operation of transistor Q_8 and to the amplifier's high differential gain. The input stage amplifies the input signal by a factor of 50 and applies it to transistor Q_6 or Q_7. These transistors possess high transconductance so that an increasing voltage as small as 50 millivolts applied to the base generates enough emitter current to raise the collector potential of transistor Q_8 and saturate transistor Q_9. When pins F and G are connected, the collector potential of Q_9 is limited to a minimum of −0.7 volts by diode D_1 and to a maximum of +0.7 volts by the base-emitter junction of Q_9. This clamping action keeps Q_8 in its active region so that it is capable of both high-speed operation and voltage gain. When no signal is present, the transistor draws about 2.4 milliamperes. About 1.2 milliamperes of this current comes through diode D_1 and the rest through R_{16}. The conducting diode establishes the collector potential of Q_8 at −0.7 volts. To raise this collector potential to +0.7 volts, the D_1 diode current must be reduced to zero, and the voltage drop across R_{16} reduced by 1.4 volts. Therefore the Q_8 collector current must be decreased by $1.2 + 1.4/R_{16}$. One and a half milliamperes of current from either Q_6 or Q_7 will effect this reduction and will cause a change in the logic state of the amplifier output.

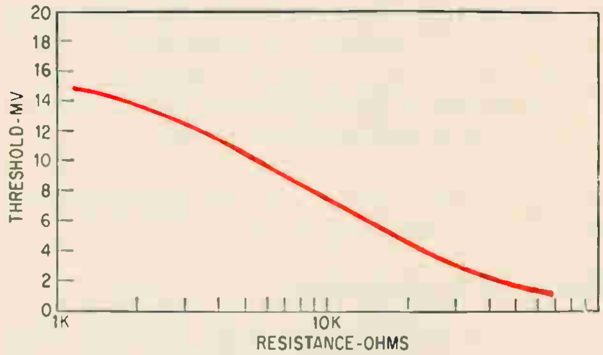
With this information, an equation may be written that relates input threshold uncertainty to amplifier and transistor characteristics. Calling the threshold uncertainty ΔV_t,

$$\Delta V_t = \frac{1.2 + \dfrac{1.4}{R_{16}}}{(G)\,(g_m)}$$

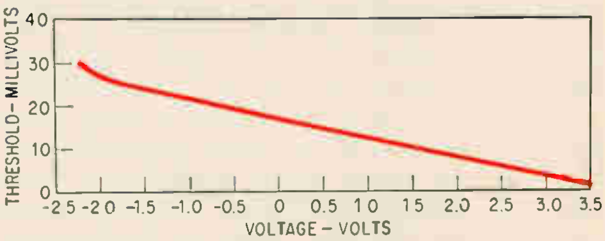
where G equals 50, the gain of the input stage, and g_m equals the transconductance of Q_6 or Q_7, which



An a-c input signal 80 millivolts peak to peak produces a 5-volt output signal. Less than 1 millivolt incremental voltage causes the output to switch; the positive and negative thresholds are both 17 millivolts, symmetrical with respect to ground.



Threshold voltage can be varied by changing the resistance between pin I and ground.

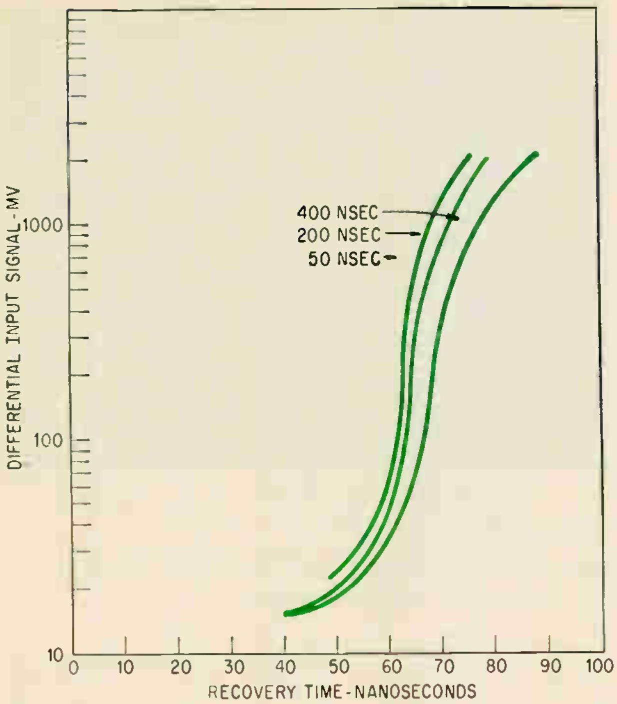


Threshold voltage can also be varied by applying a voltage at pin I.

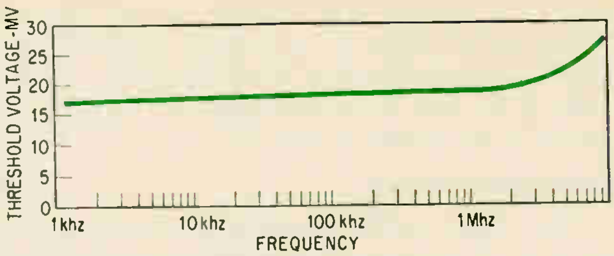
is equal to α/R_e; R_e is the a-c resistance of a transistor's base-emitter junction, about 26 volts per ampere. (The factor 26 is the approximate value of the quantity nkT/q at room temperature; k is Boltzmann's constant, T is the absolute temperature, q is the electron charge, and n, about 1, accounts for second-order effects in the junction.) The α of the transistor may be considered approximately unity, so that

$$\Delta V_t = \frac{\left(1.2 + \dfrac{1.4}{R_{16}}\right)(26)}{(50)\,(1)\left(1.2 + \dfrac{1.4}{R_{16}}\right)} = \frac{26}{50} = 0.52$$

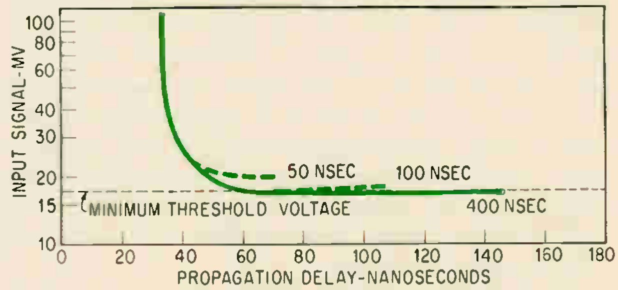
This approximation was checked against experi-



Recovery time depends both on differential overload and on pulse width, but is not seriously high even at inputs greater than a volt.



Frequency response of the sense amplifier, in terms of threshold, is flat up to one megahertz or more. Above that frequency the threshold voltage increases, reaching +3 db at 7 Mhz.



Propagation delay depends on amplitude of input pulse to 60 millivolts and on the width of the input pulse to a smaller extent.

mental evidence, and agreed well within the accuracy of the testing equipment.

Resistance to overloading

To block common-mode noise voltages, which may reach several volts, the input stage of a sense amplifier must have a large reverse bias across its collector-base junction. Otherwise, a common-mode signal may drive the input into either cutoff or saturation and the amplifier will not work. The input stage of Sylvania's sense amplifier has several volts of common-mode protection provided by a —12 volt power supply that biases the bases of the input transistors to 8 volts below their collectors. The —25 volt supply biases transistor Q_3 which also is strongly reverse biased. With these large reverse biases, the input stage can function normally even in the presence of large common-mode voltages. Common-mode pulses varying from 10 to 100 nanoseconds and up to 2.5 volts have been applied to the amplifier without affecting its output. The amplifier can reject larger common-mode sinusoidal voltages.

Large reverse biases on the input transistors also improve amplifier recovery from differential overloads. When a large differential signal appears at the base of Q_1, the constant-current source Q_3 limits the collector voltage of Q_1 to —7.8 volts. Since the bases of Q_1 and Q_2 are biased at —12 volts, the transistors will not saturate and recovery delays due to storage time are avoided.

Sense amplifier recovery time, as shown above, is relatively independent of pulse width. Even when differential overdrive exceeds 1 volt, recovery time is less than 75 nanoseconds.

High-frequency operation

The frequency response of the sense amplifier input stage should be high to avoid degrading the input signal's waveform, which would increase propagation delay in the amplifier.

The frequency at which roll-off begins for the Sylvania sense amplifier is 7 Mhz, as shown above. The graph shows the frequency response in terms of threshold voltage instead of in terms of power output, as is customary in audio and r-f amplifiers; the threshold voltage increases beyond the roll-off frequency in much the same way that power output decreases. The roll-off frequency is called the —3 db point as if power output were being measured. The 7-Mhz level is high enough to satisfy bandwidth requirements of most medium- and high-speed core memories. It reduces propagation delay in the amplifier to about 50 nanoseconds.

The chart above displays propagation delay versus input signal amplitude for various pulse widths. As the pulse width decreases, both threshold voltage and propagation delay increase, because of the finite bandwidth of the input stage. However, the overdrive above the low-frequency threshold voltage required to keep the propagation delay less than 60 nanoseconds increases only slightly as pulse widths are narrowed. For example, a 50-nanosecond pulse requires less than 15% overdrive above the 17-millivolt threshold to keep amplifier propagation delay under 60 nanoseconds. The high-speed operation and the fast recovery time make Sylvania's integrated-circuit sense amplifier useful in high-speed memory systems that have narrow output pulses and cycle times of less than one microsecond.

Circuit design

Designer's casebook

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

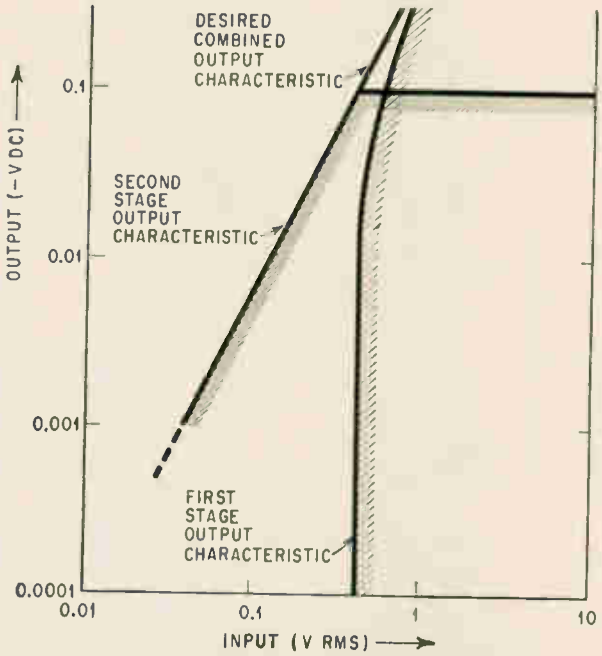
Square-law detector has 40-db dynamic range

By Robert J. Matheson

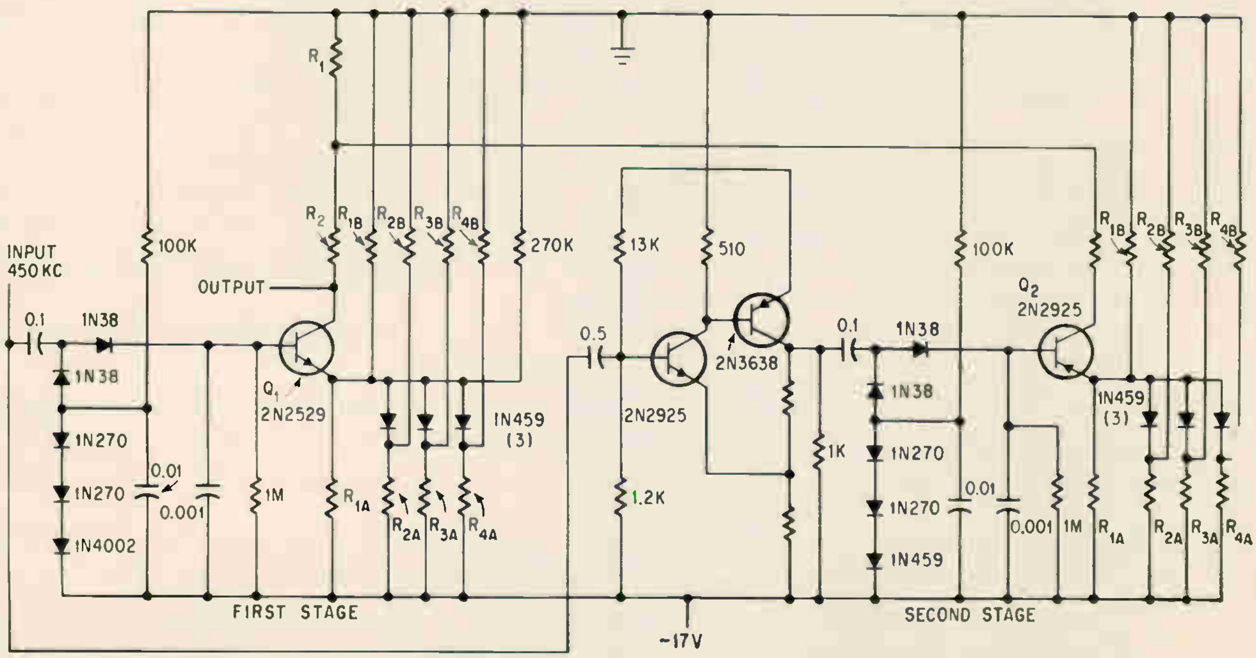
Institute for Telecommunication Sciences and Aeronomy, Boulder, Colo.

A diode network and detector circuit provides an output proportional to the square of an input voltage. It has a 40-decibel input range, uses no critical or expensive components and is easily extended to larger dynamic ranges, if required. This circuit replaces such devices as thermal converters, second-harmonic generators and diode-shaping networks in metering circuits.

Splitting its 40-db input range into two 20-db segments avoids limitations such as high-amplitude saturation and low-amplitude drifts and nonlinearities inherent in other diode network schemes [see plot directly below]. Two identical stages operating



Output characteristics required to give a square-law device with a smooth transition between stages.



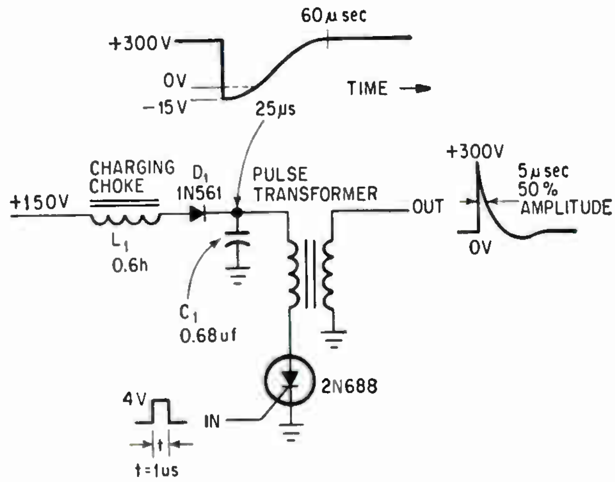
Diode network in series with the emitter lead of transistor Q_1 is the key to circuit operation. It causes the effective emitter resistance to decrease as the emitter voltage increases. Thus Q_1 acts as a current source and produces an output current proportional to the square of the base voltage. Values for resistance are as follows: R_{1A}, R_{3A} = 3.18K, R_{1B} = 57.9K, R_{3B} = 18.75K, R_6 = 3K, R_7 = 10, R_{2A}, R_{4B} = 5.06K, R_{4A} = 1.86K, R_{2B} = 64.2K, R_8 = 300 and R_8, R_9 = 990.

itor's discharging effect [see wave shapes].

An important aspect of the circuit's design is protection against accidental turn-on of the scr during the charging cycle. If low-level noise or reflections from the load were to cause such a turn-on, the entire 150-volt supply would be shorted to ground, blowing a fuse or tripping a circuit breaker in the protection circuitry [not shown].

The scr is conducting during approximately the first 10 microseconds after triggering, so false triggering pulses have no effect. For the next 15 μs, C_1 and L_1 are ringing and the voltage at C_1 is negative as shown in the waveform; the negative voltage back-biases the scr, preventing a false triggering pulse from turning on the scr. At 25 μs after triggering, when the voltage at C_1 is zero or rising, the scr is vulnerable to false turn-on by low-level noise pulses for a period of 5 μs. However, this time interval occurs long enough after discharge so that most reflective pulses have been dissipated. The circuit's 5-μs interval of vulnerability is much briefer than those of comparable scr triggering circuits and constitutes the circuit's principal advantage.

At 30 μs after discharge, and certainly by 40 μs, there is enough charge on the capacitor to forward bias the scr and a large triggering pulse is again required to turn it on. By 60 μs after discharge C_1 is again charged up to +300 volts and the circuit is ready for the next triggering pulse. The circuit's maximum pulse repetition rate is 12 khz, leaving about 80 microseconds between pulses.



Capacitor C_1 is charged by the supply through charging choke L_1 and diode D_1 to 300 volts. An incoming trigger pulse turns on the scr, discharging C_1 through the primary of the pulse transformer and producing a 300-volt spiked output pulse. The ringing of L_1 and C_1 turns off the scr.

Scr bridge inverter eliminates transformers

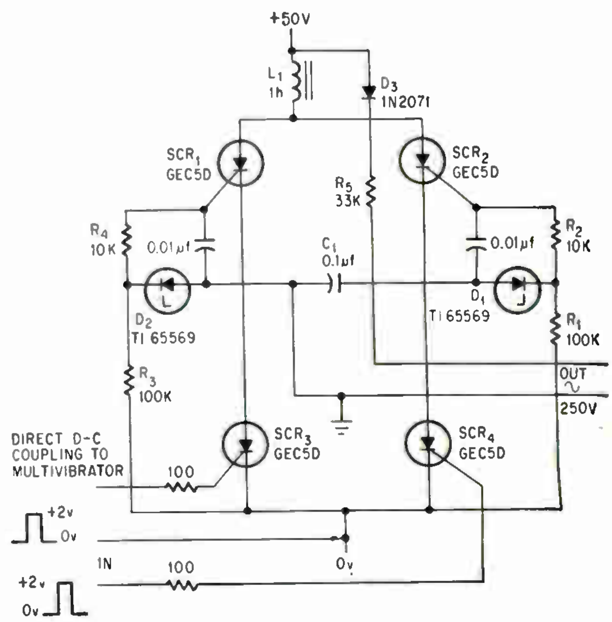
By L.M. Tibbets

Electronic Tube Division,
Sylvania Electric Products, Inc., Emporium, Pa.

A bridge inverter's cost can be cut in half by slave-triggering two silicon-controlled rectifiers with a capacitive load. Slave-triggering eliminates bulky and expensive gate transformers and enables the entire inverter to be easily mounted on a printed circuit board. The circuit at the right was designed as part of a power supply for an electroluminescent panel serving as a capacitive load.

The bridge circuit is directly coupled to a multivibrator which drives it with staggered square pulses, each 2 volts in amplitude. The input pulses drive SCR_3 and SCR_4 directly while SCR_1 and SCR_2 are slave-driven by the capacitive load C_1.

Slave triggering is an indirect switching technique, employing two or more switches, in which secondary or slave devices are turned on automatically by the energy released when a primary device, the master trigger, is fired. In this circuit, for example, slave triggering is illustrated by the sequential switching during the second half-cycle of bridge operation. Only the master trigger, SCR_3, is turned on directly; the firing of SCR_3, however, switches load C_1 into a position where it turns off SCR_4 and generates a switching signal to turn on SCR_2 (which



Capacitive load C_1 slave triggers SCR_1 and SCR_2, eliminating the need for gating transformers.

then turns off SCR_1). Thus the other three active elements in the bridge are all turned on or off by the firing of SCR_3.

An input of 800 pulses per second (both half-cycles of a 400-hertz multivibrator) gives a 400-hz output. Bridge switching inverts the second pulse of each successive pair of pulses while choke L_1 and load capacitance C_1 resonate in series to shape the resulting square wave to a sine wave with a peak amplitude of 350 volts.

An initial positive charge is placed on the right side of load capacitor C_1, through diode D_3 and resistor R_5 to prepare the circuit for bridge operation. The first half-cycle begins when a pulse turns on SCR_4; C_1 is then discharged through SCR_4, R_3 and D_2, placing 10 volts across the gate-cathode junction of SCR_1 and turning it on. C_1 now charges rapidly through the path L_1, SCR_1, C_1 and SCR_4, making the left side of C_1 positive.

While this charge on C_1 is still intact, a second pulse turns on SCR_3, placing the entire C_1 voltage across SCR_4, reverse biasing it and shutting it off. The C_1 voltage also sets up a current flow through R_1 and D_1; the resulting 10-volt drop across D_1 turns on SCR_2. With SCR_2 conducting, the anode of SCR_1 is shorted to the right side of C_1. This reverse biases SCR_2 and shuts it off. With a second charging path L_1, SCR_2, C_1 and SCR_3 established, C_1 charges rapidly in the opposite direction, and the cycle begins over again.

Feedback improves parallel-T filter

By James Strattan,

High Fidelity Recording, Wichita, Kan.

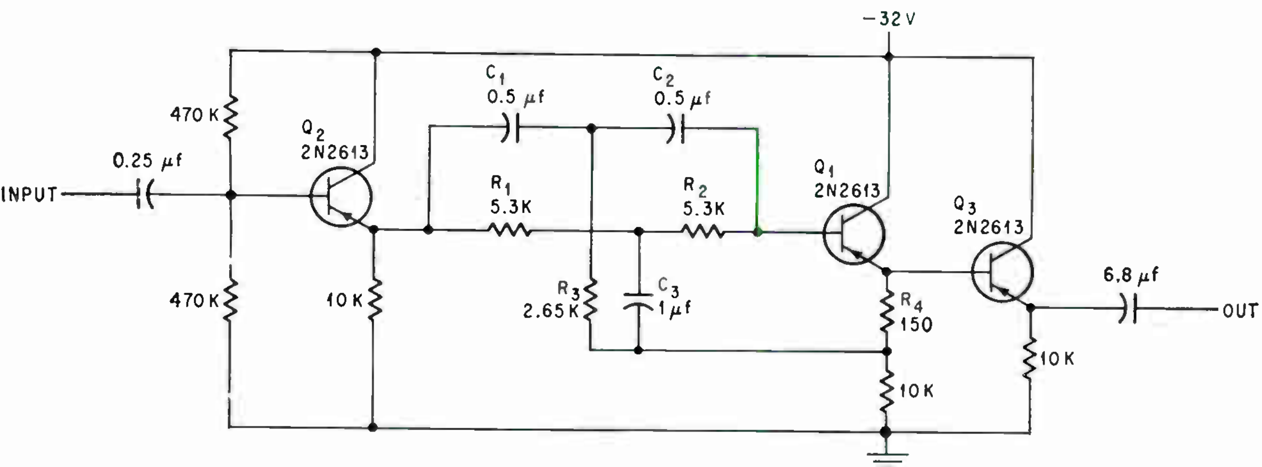
A single-transistor feedback circuit reduces the high attenuation in the pass band that severely limits the conventional T-notch filter.

Without feedback, a 60-hertz filter having the component values shown below for R_1, R_2, R_3, C_1, C_2 and C_3 will have a Q factor of 0.25. The addition of feedback between the collectors of Q_1 and Q_2 (the feedback transistor) improves the response by a factor of 80. Thus, the filter response is down 1 decibel at 62 hertz. For 120 and 180 hertz, capacitor values C_1, C_2 and C_3 decrease proportionally from those at 60 hertz.

The emitter-followers, Q_2 and Q_3, minimize the effects of source and load impedances.

The best results are obtained when preliminary adjustments on the parallel T are made with somewhat less feedback than the 150-ohm resistor, R_4, provides. To reduce the feedback, R_4 should be increased to approximately 680 ohms. If R_4 is replaced by a potentiometer, the feedback can be varied. Replacing Q_1 with a transistor of higher beta, such as a 2N3390, reduces the loss through the circuit at frequencies below 60 hertz.

A basic application for this circuit is in reproducing stereo tape, where the design salvages signals normally buried far below the noise level of the original tape recording.



Transistor Q_2 provides feedback for the parallel T-notch filter. Values shown for components are designed for 60 hertz. For 120 and 180 hertz decrease capacitor C_1, C_2 and C_3 values proportionally. Control of the rejection bandwidth is provided if the 150-ohm resistor is made variable to 680 ohms. This is done with a potentiometer.

Graphs reveal reasons for high cost of maintenance

Nomograph reduces man-hour calculations and provides an easy way to pinpoint maintenance procedure problems

By G.W. Corley and Harold Faecher

Westinghouse Defense and Space Center, Baltimore, Md.

Maintenance stands out as one of the major factors in the operational cost of avionics and airborne weapons systems. About one-fourth of the annual Department of Defense budget is spent on it.

To measure this factor the parameter "maintenance man-hours per flight hour" (MMH/FH) was set up. This parameter can be calculated in three ways: by using inputs based on performance predictions, field data on similar equipment and engineering data from pilot production.

The nomograph on page 102 developed from a need to cut down on the number of calculations required. It presents all the factors contributing to maintenance man-hours per flight hour for any system, and permits rapid analysis of the effects of changes in system maintenance procedures. The nomograph is based on the equation

$$\frac{MMH}{FH} = \frac{(M_{cto}\times F_c\times P_o + M_{ctf}\times F_c\times P_f)\ K + (M_{pt}\times F_p\times P_p)}{N}$$

which is an expanded version of the maintainability equation found in Military Standard 471. (Mil-Std 471 will supersede Mil-Maintenance 26512). The equation is general enough to evaluate other systems, including ground transportation systems and complex weapons systems.

The example illustrated on the nomograph is an airborne high-frequency voice communications transceiver in need of repair. It is designed to be removed from the aircraft, replaced at the flight line and repaired at the field shop. For this particular unit, the following factors are determined:

MTBF (mean time between failures) = 210 hours
M_{cto} = 0.25 hours
M_{ctf} = 4 hours
M_{pt} = 7.5 hours

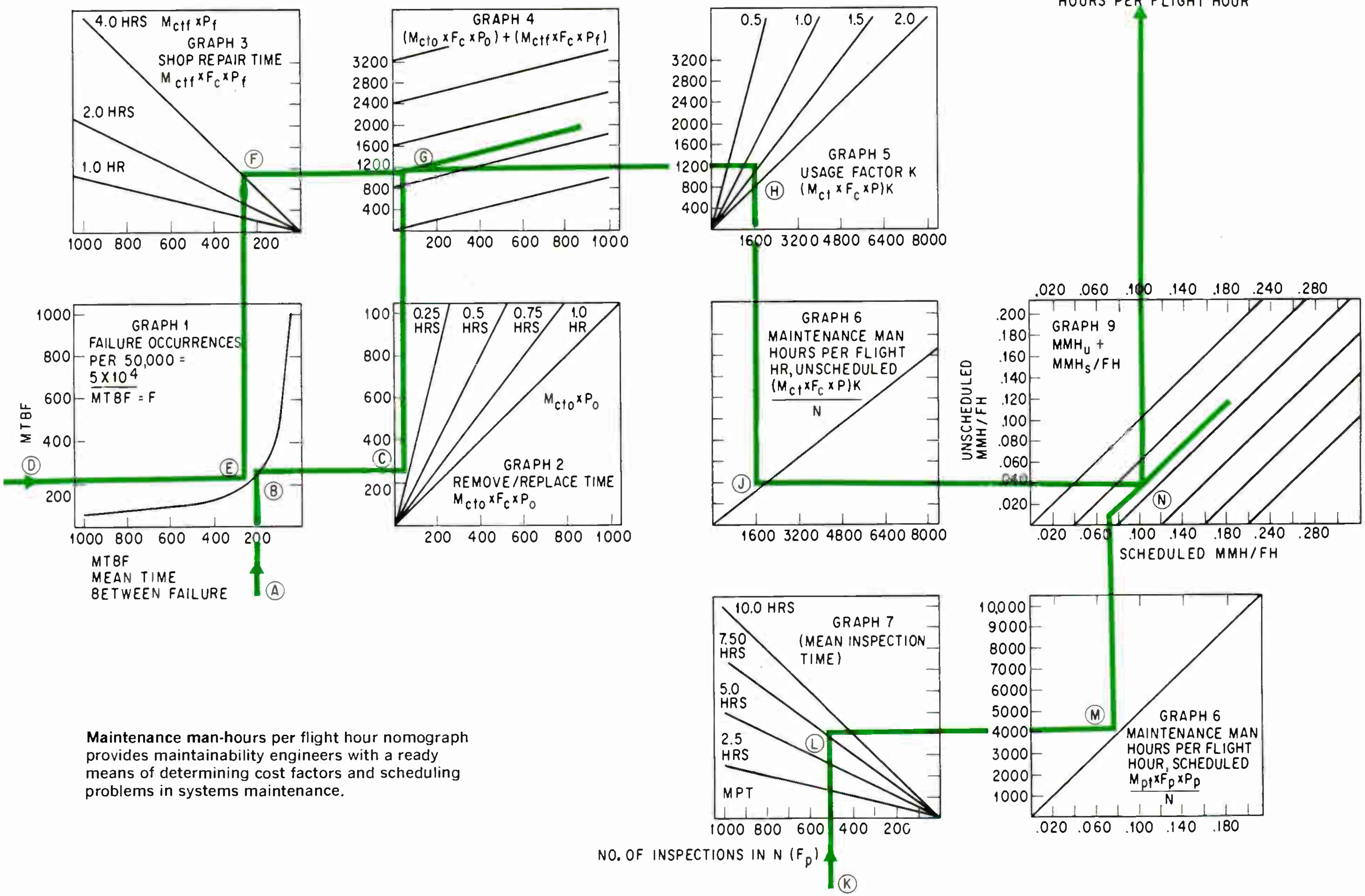
In this case, the number of preventive maintenance actions in a given time interval, N_P, is calculated by dividing the total operating time N of 50,000 hours by the average time between preventive maintenance actions. Thus $N_P = 50{,}000/100 = 500$.

The number of operating hours is 1.5, since for every hour of flight, an additional 0.5 hour is devoted to ground checks, runway holding patterns and other tests.

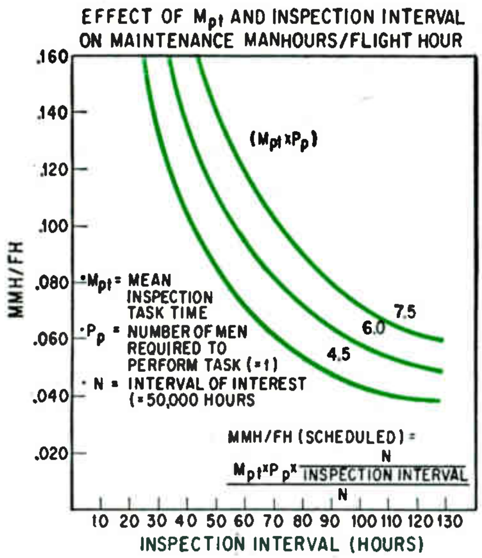
Glossary of maintenance terms

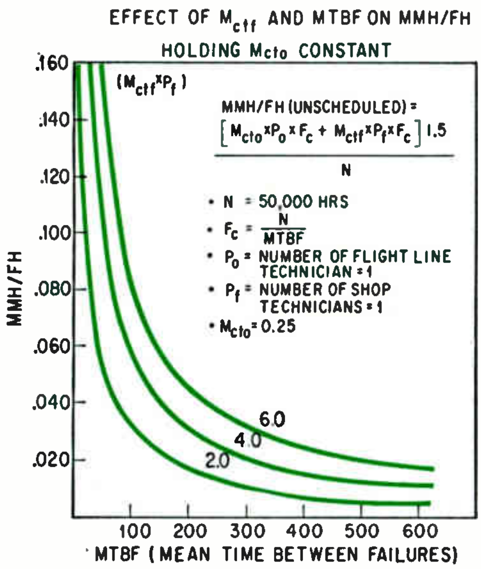
- M_{cto} = mean active corrective maintenance time (arithmetic mean) at the organizational level (flight line).
- M_{ctf} = mean active corrective maintenance time (arithmetic mean) at the field shop level.
- M_{pt} = mean active preventive maintenance time (arithmetic mean).
- F_c = number of expected corrective maintenance tasks occurring during the representative operating time period (N).
- F_p = number of expected preventive maintenance tasks occurring during the representative operating time period (N).
- P_o = average number of personnel required to perform organizational level corrective maintenance.
- P_f = average number of personnel required to perform field shop level corrective maintenance.
- P_p = average number of personnel required to perform preventive maintenance.
- K = average operating hours per flight hour. This is a constant normally greater than one since the equipment is operated on the ground during maintenance checks in addition to being operated in flight.
- N = an arbitrary number of operating hours, usually very large compared to equipment failure rates.

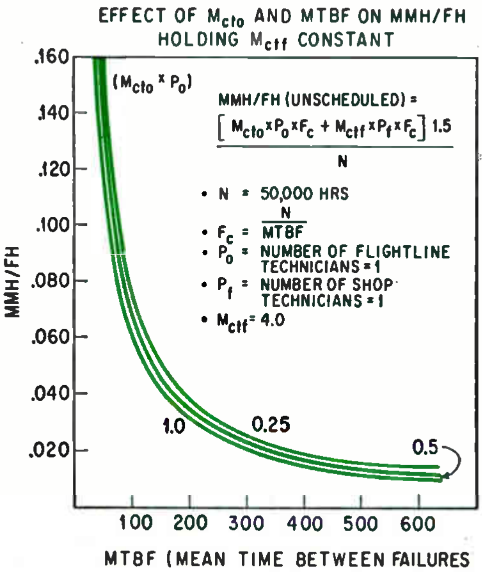
Examining cost and scheduling problems



Maintenance man-hours per flight hour nomograph provides maintainability engineers with a ready means of determining cost factors and scheduling problems in systems maintenance.







Sensitivity curves for use with nomograph. Analysis shows the effect of changes in maintenance procedures.

Additional analysis shows that $P_o = P_f = P_p =$ 1 man.

Procedure

The nomograph can now be used to determine the major contributors to the maintenance burden of the airborne receiver.

- Enter graph 1 at point A (MTBF = 210 hours) and proceed vertically to point B. Point B represents the number of expected corrective maintenance actions (F_c) in a given time interval N (50,000 hours was the time interval used in the preparation of this example).
- From point B move horizontally on graph 2 to intersect the line representing 0.25 hours (M_{cto} x P_o) at point C.
- Enter graph 1 at point D (MTBF = 210 hours) and proceed horizontally to point E.
- From point E move vertically on graph 3 to intersect the line representing 4 hours (M_{ctf} x P_f), at point F.
- From points C and F move vertically and horizontally to sum the two quantities on graph 4 at point G.
- From the summing point (point G) move horizontally on graph 5 to intersect the line representing the usage factor (K) of 1.5 (operating hours per flight hour) at point H.
- From point H move vertically to intersect the line on graph 6 at point J; then move horizontally on graph 9 to determine the unscheduled maintenance man-hours per flight hour (0.029).
- Enter graph 7 at point K (N_p = 500) and proceed vertically to intersect the line representing 7.5 hours (M_{pt} x P_p) at point L.
- From point L move horizontally to point M on graph 8 then vertically to point N in graph 9.
- Sum the scheduled and unscheduled maintenance times on graph 9 as shown (0.104 MMH/FH).

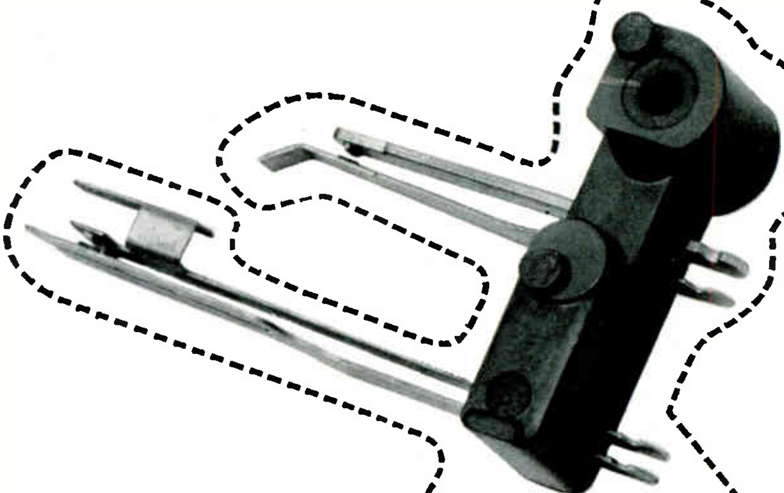
For this example, the nomograph clearly shows that the man-hours given to preventive maintenance (periodic inspections) far exceed time spent on corrective maintenance. If the predicted maintenance man-hours per flight hour of 0.104 must be reduced to 0.09 to meet a contractual requirement, a more detailed analysis is required. A study of the nomograph and the sensitivity curves at the left shows that this can be accomplished by any one of the following:

- Increase mean time between failures from 210 to 425.
- Decrease shop repair time (M_{ctf}) from 4 hours to 1.85 hours.
- Increase interval between periodic inspections from 100 hours to 125 hours.
- Decrease mean inspection time (M_{pt}) from 7.5 hours to 6.1 hours.

Once each approach has been analyzed and its cost factors and schedule impact determined, a trade-off study will show which approach or combination of approaches will eventually be the most economical.

Any material that can help Western Electric cut down its phone bill must be something.

Something called Plaskon Epoxy.



This phone dial relay switch used to be molded of soft-flow phenolic. Now it's made of a stronger, more versatile Plaskon® epoxy molding compound. Because of that, Western Electric was able to eliminate an expensive metal flange with no loss of strength. And at a substantial saving, considering the millions of parts that were made.

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Divic gives answers to complex navigation questions

A special algorithm and a unique combination of digital and differential processing techniques make up a microelectronic computer that solves problems in hyperbolic navigation systems

By Joseph A. Parini
Lear Siegler, Inc., Instrument Division, Grand Rapids, Mich.

A computer that combines the speed of a digital differential analyzer with the flexibility and accuracy of a general-purpose machine is being flight-tested for use with a wide variety of air navigation systems. The computer, developed by the Instrument division of Lear Siegler, Inc., can solve problems in spherical trigonometry and computes with an algorithm that permits flexible design and high speed, but doesn't require a large memory.

The computer, called Divic, for digital variable increment computer, was built for the United States Coast Guard and the Federal Aviation Agency. The key to Divic is its ability to be adapted to various navigation systems. Divic is constructed of monolithic integrated circuits and has a stored program in a core-rope memory which can be replaced easily if the application of the computer must be changed. Flight tests will continue through autumn and 20 computers will be built for the Coast Guard for delivery in early 1967. Lear Siegler anticipates orders for a great many more computers, and is considering modifying the design for commercial aircraft.

A prototype version of Divic was flight-tested in 1964. It was built of thin-film hybrid microcircuits assembled in standard packages. It followed a parallel processing-serial arithmetic organization and its program was wired into the machine.

Both versions of the Divic are more accurately described as hyperbolic-coordinate converters. An aircraft's location is given in terms of the intersection of two hyperbolas in navigation systems such as loran, Omega, or Decca. However, this information must be translated into latitude and longitude to be intelligible to the pilot, and the translation also can provide range and bearing information [see panel, pp. 106-107]. The hyperbolas are derived from two time differences between pairs of signals broadcast by three synchronized radio transmitters. The navigation systems have different signal formats (pulse or continuous wave), power, frequency and range. For instance, loran C sends out pulses one millisecond apart in each of three phase-coded pulse trains; the airborne receiver, which is capable of some elementary computation, measures the intervals between the received pulses and produces time-difference signals that are processed manually or by a navigation computer.

Hardware configuration

The improved Divic is a stored-program machine containing two core memories: a core-rope permanent memory, part of which stores the program; and a scratch-pad memory for temporary storage of data. The core rope has a capacity of 2,048 words with 70 bits per word. The scratch-pad memory contains 128 words of 30 bits each. The cores for

The author

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the permanent memory are made of molybdenum permalloy tape ⅛ inch wide, and the temporary memory is made of lithium-ferrite cores.

The integrated microcircuits are attached by gap soldering to printed circuit boards that plug into a "mother" board; the latter interconnects the various modules such as the arithmetic unit, input-output registers and memories [see photograph, p. 111]. With this packaging arrangement, a typical navigation computer that can convert hyperbolic coordinates, compute dead reckoning and perform guidance functions will take up only half a standard rack. A program change provided by a change of the core-rope memory would allow a similar computer to process inertial or celestial equations.

Therefore, the basic Divic computer organization can be used with radio, inertial or celestial sensors, either individually or in an integrated system, in approximately the same configuration. Other hardware changes that would be necessary in changing the purpose of the computer are in the input-output interface between the sensors and the computer, controls and displays. These are required because the signal content varies in rate, form and resolution in the different systems. Therefore, with a defined application, a design engineer can estimate in the early phases of the program the size and weight of the necessary Divic to do the job.

Navigational problem

The time-difference signals that are inputs to the Divic computer may be either analog or digital. For instance, the AN/ARN-78 loran C receiver built by the Sperry Rand Corp. has an optional digital output that produces six binary-coded decimal signals indicating the time difference precise to microseconds. The two time differences are produced alternately. An analog output is produced by International Telephone and Telegraph Corp.'s AN/APN-152 Omega receiver—two lines carrying pulses whose durations are proportional to the time differences measured by the receiver. The Divic computer comes with the proper interface equipment so that it may be used with any kind of autotrack (non-manual) receiver.

Divic must first translate these time differences into hyperbolic coordinates. It then computes the latitude and longitude from these coordinates, using the previously stored position of the transmitters as a reference. The latitude and longitude are displayed on dials for the pilot's reference. With successive values of latitude and longitude,

Finding yourself with hyperbolas

Hyperbolic coordinates were first used during World War II to determine the position of ships at sea. That navigation system was loran, now known as loran A to distinguish it from its successors.

With loran A, a navigator tuned his receiver to pick up pulse signals from three radio stations 200 to 300 miles apart on shore. These signals were carefully synchronized at the transmitters; but in general they were not synchronized when the receiver picked them up, because of propagation delays. The navigator displayed the pulse signals from two stations on an oscilloscope and measured the time difference between them. This time difference told him that he was somewhere along a hyperbola whose focuses were the two stations he was listening to at the moment. (A hyperbola is a curve described by the motion of a point whose distances from two fixed points—the focuses—maintain a constant difference.)

Then the navigator checked the time difference between one of these two signals and the signal from the third transmitter. The second time difference gave him another hyperbola, and the intersection of the hyperbolas was his position at sea. The whole procedure took about three minutes.

If the vessel's navigator found all three signals still in synchronism, just as they were broadcast, then he knew he was at the intersection of the perpendicular bisectors of the straight lines joining the three stations.

Airborne navigators could also take advantage of loran A, except that they had to take a second reading on the first pair of stations and average the two. The reason, of course, was that an aircraft—even of World War II vintage—can travel quite a long distance in three minutes.

Later versions of loran broadcast different frequencies and signal formats, and station spacings were changed to improve range and accuracy. The newer versions also rely on the receiver to generate the time difference directly, so that the navigator or pilot doesn't have to twiddle dials or look at oscilloscopes.

Other hyperbolic-coordinate navigation systems include Decca, Dectra and Omega. Decca and Dectra broadcast continuous-wave signals and the receiver measures phase differences instead of time differences. In Dectra, two of the stations are relatively close together—about 80 miles—so that the hyperbola determined by these stations is nearly straight. Omega is a very low frequency system intended to provide worldwide coverage with only eight stations.

Despite the improvements in the navigation systems the navigator, knowing that he is at the intersection of two hyperbolas, isn't much smarter than he was before. What he really wants to know is his position in latitude and longitude, or even better, the direction and distance to his destination. In the past, he has had several tools to help him.

One scheme gave him a distorted map on which the hyperbolic coordinates were printed directly. This isn't too bad for ships at sea, where there are no landmarks; but for airplanes, especially one-man airplanes in which the pilot must do his own navigating, it's confusing. When the pilot's map tells him he is flying over a round lake and he looks out the window and sees a kidney-shaped lake, that's when he turns off the radio and flies by the seat the computer also computes direction and velocity of the aircraft. Finally, the computer works out the range and bearing of the destination and the cross-track error—distance right or left of course—of the aircraft for course correction.

Because the earth is round, latitude, longitude, range and bearing are all expressed as angles. Therefore, spherical trigonometry is required in all these computations. Bearing is the angle measured eastward from north, varying from 0° to 360°; range is measured in degrees of arc, ordinarily much less than 180°, but displayed in nautical miles. Latitude and longitude, of course, are in degrees of arc, with ranges of —90° to +90° and —180° to +180° respectively.

Algorithm for solution

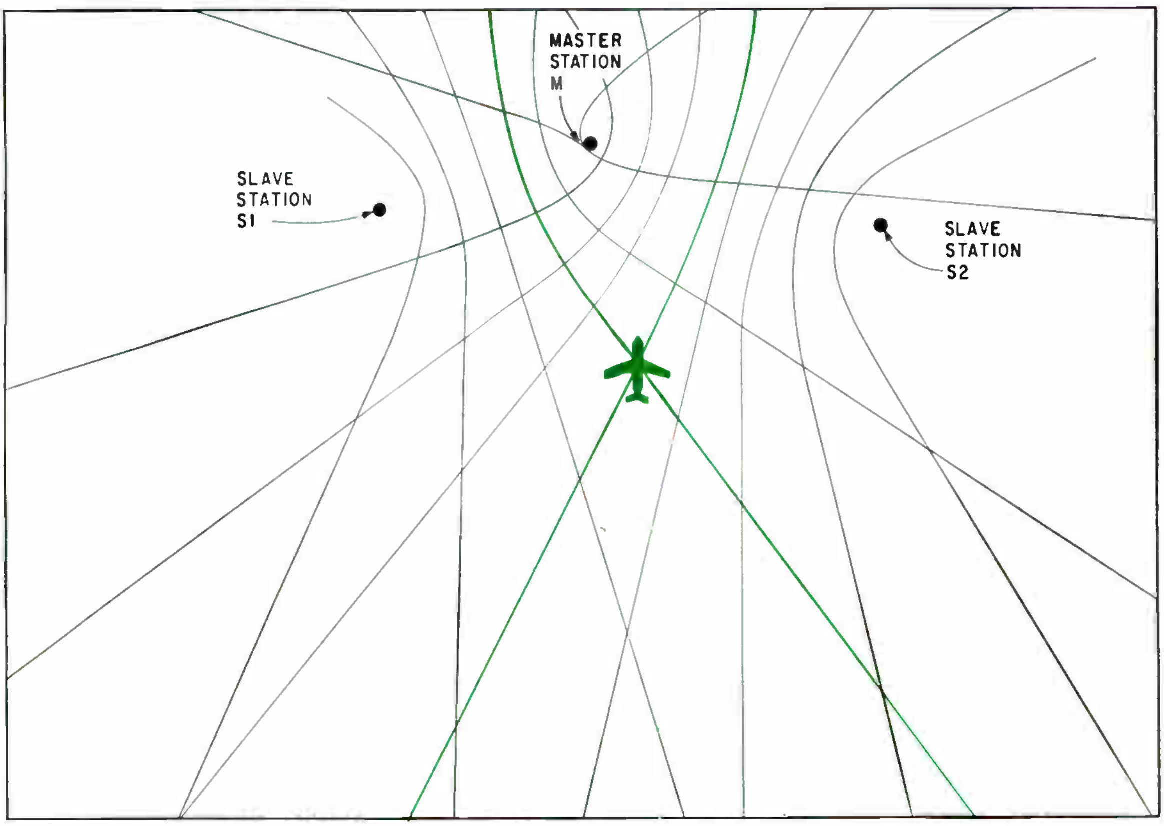
The Divic computer uses the computing algorithm for circular functions that was worked out in 1959 by J.E. Volder.[1] This algorithm provides a method for the rapid evaluation of trigonometric functions and related expressions. The Divic therefore has the accuracy of a general-purpose computer coupled with the speed of a digital differential analyzer—the digital equivalent of an analog resolver.

The equations that relate time differences to latitude, longitude, and other navigational measurements consist of sums and products of sines and cosines [see panel, p. 108]. The Volder algorithm evaluates sines and cosines by an iterative process that is easily implemented in digital circuitry. The same technique can convert rectangular to polar coordinates, and binary to binary-coded decimal numbers, and vice versa, and it can evaluate hyperbolic functions such as sinh u and cosh u.[2] (These hyperbolic functions are only indirectly related to the hyperbolic coordinates that are inputs to the Divic.) At Lear Siegler, the Volder algorithms have been extended to carry out multiplication, division and square root.[3,4]

All the algorithms require four registers for temporary storage of intermediate results, and relate successive values of results by shift-and-add or shift-and-subtract operations. The algorithms differ principally in the convergent series that they use for various functions.

Two categories

In general, computational algorithms—Volder's or any other—may be implemented in a digital computer in either of two ways. The computer may

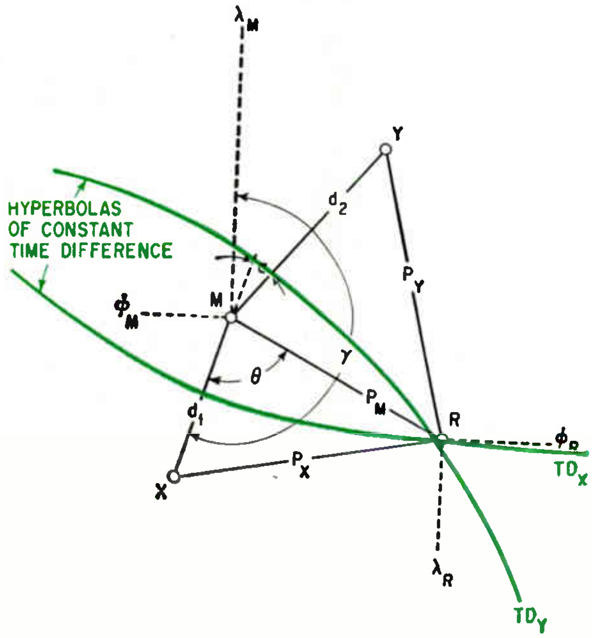


of his pants.

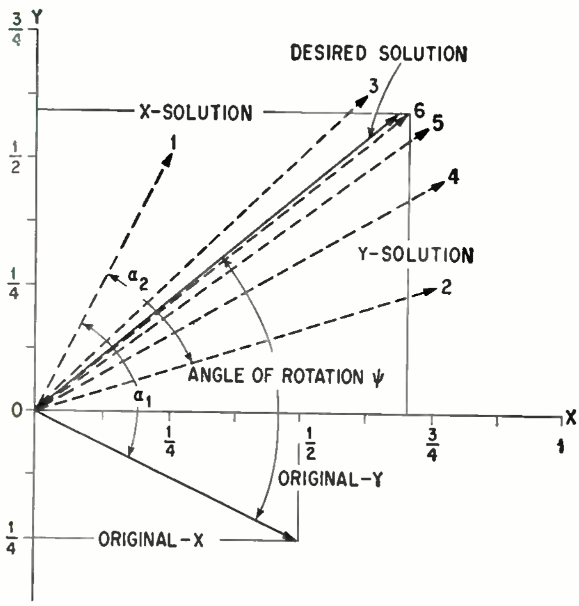
Another way gave the pilot a standard map with hyperbolic lines of position printed on it. This wasn't quite as confusing, but with so many lines going every which way on the map, the pilot of a 600-mph jet can easily go 30 or 40 miles while trying to figure out where he is—or where he was.

How convenient it would be to have an "instant navigator" to make the difficult computations to convert hyperbolic coordinates into latitude and longitude. Divic not only does that but displays the latitude and longitude readings on dials, too.

Equations of position



Two spherical triangles must be solved and the results transformed into position and course data in a hyperbolic coordinate system. The symbols ϕ and λ represent latitude and longitude, respectively; the subscripts represent the master station, M, and the receiver, R.



Typical rotation operation is shown plus the steps toward its solution with the Volder algorithm. The angle after the rotation is approached with steadily decreasing steps; the magnitude steadily increases with each step and in general will require correction, the amount of which depends on the computer word length and the number of steps taken.

There are several ways to transform an unprocessed set of time differences into the various outputs required in navigation. One set of equations that gives range and bearing directly in terms of the time differences [see diagram at the left] is:

$$P_m = \tan^{-1}\left[\frac{(\cos d_2 - \cos \xi_y) + \omega(\cos d_1 - \cos \xi_x)}{\sin \xi_y + \omega \sin \xi_x + \sin d_2 \sin \alpha \sin \theta}\right]$$

$$\theta = \cos^{-1}\left[\frac{\cos \xi_x - \cos d_1 - \tan P_m \sin \xi_x}{\tan P_m \sin d_1}\right]$$

where

P_m = distance of receiver from master station (range)

θ = angle between master-receiver line and master-slave base line

ξ_x = $P_x - P_m$ (expressed as time difference)

ξ_y = $P_y - P_m$ (expressed as time difference)

$$\omega = \frac{\sin d_2 \cos \alpha}{\sin d_1}$$

α = supplement of angle between d_1 and d_2

Then the latitude ϕ_R and longitude λ_R of the receiver can be determined with the equations:

$$\phi_R = \tan^{-1}\left[\frac{\cos(\lambda_m - \lambda_R)\,[\cos P_m \cos \phi_m + \sin P_m \cos \phi_m \cos(\gamma - \theta)]}{\cos P_m \cos \phi_m - \sin P_m \sin \phi_m \cos(\gamma - \theta)}\right]$$

$$\lambda_R = \lambda_m - \tan^{-1}\left[\frac{\sin P_m \sin(\gamma - \theta)}{\cos P_m \cos \phi_m - \sin P_m \sin \phi_m \cos(\gamma - \theta)}\right]$$

Other sets of equations may also be used, perhaps to determine latitude and longitude first and then range and bearing; or one could begin with a different set of measurements.

The Volder algorithm consists of an iterative process that can evaluate these equations with a series of shift-and-add operations based on the following relations:

$$x_{i+1} = x_i \pm 2^{-(i-2)} y_i$$
$$y_{i+1} = y_i \mp 2^{-(i-2)} x_i$$

The initial values are $x_1 = 1$, $y_1 = 0$. This is equivalent to a series of diminishing rotations. Each increment of rotation is an angle α such that:

$$\alpha_1 = \tan^{-1} \infty = 90°$$
$$\alpha_2 = \tan^{-1} 1 = 45°$$
$$\alpha_i = \tan^{-1} 2^{-(i-2)} \text{ for } i \geqq 2$$

A similar algorithm may be used to evaluate the new coordinates of a vector rotated from a position with a given coordinate. For example, in the rotation operation shown in the diagram at the left, the vector with coordinates (½, −¼) is to be rotated through an angle of 67.5° counterclockwise. The initial coordinates are placed in the machine and the first rotation is 90° counterclockwise. Subsequent rotations are smaller and smaller in accordance with the inverse tangent formula, in directions that make them zero in on the desired angle.

Comparing computation times

Operation	General-purpose computer			Divic computer		
	Bit Times per Operation	Frequency	Total Bit Times	Bit Times per Operation	Frequency	Total Bit Times
Add	n	1	n	n	0	0
Subtract	n	2	2n	n	1	n
Multiply	n^2	7	$7n^2$	n^2	1	n^2
Divide	n^2	1	n^2	n^2	0	0
Sine	$5n^2 + 3n$	3	$15n^2 + 9n$	....	....	....
Cosine	$5n^2 + 3n$	4	$20n^2 + 12n$	....	....	....
Inverse tangent	$8n^2 + 6n$	1	$8n^2 + 6n$	....	....	....
Inverse cosine	$8n^2 + 6n$	1	$8n^2 + 6n$	....	....	....
Rotation	....	....	....	n^2	6	$6n^2$
Resolution	....	....	....	n^2	2	$2n^2$
Total			$58n^2 + 36n$			$9n^2 + n$

handle numbers either incrementally or as whole numbers, and the algorithm is implemented accordingly. The digital differential analyzer is an example of an incremental computer; it repeatedly adds a variable y to an accumulator, which therefore contains the integral of y. Conventional general-purpose computers are examples of whole number machines.

Since the differential analyzer can handle only increments of numbers, it solves the equations of conversion, range and bearing and position by a proper application of its basic integration algorithm. It arrives at a solution quickly, but it may be subject to a cumulative error.

The general-purpose computer on the other hand has available all standard arithmetic operations; namely, add, subtract, multiply and divide. In addition, hardware or software algorithms based on infinite series for forming trigonometric functions using only arithmetic operations may be available. The equations can be evaluated with great precision using these algorithms, but at the cost of either much hardware or much time.

The Divic is neither an incremental nor a whole-number machine, but something between the two. It solves the equations by using the standard arithmetic operations plus rotation and resolution. The rotation operation rotates a vector R defined by its x and y components R_x and R_y through an angle θ and computes the new x and y components R'_x and R'_y. The new components are related to the original ones by:

$$R'_x = R_x \cos\theta - R_y \sin\theta$$
$$R'_y = R_x \sin\theta + R_y \cos\theta$$

Resolution computes the magnitude and direction of the vector from the vector components R_x and R_y:

$$R = R^2_x + R^2_y$$

$$\alpha = \tan^{-1}\frac{R_y}{R_x}$$

The speed of solution of the equations can be estimated by determining the amount of time required for each operation and the relative frequency of use of each.

The frequency of use depends on the programer's skill; the frequencies in the summary table shown below are typical. This table shows that the Divic can solve the same problem that a general-purpose computer can solve, with less hardware and six times faster.

Computer organization

Implementation of an algorithm like Volder's in a computer like Divic requires a special arithmetic unit. The design of the arithmetic unit, in turn, depends on the speed required of the machine. The other basic subdivisions of the computer—the control unit, the memory unit, and the input-output interface—are not directly affected by the computational algorithms.

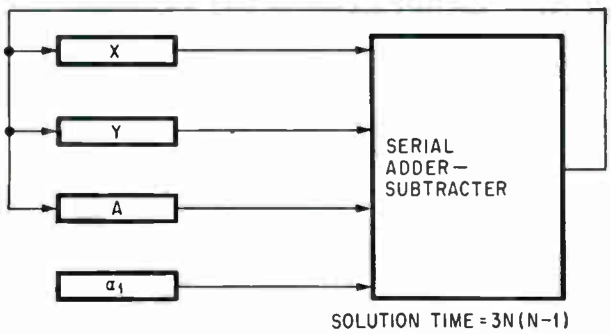
The arithmetic unit may operate serially or in parallel, or in combinations of these two basic methods. Four such designs—serial processing-serial arithmetic, parallel processing-serial arithmetic, serial processing-parallel arithmetic, and parallel processing-parallel arithmetic—are shown on the next page. To implement the rotation algorithm, three steps are required for each iteration: the sum or difference of x and shifted y to find the new x; the difference or sum of y and shifted x to find the new y; and the sum or difference of the angle and the angle increment to find the new angle.

These three steps are repeated during n—1 iterations to solve the rotation algorithm, where n is the word length in bits.

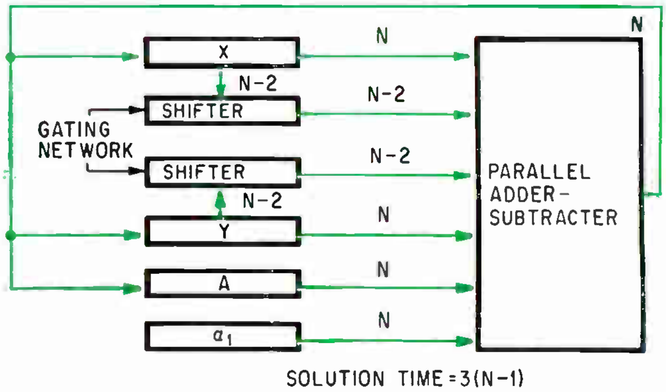
The four configurations have different solution times and require different amounts of hardware:

- For serial processing and serial arithmetic, only a single adder-subtractor is required. It will be time-shared by the four shift registers, which make up the other parts of the arithmetic unit, as

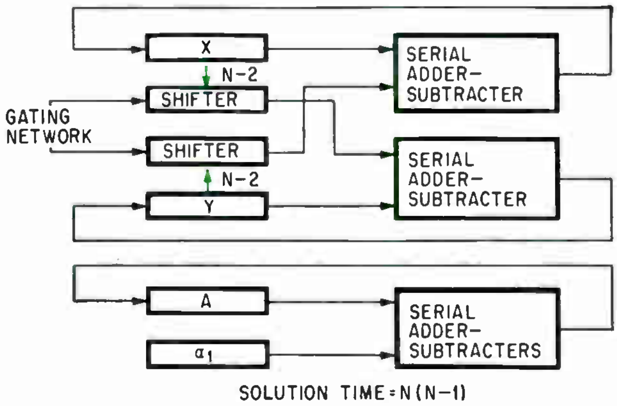
Four computer organizations



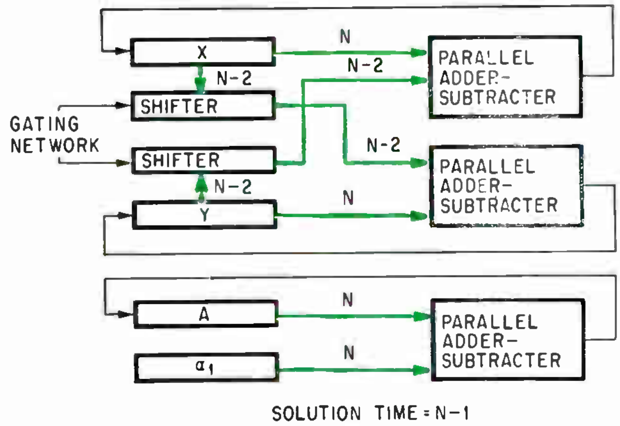
The simplest organization for a Divic computer is when data is processed serially, and arithmetic operations are performed serially.



Still faster operation is possible with a parallel arithmetic unit that retains the simple serial shift-registers of the basic organization.



A somewhat faster and more complex organization is parallel processing. It increases the speed and requires additional hardware; serial arithmetic is retained. The arrows in color refer to a number of parallel lines.



The fastest and most complex layout uses both parallel arithmetic units and parallel processing from all registers. This organization also costs the most.

at the top left above. Each of the four registers are n bits long. The three steps required for each iteration of the algorithm are computed in series; thus the total solution time becomes 3n(n—1) bit times. The shifted values of x and y are obtained by transferring numbers between registers with proper timing.

▪ In the second design of an arithmetic unit, at the lower left above, computation is made faster by processing many serial arithmetic operations at one time. In this configuration a gating network on the x and y registers obtains the shifted values of x and y. The arithmetic unit requires three adder-subtracters, four shift registers, and two sequential gating networks. Since all three steps are now processed at one time, the solution time is n(n—1) bit times for this design.

▪ An arithmetic unit with serial processing and parallel arithmetic, like the first method, takes three steps to process the information. However, with a parallel adder-subtracter, as in the diagram at the upper right, gating networks route the shifted values of x and y from each register into the adder-subtracter. This arithmetic unit now requires four n-bit storage registers, two gating networks, and one parallel adder-subtracter. The solution time now becomes the speed of the parallel adder-subtracter divided by the three sets of inputs. If the speed of the parallel adder-subtracter is one bit time, the solution time is 3(n—1) bit times.

▪ Parallel processing with parallel arithmetic is the fastest method of processing information. In this method, the shifted values of x and y are again obtained with gating networks, as in the lower right diagram. By processing the information in parallel, the solution time for this method is reduced to n—1 bit times—the fastest way to solve the algorithms in an arithmetic unit.

Speed and cost comparisons

The selection of the organization to fit the requirements of a particular application will depend on the solution time required for the problem and the cost. As the speed increases with the introduction of parallel processing, more hardware is required.

The graphs on page 112 compare the different arithmetic unit solution times for various word lengths and the relative hardware complexity of each arithmetic unit in terms of the integrated-circuit modules needed for the basic arithmetic functions. These numbers do not include any control circuitry.

Therefore, the selection of the optimum computer requires a diligent study of all methods and their trade-offs; the faster the information processing, the more costly the arithmetic unit.

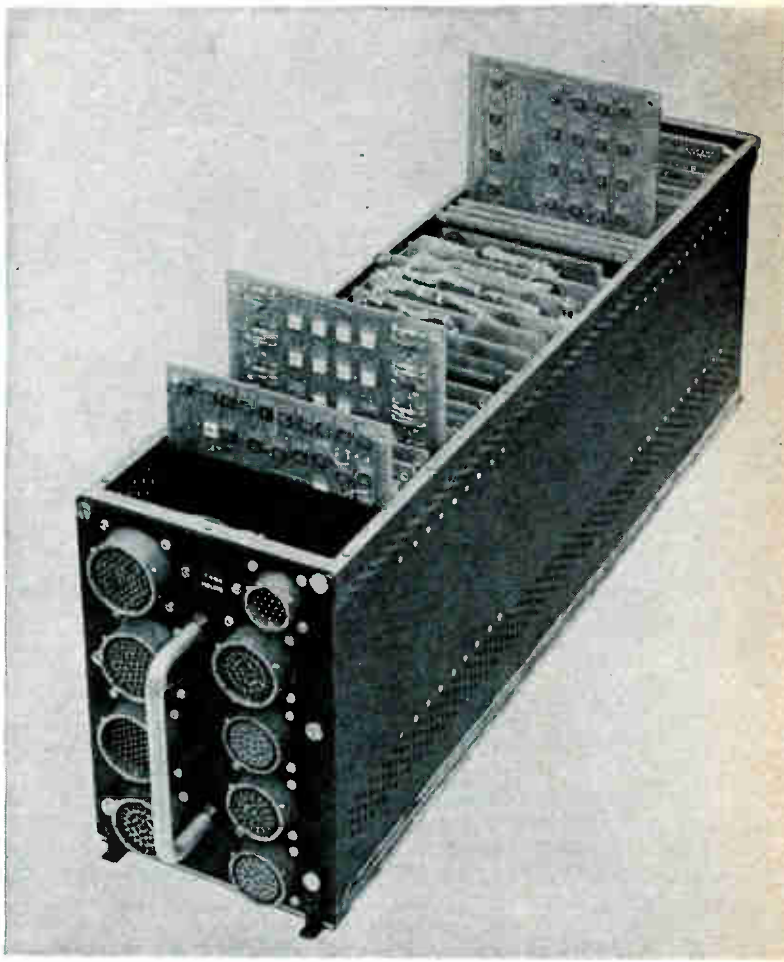
The table shown below illustrates these principles for a typical navigational problem—depicting the bit times for the various algorithms as a function of the computer organization, along with the total bit times and the resulting solution times for a 32-bit word and 1-Mhz clock frequency. A comparison of the cost of each computer organization with a 32-bit word is also shown.

Flight test proves the system

A prototype Divic computer with a parallel processing, serial arithmetic design was flight-tested two years ago in the East Coast loran-C chain. Time difference signals were obtained from an AN/SPN-30 receiver and fed into the computer. Outputs of the computer were present latitude and longitude, distance to go, bearing angle and steering signal commands.

The tests totaled more than 120 flight hours in various types of aircraft. A typical flight began at Grand Rapids, Mich., and went to Miami, San Juan, Bermuda, Washington and back to Grand Rapids. The computer was tested on both the land and sea sides of the chain of loran stations, both in and out of the area covered by the ground wave. Accuracy was checked against air traffic control radar, Atlantic missile range radar, very high frequency omnirange and visual landmarks. The mean error in all flights under a variety of conditions was about 1 nautical mile (approximately 1.15 statute miles).

The flight tests of the prototype showed, among other things, that the parallel processing-serial arithmetic organization was adequate for the straight forward conversion of hyperbolic coordinates in aircraft. With this in mind, and with plans to alter the packaging and to replace the wired program with a stored program, the design was simulated on an International Business Machines Corp. 1620 computer. The simulation bore out the

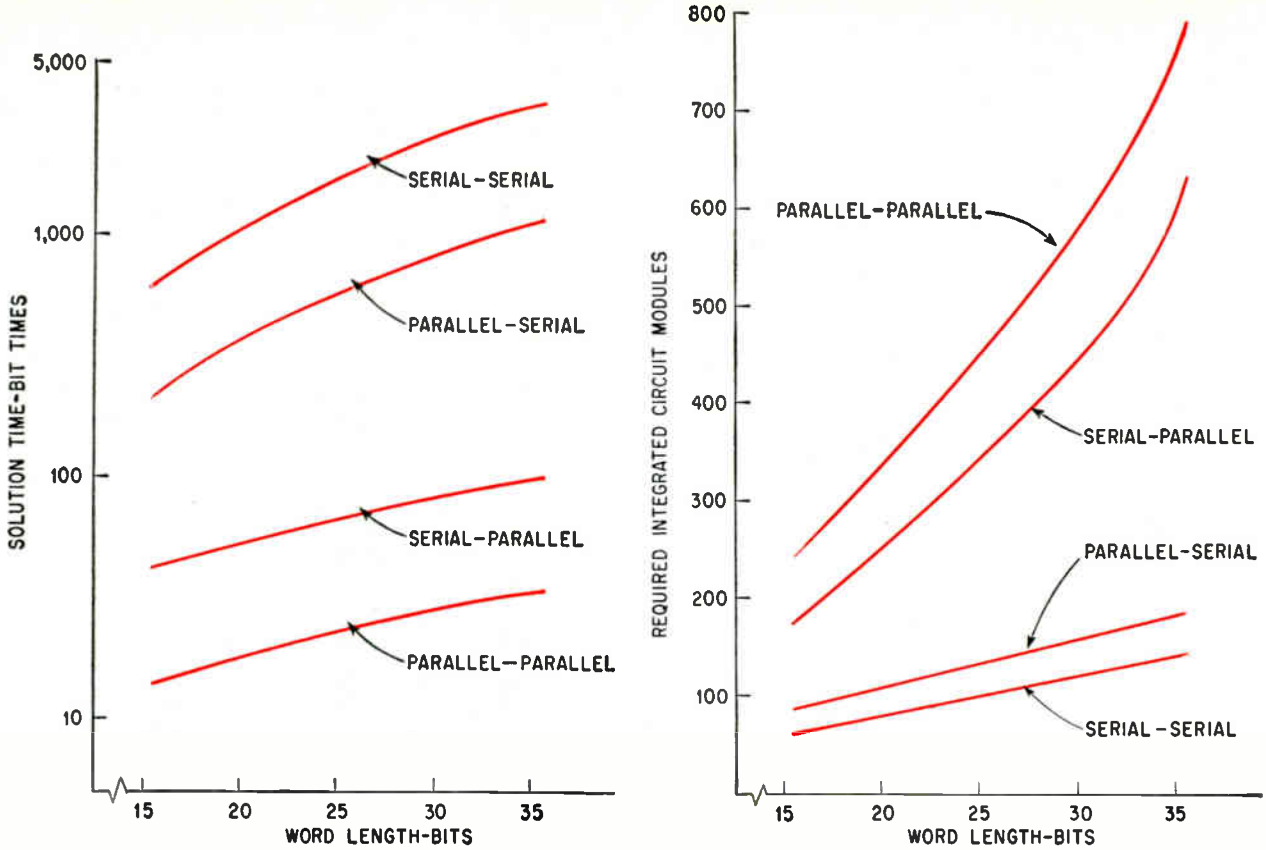


The Divic computer with the top cover removed and some of the circuit cards partly pulled out. The group of cards in the center carry the core-rope memory; portions of the rope are just visible. The ferrite core memory is on the module at the rear; only a few test points are visible.

Speed-cost trade-offs

Operation	Computer speed			
	Serial-serial	Parallel-serial	Serial-parallel	Parallel-parallel
Subtraction	2n*	2n	2	2
Addition	n	n	1	1
Multiplication	$6n^2$	$3n^2$	6n	3n
Rotation	$3n^2 - 3n$	$n^2 - n$	$3n - 3$	$n - 1$
Resolution	$3n^2 - 3n$	$n^2 - n$	$3n - 3$	$n - 1$
Total	$12n^2 - 3n$	$5n^2 + n$	$12n - 3$	$5n + 1$
Total for n = 1 usec**	12.192 msec	5.152 msec	0.381 msec	0.161 msec
Cost in number of modules	135	172	505	660

*n=time required to process one bit
**Assumes 1 megahertz clock, 32-bit word



Solution time increases as word length increases. The increase in time is more rapid for the simpler computer organizations. Hardware costs also increase as word length increases but less rapidly for the simple organizations. The designer must use a word length and an organization that will provide the required solution time at a price he can afford to pay.

results of the flight test and gave the accuracy of the algorithm as a function of word length. Therefore the improved design for Divic retained the parallel-serial organization, with a word length of 30 bits as indicated by the simulation.

Divic has many faces

Any equation using trigonometric functions can be evaluated by a Divic computer as well as by a digital differential analyzer or a general-purpose machine. Most of the applications are in navigation systems of various kinds.

In hyperbolic systems, such as loran C, velocity and direction can be derived. When position, velocity and direction are known, the computer can resolve the guidance for the aircraft in the form of error or command signals and feed these to the autopilot and displays. Bearing, great-circle distance and along-track distance also can be computed and displayed.

In dead-reckoning systems, such as inertial, doppler-gyro or airspeed-heading systems, the sensor inputs usually are in the form of pulses from an accelerometer, a frequency representing velocity from the doppler radar, and synchro d-c or a-c voltages. From these inputs, velocity, direction and position can be computed just as in the hyperbolic system. The differences between the dead-reckoning navigation computer and the hyperbolic computer is the replacement of the coordinate conversion routines with integration routines that involve programing changes in the core rope. Also a faster computer is needed in an inertial system; the system has a higher data rate, so the computer must process more data in less time, even though it executes fewer instructions. The speed can be increased either by increasing the clock rate (if the modules are capable of the higher rate) or by using a parallel computer organization.

Many integrated systems, such as loran-inertial, Omega-inertial, loran-doppler, and so forth, can use the Divic. In the simpler integrated systems the time-independent systems update the time-dependent systems; in others, the systems mutually aid each other. The most advantageous application of the Divic computer in an integrated system is to reduce each navigation subsystem to a common frame of reference and then to operate on the inputs, processing the common data to the mutual advantage of both systems. The resultant system is usually more accurate than either system individually.

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Pumping new life into ruby lasers

New pumping system and low-cost mercury flashtubes bring longer life and high repetition rates, promising to change the ruby laser from a laboratory instrument to a production tool

By Dieter Roess and Guenter Zeidler

Central Laboratories, Siemens & Halske AG, Munich, West Germany

A ruby laser has been developed that promises to move the bright red beam from laboratory work to the production line. The new laser achieves the highest pulse repetition rate of any ruby laser and its beam can be focused to an extremely fine point yet it is cheap to operate and has long life. Its secret is a new pumping system and an especially designed mercury vapor flashtube that replaces the conventional xenon lamp of ruby lasers. The new tube has from 100 to 100,000 times the lifetime of a xenon tube at one-tenth the cost per tube.

Developed by Siemens & Halske AG in West Germany, the new laser is particularly suited for commercial micromachining processes such as melting, drilling, cutting and trimming. In the laboratory the laser has corrected the wiring of large-scale arrays of integrated circuits by vaporizing the leads to unwanted or faulty elements and has accurately trimmed thick- and thin-film elements by partially vaporizing their materials.

Until now three serious imperfections have held back the commercial development of ruby lasers:

- First, the characteristics of the output beam have been far from ideal, making it impossible to focus to a sharp enough point. The beam has not been restricted to the zero-order mode, the mode easiest to collimate, giving it divergences 10 to 100 times greater than desired. Also, the beam is not uniform but has maximums and minimums that vary from pulse to pulse.
- Second, the xenon flashtube, which is ordinarily used as a pump light source, can deliver only from 100 to 100,000 pulses—too few at $100 per tube.
- And finally, typical pulse repetition rates vary from 0.1 to 1 hertz. Higher duty cycle operation is possible with forced cooling but this is still impractical because the flashtube would be quickly destroyed and a very large and costly power supply would be needed.

The Siemens laser goes a long way towards overcoming these defects. It has an output pulse repetition rate ranging around 100 hz and its ellipsoidal pumping system yields greatly improved beam divergence and stability because the laser generates a perfectly circular, uniform beam and can operate largely in the zero-order mode.

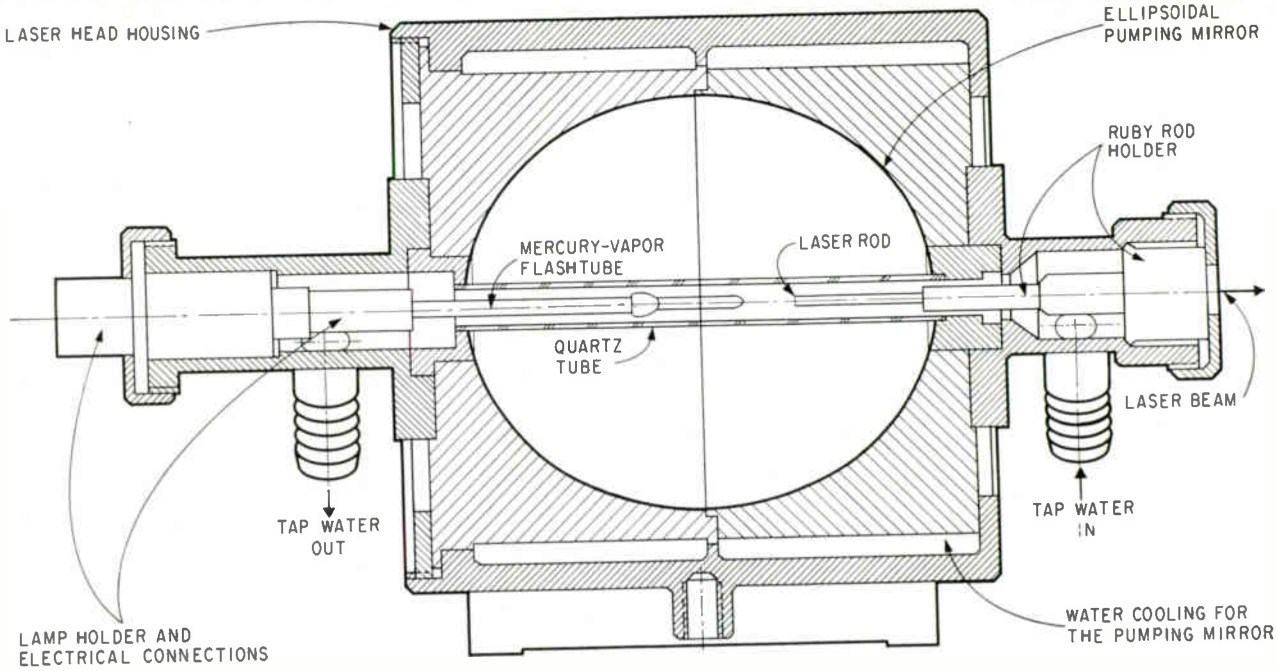
The xenon lamp is replaced by a $10 mercury flashtube having an exceptionally long life of 10 million pulses. The mercury unit also has high efficiency at small arc dimensions.

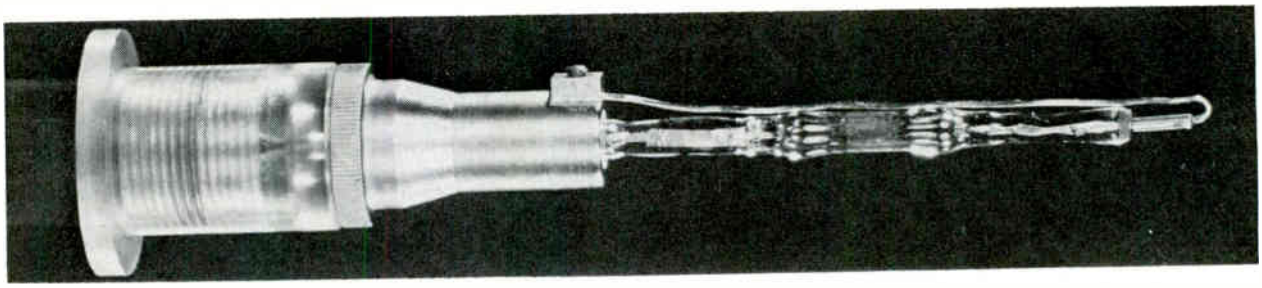
Absolute output efficiency of the system, which uses a ruby rod only 1-inch long and 80 mils in diameter, is about 0.22% [see table on p. 117].

The pumping system[1] shown on page 116 has the special characteristic that its efficiency does not drop for a small crystal length, as it does in cylindrical units, because no end effects are present. A

The authors

Guenter Zeidler, left, is a research engineer at Siemens & Halske engaged in solving laser problems. He graduated from the Technische Hochschule in Munich in 1964. Physicist Dieter Roess holds a doctorate from the University of Wuerzburg. With Siemens & Halske since 1960, he is manager of the maser and laser research laboratory.





Ruby laser with repetition rate of 100 hz uses ellipsodial pumping mirror, 1-inch-long ruby rod, high-pressure mercury-vapor flashtube. Absolute output efficiency is 0.22%. Flashtube, in photograph has preadjusted, interchangeable holder and electrical plug-in. It can be produced cheaper than xenon units.

similar ellipsoidal system had been used previously for continuous operation of ruby lasers at room temperature.[2]

The light source is placed along the axis of an ellipsoidal mirror between one of the focuses and the neighboring apex, as in the basic optical diagram on page 117. In the corresponding area at the other half of the ellipsoid is the laser rod. Tap water flowing through a concentric quartz tube cools the rod and light source. The pumping mirror is cooled by tap water flowing around the outside of the system.

The pump pulses of the laser are derived from the triggering of a Siemens (STE-6011) thyratron. These triggers can be varied between 50 and 120 hz. Standby current of 100 milliamperes is furnished by a 1,500-volt d-c power supply.

With the present power supply—a commercially available Siemens unit shown in the schematic on page 117—maximum output power is obtained at 70 hz. At this frequency, the average pump power can be varied from 500 to 1,000 watts. The pump pulse duration is 2 milliseconds with the laser output pulses lasting from 1 to 1.5 msec. The threshold energy was measured at 2.5 to 3.5 joules. Measurements were taken indirectly since the laser was above threshold even with minimum input power.

At a pump power of 900 watts into the lamp, and using a mirrored rod of 10% coupling, the average laser power is 2 watts with 80-watt peaks. This value drops by about 30% after 20 hours of operation at 10^7 pulses.

In one experiment a ruby rod was operated with one end antireflection-coated and with an external curved mirror. Maximum average power was 1.5 watts. This laser was also operated in 70-hz giant-pulse mode with a saturable absorber as a Q switch. The amplification in the 1-inch rod was as high as 1.5 per light pass—high enough so that the laser can be operated with several damping elements in the resonator. The amplification of gas lasers, for example, is much lower; a typical value for a helium-neon laser is 1.06.

Mercury tube advantages

The prime advantage of the mercury flashtube is, of course, its long life. The tube doesn't deteriorate because there is no low-pressure discharge phase, as in low-pressure xenon tubes, during which the electrodes can evaporate. Steady internal pressure of about 100 atmospheres, equal to 1,470 pounds per square inch, is maintained and this sharply reduces the evaporation and deterioration.

Another advantage of the mercury lamp is that its efficiency is high at small discharge lengths. With xenon tubes, efficiency decreases when the discharge path is less than 2 inches. High efficiency means there is little heating of the electrodes. The lamp can be very small and can be produced much more cheaply than the xenon units.

Over-all system efficiency is increased still further using the mercury tube because its emission lines match the laser pump band of ruby extremely well, as shown on page 118.

To keep the mercury in a gas state, the laser must run almost continuously above a minimum average power. The present system was designed for a repetition rate between 50 and 120 hz.

With almost continuous operation the laser rod is in thermal equilibrium.[2,3] This is important in generating identical pulses.

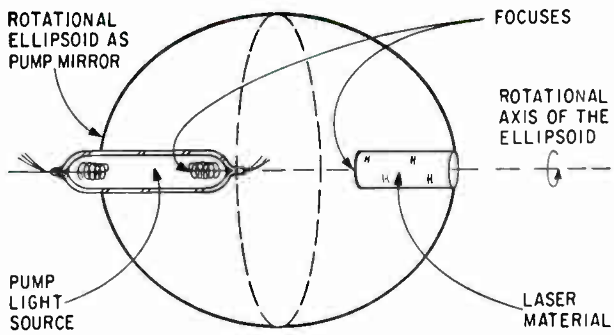
Hot rod

The pumping and lasing processes generate heat in the ruby of the laser. Temperature gradients in the rod cause curvature at the end faces and, because the refractive index is temperature dependent, the light rays in the material also curve. A pumped laser rod, therefore, acts like a lens whose focal length depends upon the temperature distribution in the rod, which, in turn, depends upon the distribution of the pump light.

In high pulse-rate operation curvature by thermal gradients is practically constant. This contrasts with the operation of single-pulse lasers in which the curvature is strongly time-dependent and fluctuates with the thermal history of the laser during the thermal relaxation times.

The thermal curvatures of nominally plane-parallel resonators cause the imperfect beam-divergence characteristics of solid-state lasers. In the new ruby system, however, the thermal spherical curvature of the resonator is corrected optically as on page 118. The end faces are curved negatively in such a way that in the hot rod the curved light rays of the zero-order mode hit the mirror at right angles at any point in its cross section. Hence, only the zero-order mode is excited.

It's interesting to note that the corrected laser rod cannot be run cold in single pulses because the negative curvature of the resonator introduces high losses that cannot be overcome by laser amplification.



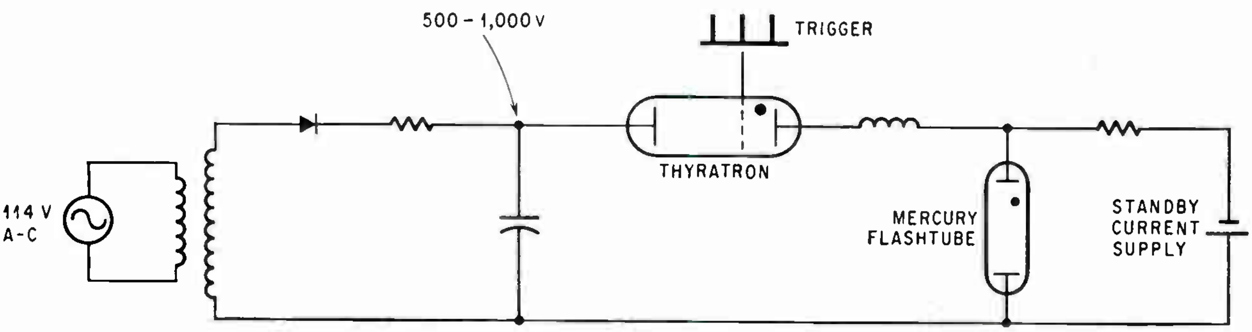
Light source is placed between focus and apex of the rotationally symmetric ellipsoidal pumping mirror. Reflection properties of ellipsoid cause light rays from the pump light source to be reflected through the focus-apex area at the opposite side of the ellipsoid where the laser material is located.

Only when part of the curvature is compensated for by thermal expansion of the rods, and the rest by a bulk lens effect, do the resonator losses drop below the threshold value. Proper correction, it was found, was not very sensitive to the average pump power so that high-mode selection can be achieved for all possible pump powers.

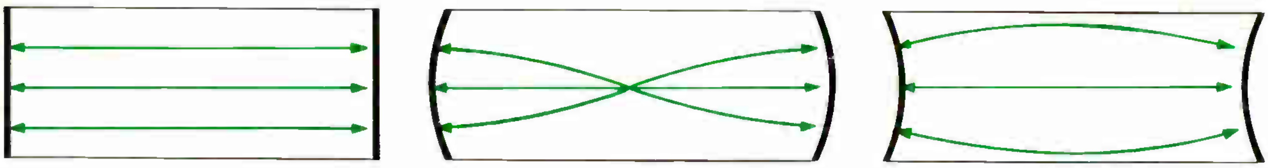
A special advantage of the ellipsoidal pumping system is that the pump light distribution and

Operating data of ruby laser

Wavelength	0.6943 micron
Laser material	ruby, 25 mm long, 2 mm diameter
Ruby volume	0.08 cm^3
Pump pulse duration	2 msec
Pulse repetition rate	50 to 120 hz with 70 hz optimum
Pulse threshold energy	2.5 to 3.5 joules
Maximums	
Pump energy	15 joules (4 to 6 times threshold)
Average input power	1,000 watts (120 hz)
Average output power	2 watts (70 hz)
Peak output power	N 80 watts
Output efficiency	
Absolute	0.22% (70 hz)
Differential	0.87% at max. pump power
Lamp lifetime	$> 10^7$ pulses $\approx$ 20 hours at 70 hz



Trigger pulses on the thyratron determine the pumping frequency (50 to 120 hz) of the flashtube in this simplified schematic of the commercially available Siemens power supply.



Thermal resonator curvature. In nominally plane-parallel resonator, left, zero-order mode exists across the whole cross section. Thermal curvature makes the resonator confocal, center; the zero-order mode exists only near the axis and high-order modes predominate. Curving the surfaces negatively compensates for thermal effects, right.

therefore the thermal curvature are of exact rotational symmetry.

With the lamp and laser rod placed along the rotational axis of the ellipsoidal mirror the pump light hits the cross section of the laser in the same rotationally symmetric way that it leaves the lamp cross section. Consequently, the cross section of the laser beam stays perfectly circular and has no pronounced minimums.

In contrast, the pump light in cylindrical systems strikes the laser cross section with a concentration in preferred planes because of image distortions. The temperature distribution in the rod curves and twists the resonator, leading to a less well-defined laser beam.

Applications and future developments

With this laser the price per laser flash no longer places an economic limit on its application, but its economy is not its only advantage:

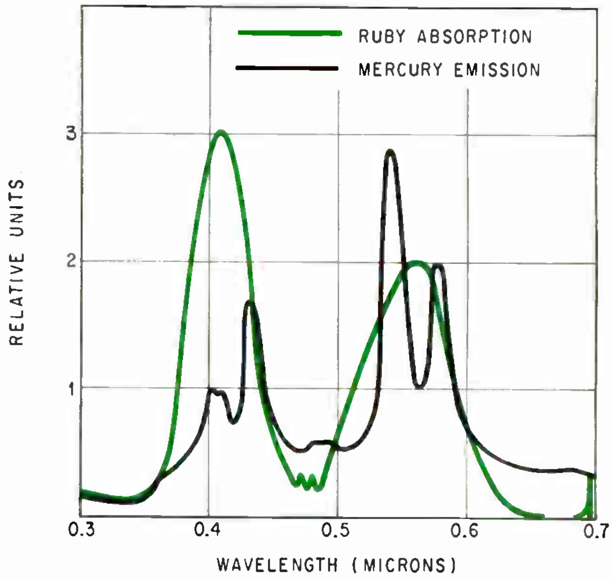
- For machining purposes, the laser's ability to apply a large number of consecutive pulses, each with low energy, allows the operation to be better defined and controlled than if single, high-energy laser flashes were used. Reduction of the peak power increases the life of the optical components.
- For ranging, the laser can be used in fast-measuring and scanning systems having high angular resolution because the beam can be collimated to divergences of seconds of arc. In single-distance measuring systems the input power can be reduced considerably.

Even with the present 1-inch system, in which a volume of ruby less than 0.08 cubic centimeters is operating, several practical applications have been demonstrated.

At 1.5 watts of average power, the focused beam evaporates absorbing materials, such as ferrite or germanium in bulk, with a bright plume. Thin layers of highly reflective metals, such as gold or silver, are easily cut and working diameters of 3 to 5 microns can be achieved.

Living tissue is coagulated at average powers below 0.5 watt in the focused beam. Retinal coagulation was successfully performed in a joint experiment conducted by the authors and Drs. F. Fankhauser and W. Lotmar of the University of Bern, Switzerland. Here, operating with an almost continuous, stable beam of exactly adjustable power and of moderate peak power seemed to be of special advantage.

Because of its good spatial coherence the ruby laser is also a good bright light source for coherent wavefront reconstruction of holograms. And, it is a powerful excitation source for Raman spectroscopy, a method widely used in the chemical industry to determine the structure of organic molecules.



Absorption bands of ruby match very favorably the emission lines of the mercury-vapor flashtube. Peaks occur at almost the same wavelengths.

Further applications of the laser are possible with giant-pulse operation. At 70 hz, giant pulses of 30 nanoseconds duration with 10 to 100 kilowatts peak power were obtained in one single-axial and transverse mode. The 100-kw pulses obtained at 70 hz are believed to be a record with a ruby of such small volume. The average power at 100 kw maximum is 100 milliwatts. With single-pulse lasers having ruby crystals 30 to 100 times larger than the experimental laser, powers in the megawatt and gigawatt range have been achieved.

Currently being investigated is the possibility of extending the operation to large crystal volumes. Special flashtubes for this purpose are now being developed. With a 3-inch, 4-millimeter diameter ruby rod an average power of 30 watts at 1% efficiency seems to be a safe goal. Beam welding of bulk materials is one application that will be possible at this power level.

References

1. D. Roess "Exfocal Pumping of Optical Masers in Elliptical Mirrors," Applied Optics Vol. 3, No. 2, 1964, p. 259.
2. Electronics, Feb. 8, 1965, p. 17.
3. D. Roess, "Room Temperature CW Ruby Lasers," Microwaves, Vol. 4, No. 4, p. 29.

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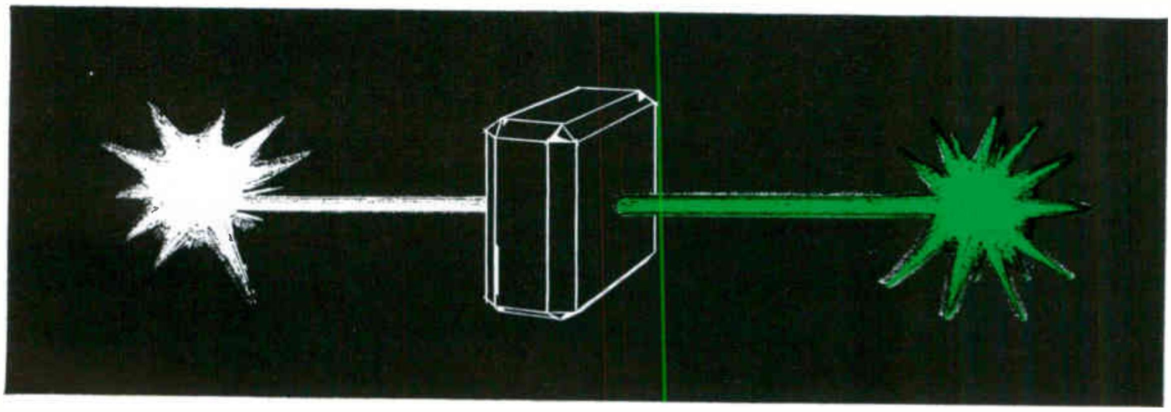

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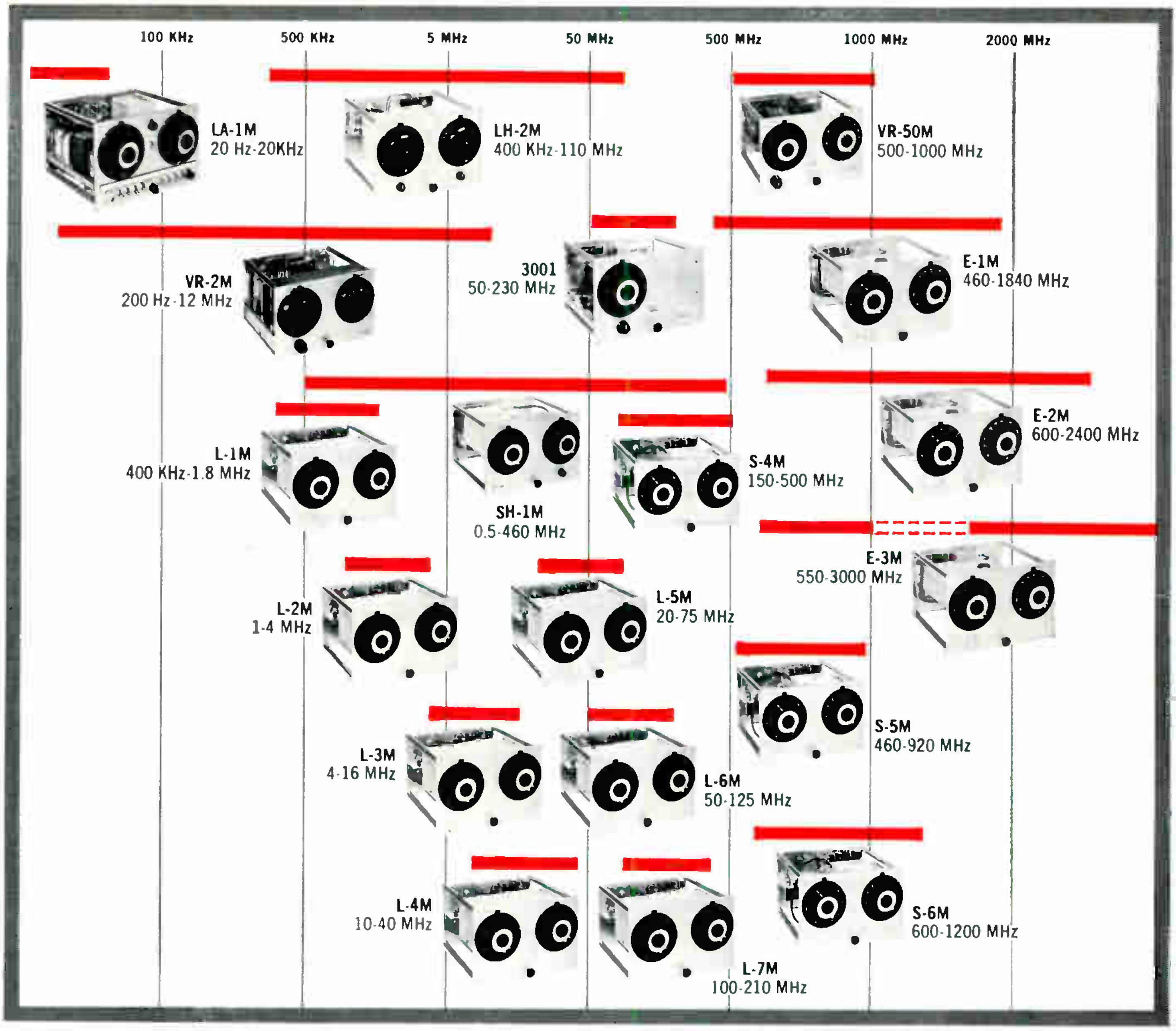

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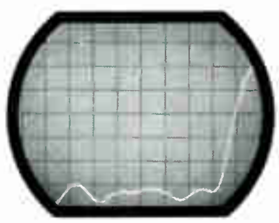

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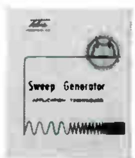

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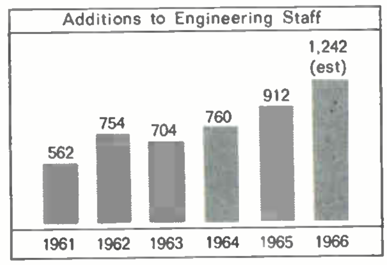

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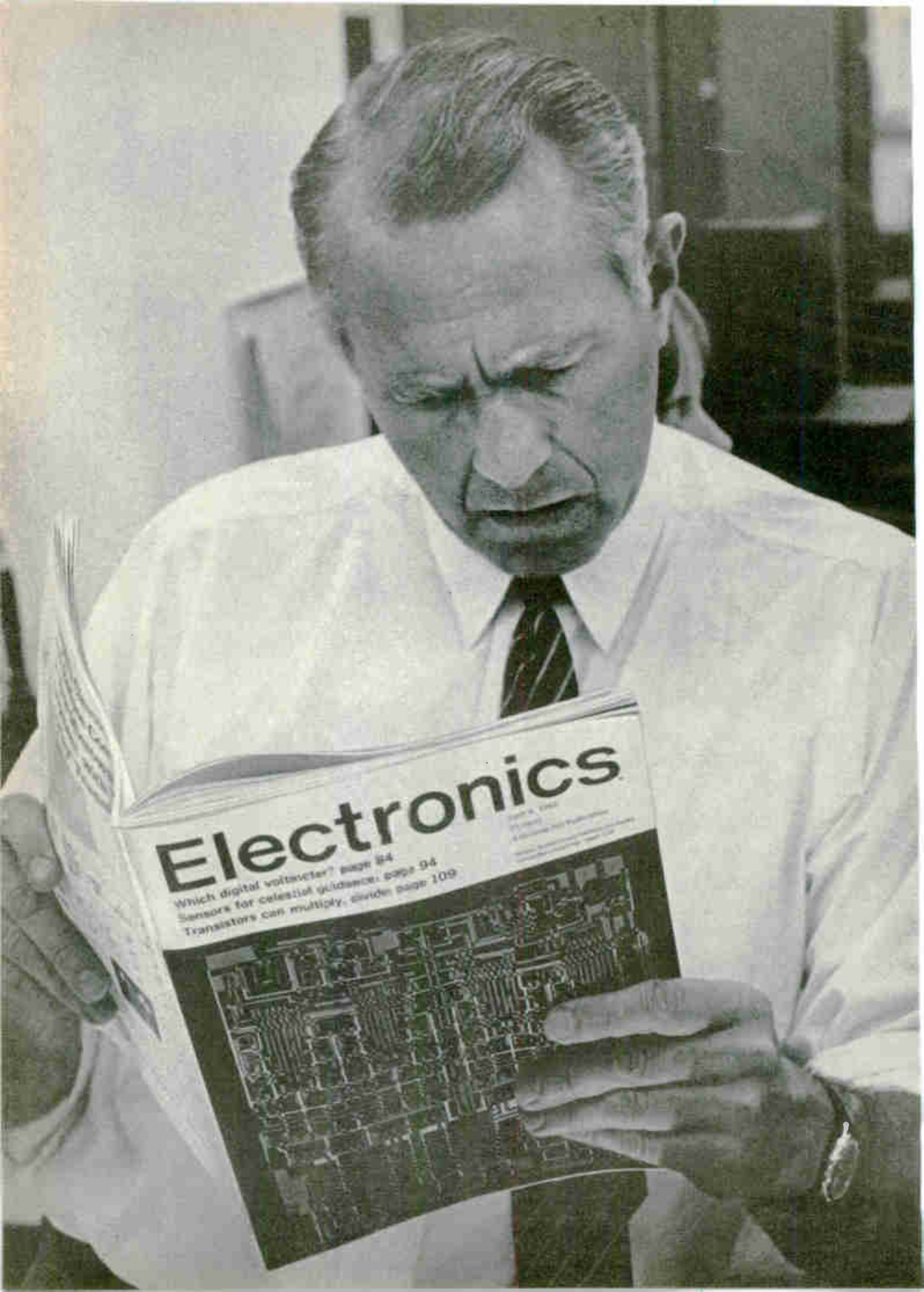
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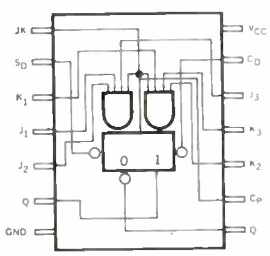

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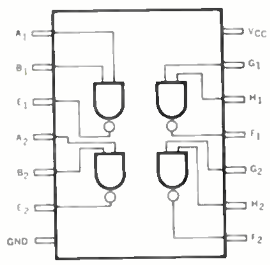
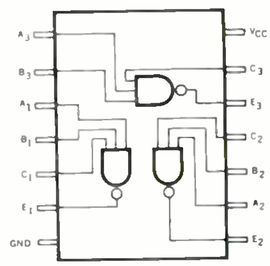
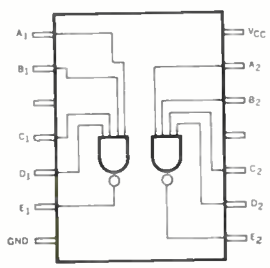


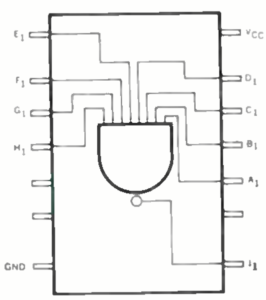
9002 Quadruple 2-input positive NAND gate.



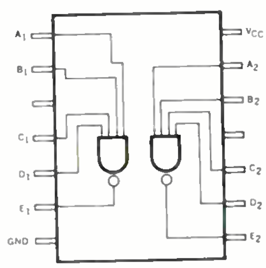
9003 Triple 3-input positive NAND gate.



9004 Dual 4-input positive NAND gate.



9007 8-input positive NAND gate.



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Probing the News

Instrumentation

Government and industry seek to block interference

Radio-frequency interference is becoming more of a problem in communications as use of the electromagnetic spectrum expands

By Carl Moskowitz
Instrumentation Editor

Soon after Christmas last year, many of the 900,000 or so radio operators who use the Citizens' band (27 megahertz) were horrified to find their adult business world invaded by a barrage of children's voices claiming to be cops, robbers, Indians and cowboys.

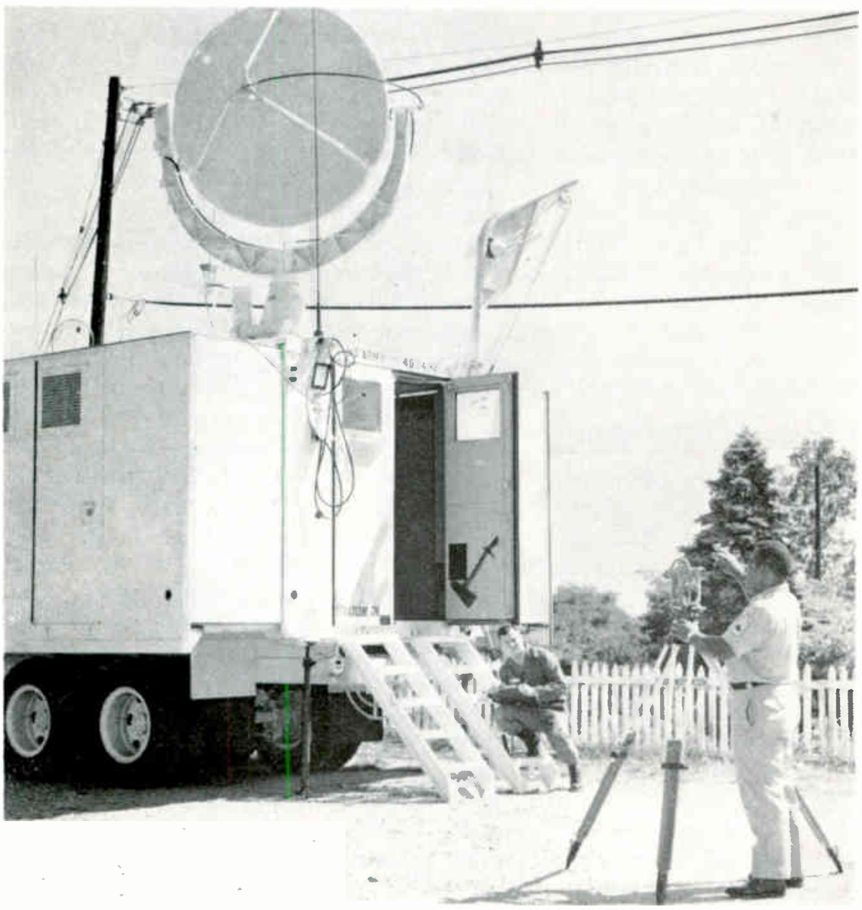
The new transistorized walkie-talkies, operating on the same frequency as radio-equipped trucks and cabs and car telephones had hit the Christmas market, and were being operated by children across the country. Besides disturbing the Citizens'-band operators, the new toys interfered with television sets in some cities.

Last December, when Frank Borman and James Lovell orbited the earth in Gemini 7, the tracking station at Corpus Christi, Texas, lost contact with the astronauts. It was soon discovered that the cause was radio-frequency interference from the motor of a crane in a nearby steelyard. Since the noise blocked most of the useful data from the spacecraft, the National Aeronautics and Space Administration halted the crane's operation until the mission ended.

These cases of rfi are only two of many that take place in the increasingly crowded electromagnetic spectrum. But Citizens'-band operators and astronauts are not the only ones plagued by the problem. Perhaps more involved are the military services, the Federal Communications Commission, industry and research centers. "There are serious implications to the problem," states Major General Richard J. Meyer, Commanding General of the Army's Strategic Communications Command. "Radio interference can be severe enough to result in the loss of some defense capability."

New muscle to fight rfi. While no nationwide drive can clear up the whole problem, the various groups involved are increasing efforts to prevent transmitting noise as well as receiving it.

To protect home and car radio listeners, Congress is considering an amendment to the Communica-

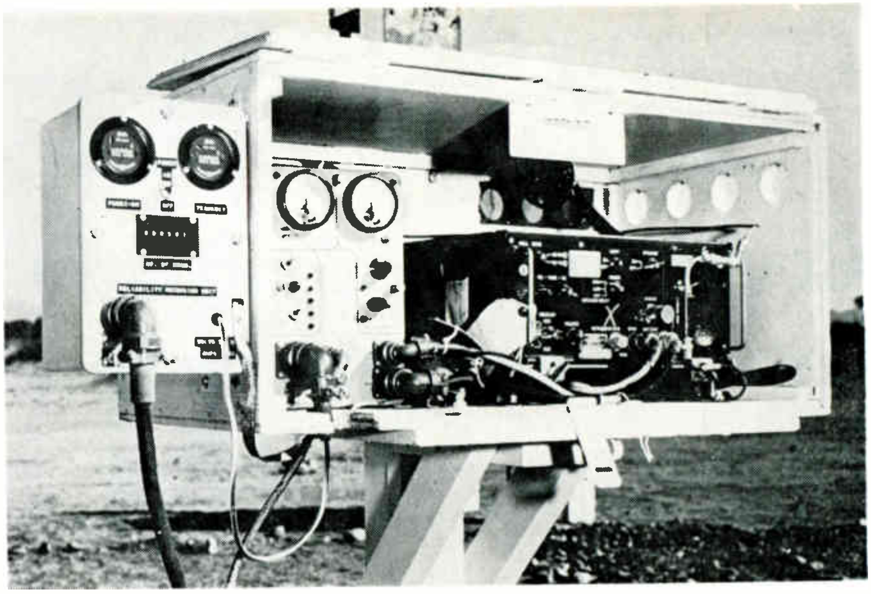


Stratcom's mobile rfi detection system provides the capability for on-site interference measurements. The antenna orientation is checked with a transit.

tions Act of 1934 to give the FCC regulatory powers to suppress radio interference. To try to put some order in the thousands of radiating devices operated by the Defense Department, the Pentagon established a facility to investigate compatibility problems—the Electromagnetic Compatibility Analyssi Center (ECAC) [Electronics, May 18, 1964, p. 79].

The Army's Strategic Communications Command (Stratcom) developed an rfi detection system to measure and record the spectral content of rfi in the field. The Army also built an electromagnetic environmental test facility at its Electronic Proving Ground at Fort Huachuca, Ariz., to investigate interference problems within large concentrations of tactical communications. The Air Force and the Navy have similar facilities.

Industrial groups also organized defenses against the problem. The Society of Automotive Engineers' technical committee AE-4 has studied the electromagnetic compatibility problem for more than 10 years. The Institute of Environmental Sciences, formed to study the deleterious effects of such environments as vibration, shock, temperature, humidity and altitude, decided this past May to form a technical committee on rfi. Its program is to create an awareness of the electromagnetic environment within the environmental sciences field, to act as a liaison between electromagnetic compatibility engineers and environmental scientists and to provide a means for exchanging information throughout the electronics industry.



Electromagnetic environmental generator site, shown in photo at the right, used to produce a specified interference situation that could occur within an army corps. The van houses the equipment to monitor and record the electromagnetic content of the environment. The small enclosures scattered around the area, closeup above, contain equipment designed to simulate the electrical characteristics of a normal tactical radio installation.

I. Pentagon hunts static

The Defense Department set up ECAC in 1961 to advise the military services on their plans for installing radiation-emitting and receiving equipment and operating frequencies. According to Lt. Col. James Wishart, ECAC's chief for plans and programs, the need for such a central facility became apparent with the proliferation of communications and other electronic equipment in the services. Expenditures in military communications electronics skyrocketed from $10 million to almost $7.5 billion in the past 25 years.

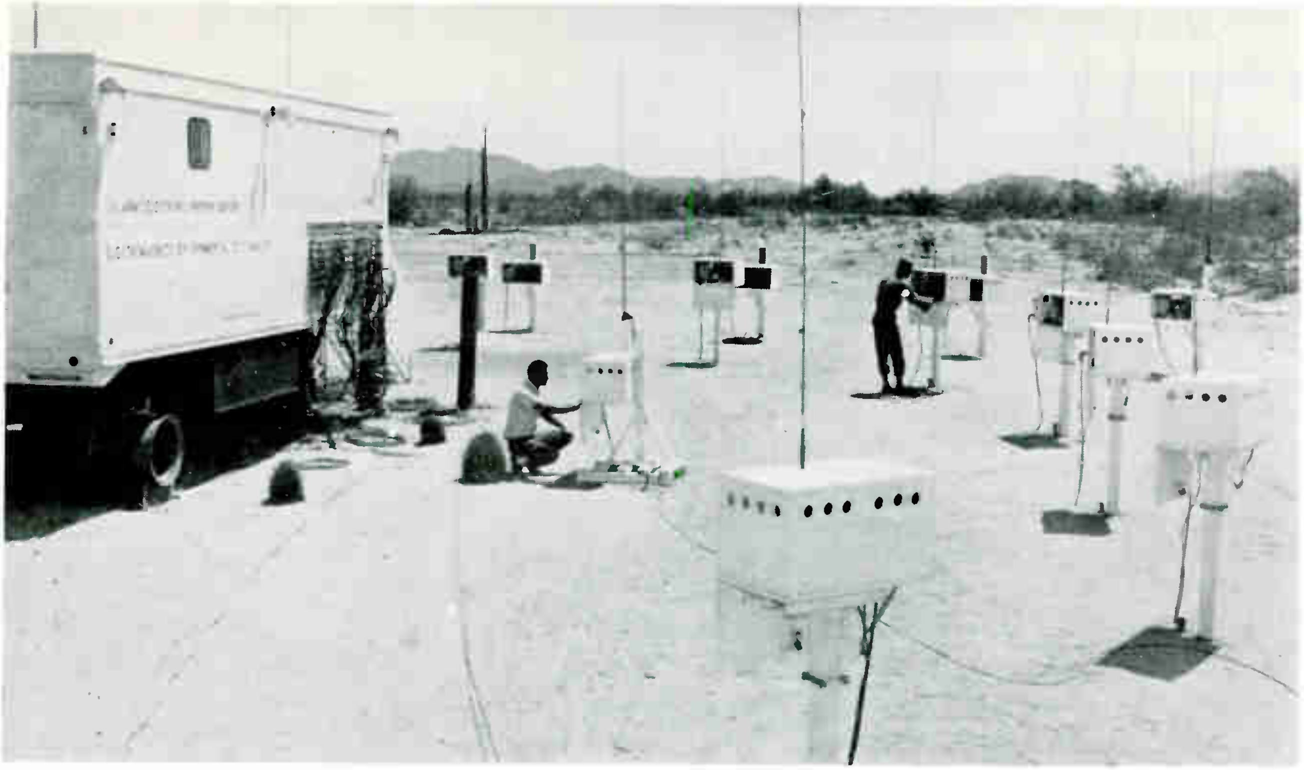
ECAC, at the U.S. Navy Marine Engineering Laboratory, Annapolis, Md., now has sufficient data to devote its full energies to predicting interference in operational situations and recommending solutions. To do its job, ECAC continually accumulates this data to enable engineers to predict rfi for specific equipment in a particular environment. The data includes an environmental file, a terrain data file and an equipment characteristic or spectrum signature file.

- The environmental file contains technical information, operating characteristics and site information relating to communications and electronic equipment already deployed. The file has been developed from field surveys as well as data from such agencies as the FCC, the Federal Aviation Agency, the Weather Bureau and the Coast Guard. The data includes geographical location of the equipment, the operating agency, operating frequency, duty cycle, antenna orientation and carrier modulation characteristics.
- The terrain data file permits computation of terrain dependency effects, such as propagation losses at existing and proposed sites. This data consists of a computer-stored matrix of latitude and longitude versus elevation above mean sea level from information supplied by the Army's map service.
- The equipment characteristic file contains general technical performance and the nominal electrical characteristics of specific equipment in both the military and nonmilitary inventory. ECAC compiles the file from technical manuals, technical reports and spectrum signature tests performed in accordance with military specifications. The data includes transmitter power output and modulation, and receiver bandwidth and tuning ranges.

The information is stored in a computer format for use with the center's Univac 1107 computer. For a specific problem the computer calculates rfi levels and eliminates all equipment from the environment which cannot possibly cause interference. "The computer reduces the rfi problem to a size that can be analyzed by the engineer," says Stanley Safferman, one of the ECAC research engineers. Further analysis can determine degradation in system performance. Recommended corrective measures complete the investigation.

II. The Army way

The purpose of the Army's Stratcom project is similar to ECAC's —studying the effect of rfi on fixed, strategic communications systems in their proposed environments. "But," says Sol Perlman, technical



director for Stratcom-Conus' Fort Monmouth, N.J., facility. "our work starts where ECAC leaves off. Its activities are essential as a preliminary for the Army, but the answers we get are sometimes different since ECAC is only a predictive facility based on worst case analysis whereas we make actual measurements."

Stratcom, organized in 1964, is the managing agency for the Army's global communications networks, and is responsible for fixed plant communications equipment estimated at nearly $1.5 billion.

In the field. Stratcom's weapons against rfi are two mobile radio-frequency interference detection systems; each truck tows a trailer that has a 15-kilowatt generator with a second for backup and storage for the three-foot dish receiving antenna and its yoke.

The rfi detection systems measure unwanted signals that interfere with operation of satellite ground stations, troposcatter installations and point-to-point high-frequency installations. Eight enlisted men and one officer run each system. Sometimes a civilian engineer provides technical backup.

Stratcom does not send out the detection team whenever and wherever interference crops up. "The measuring teams are an important instrument for analysis," says Perlman, "more important is what we do with the data we get. For example, the measurements enable us to interpret typical problems in terms of environment and yield a useful by-product—guidelines or rules of thumb that military commanders can use to cope with their particular rfi problems."

Stratcom-Conus' location at Fort Monmouth—between New York and Philadelphia—is a fortunate one. The concentration of powerful tv and radio broadcasting stations and military transmitters in this area enable the engineers to simulate almost any communication installation.

III. Tactical communications

The Army's problem with rfi is not confined to strategic installations. Field units use more electronic gear than ever—radios and devices for battlefield surveillance, jamming enemy communications, fire control, telemetry, drone controls and navigational aids. The Army says a typical field army in World War II, such as Patton's Third Army, had about 12,000 sets; today a comparable unit would have more than 65,000 sets.

What would happen if all these transmitters were operated simultaneously? To answer this question, the Army set up tactical transmitters in a 40- to 60-mile area at its test facilities near Gila Bend, Ariz. The complexity and density of traffic flow is varied and detailed measurements are made of the interference. Also measured is the interaction as new equipment replaces older models or additional equipment is added to the network. The interference patterns then determine the offending transmitters.

The engineers went a step further and developed what is called an articulation index that shows the intelligibility of a specific piece of equipment in the presence of measured amounts of interference. The index derives from a device that measures the effects of noise and interference on a special test signal representing a voice signal in a radio receiver. The articulation index when compared with actual listening tests produces what is, in effect, a calibration curve for a particular radio receiver.

The engineers also use a computer and a mathematical model of an Army field communications network to predict rfi problems that can't be set up at the test facility.

IV. NASA

NASA's extremely sensitive receiving equipment makes it particularly vulnerable to interference. The chances, however, of an operator on the same, or very close frequencies, affecting NASA's opera-

... tracking down pockets of electromagnetic pollution on campus ...

tions has been reduced because the International Telecommunications Union set aside the 136-to-138, 1,700-to-1,710 and 2,290-to-2,300 Mhz bands exclusively for space purposes. NASA, however, can and does use other frequencies too.

Another source of interference harassing space agency officials arises from ordinary electrical equipment. Even an automobile ignition system or an electric mixer generates electromagnetic radiation. Usually, the effects are relatively harmless, such as blurring the picture of a tv set, but the crane incident showed how serious this type of interference can be.

Dictator. The agency combats rfi with a broad program that has generally paid off. NASA almost always builds ground stations in isolated areas, often with mountain barriers to block any possible rfi. (Corpus Christi was an exception; it was used because Government buildings were already there.) NASA also assigned frequency coordinators to each of its centers to choose the best available frequencies with the least potential interference. At the Cape Kennedy Space Center, the coordinator wields a virtual dictatorship over the adjacent area. Two hours before a launching, he orders taxis, ships and nearby ham radio operators off the air. Because of their rfi potential, electric garage door openers are strictly taboo in the Cape Kennedy area.

Cases of interference around the world are reported to an rfi control center at Andrews Air Force Base, Md. The center immediately contacts the responsible military base, or in the case of a foreign country the State Department, to set corrective steps in motion.

The problem is not always as simple as merely eliminating interference at ground receivers. NASA must also worry about stray signals reaching a spacecraft. It does not announce the frequencies used on manned missions for fear that ham operators in the band could contact the craft. Another fear is interference from high-powered radars already suspected of prematurely triggering satellite equipment.

NASA's problem may be simplified somewhat when the agency moves to higher frequencies less subject to interference than the present frequencies. But this changeover is moving slowly. The Defense Department says this is to take place by 1970.

V. Industry and research

Scientific communities and research centers also have their share of rfi problems. For example, an aerial survey of r-f noise levels reportedly showed that the industrial area around the Massachusetts Institute of Technology in Cambridge, Mass. is the second noisiest r-f location along the East Coast. Only a huge shipyard along the East Coast produces more electromagnetic radiation.

On the MIT campus itself, there are hundreds of r-f radiators such as experimental radars, communication equipment and lasers. The complaints of interference have increased over the last few years.

"The man who screamed the loudest got the job of doing something about it," says one faculty member. As a result, bearded Robert P. Rafuse, an assistant professor of electrical engineering, now heads a faculty committee to solve MIT's rfi problems. The Institute made an initial investment of $100,000 in the program.

Rafuse's goal is to track down the pockets of "electromagnetic pollution"—as he calls rfi—and prevent new ones from developing within campus boundaries.

The offenders. On campus, an rfi officer, Ralph C. Burgess, enforces the rules set by the faculty committee and searches for offending equipment.

Burgess designed and built an rfi wagon instrumented to measure radiation from 20 hz to 22 Ghz. The instrumentation is designed around calibrated receivers whose intermediate frequency outputs can be fed into spectrum analyzers. A 100-Ghz oscilloscope displays waveform characteristics and an x-y plotter measures frequency amplitude.

Because it has its own power source, the rfi wagon can take measurements free of noise on the commercial power line and can go anywhere on the campus. The self-propelled wagon cruises at four miles per hour, can climb a 20° slope and fits into any elevator at the Institute.

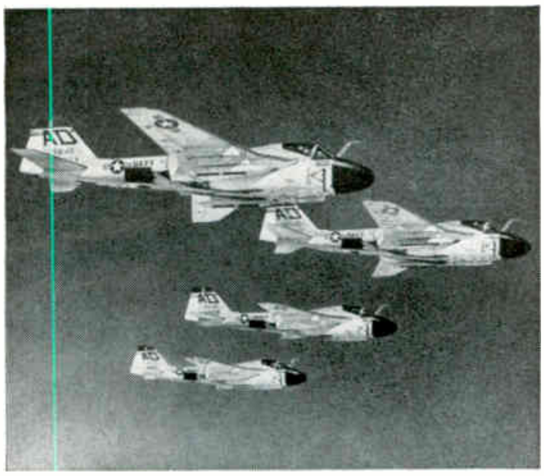
Under the program started at MIT, the interference officer will have a role similar to that of the safety officer. He will have some say about the type of equipment purchased and some control over installation methods. Eventually, the interference officer will map out the campus to pinpoint good and bad locations for r-f transmitters.

Building blocks. Even buildings present problems. One new one at MIT is thought to be a quarter-wave resonator to the broadcast signal from a Boston radio station. But measurements have not yet been taken to confirm this.

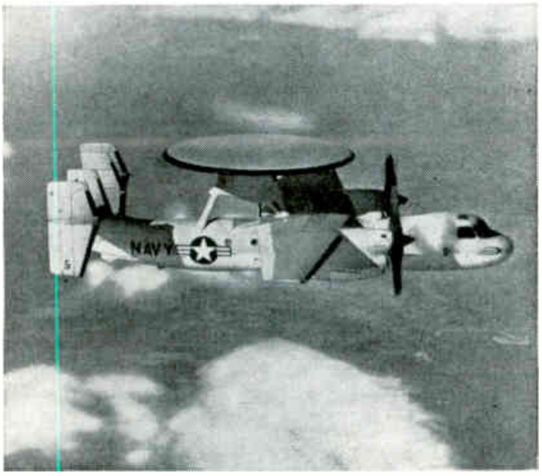
When a building in the path of a signal measures from base to top about one-quarter the length of the radio wave, the resulting resonance can start high currents flowing at the base of the building. These can be the sources of interference to equipment in the neighborhood. "The building becomes a parasitic antenna," says Burgess. "The diameter of the building makes little difference. The structure acts like a radio tower, which is—after all—a building excited to radiate at a set frequency." The problem is compounded if the building has not been designed with rfi in mind, if it is not grounded as an electrically integrated structure. Then, metal parts that are electrically floating can produce harmonics and intermodulations of the signal and radiate these to the surrounding area.

The rfi faculty committee advises the MIT administration on the design of new buildings. Rafuse considers this one of the most important areas in the crusade against electromagnetic pollution. Rafuse has taken a stand against poured concrete buildings. The reinforcing rods—left floating within the walls—are not electrically grounded and can pass currents along in the presence of strong fields. Also, says Rafuse, iron oxide and other chemicals formed between two adjacent rods can form rectifying contacts and produce harmonics of a signal being reradiated.

What cable jacket material has the toughness Grumman wants



for its A6A Intruder?



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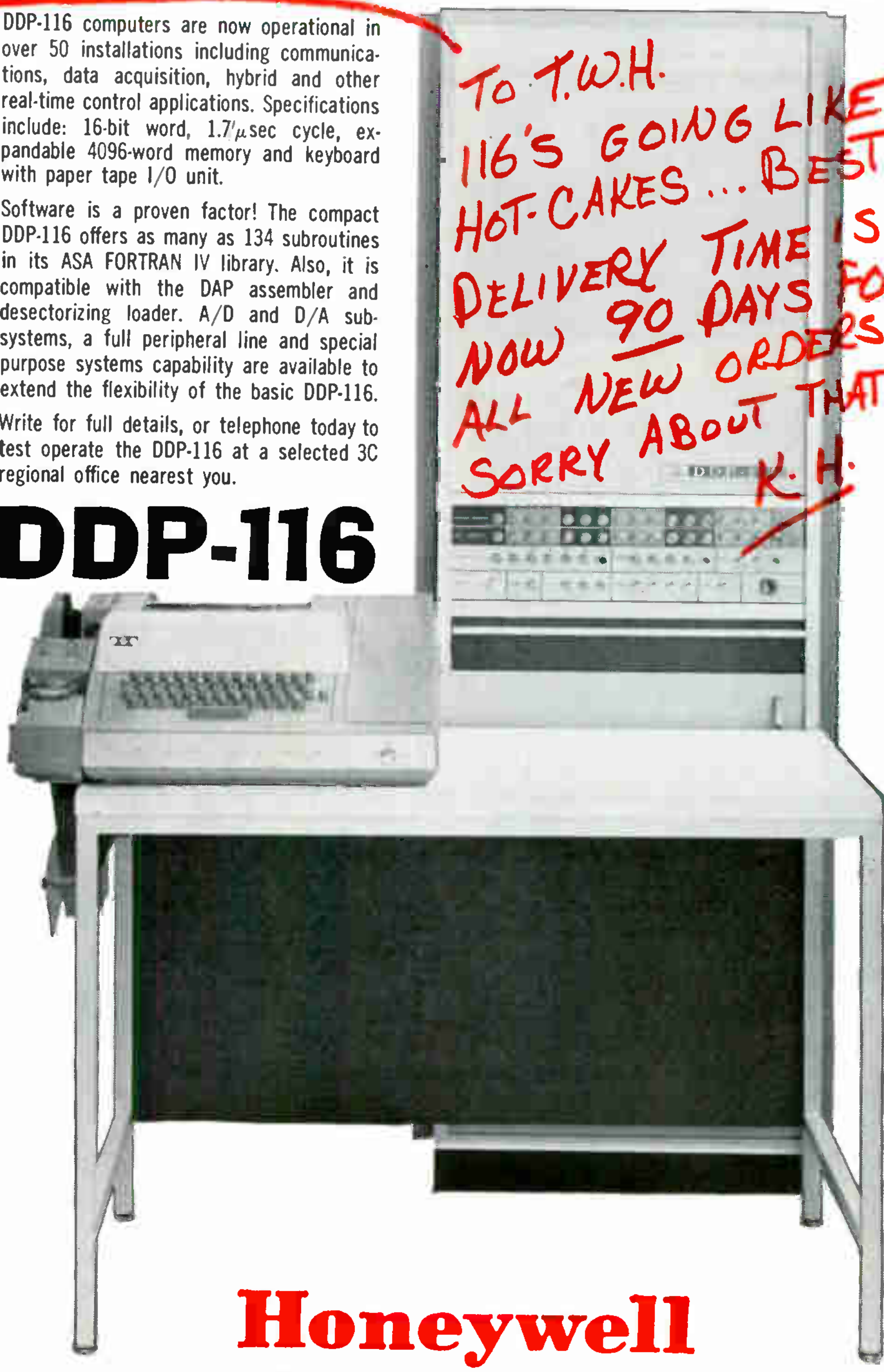

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The best of Tiros and Nimbus

RCA seeks combination of reliability and large size in a weather satellite that will carry a variety of optional sensors

By John Rhea
Electronics Washington Bureau

The nation's meteorological workhorse for the early 1970's promises to be a new satellite that combines some of the best features of the ultrareliable but limited Tiros and the big, sophisticated Nimbus that turned out to be too expensive and not reliable.

Tiros-M, as the satellite will be called, is still conceptual, with nothing more tangible built than a mockup at the Radio Corp. of America's Astro-Electronics division in Princeton, N.J. RCA has a $932,000-contract with the National Aeronautics and Space Administration to improve Tiros.

Space bus

Unlike the operational Tiros, the new satellite will be a space bus, which means it can carry different experiments and instrumentation on every launch. Tiros-M will be bigger than its predecessors and carry more instrumentation.

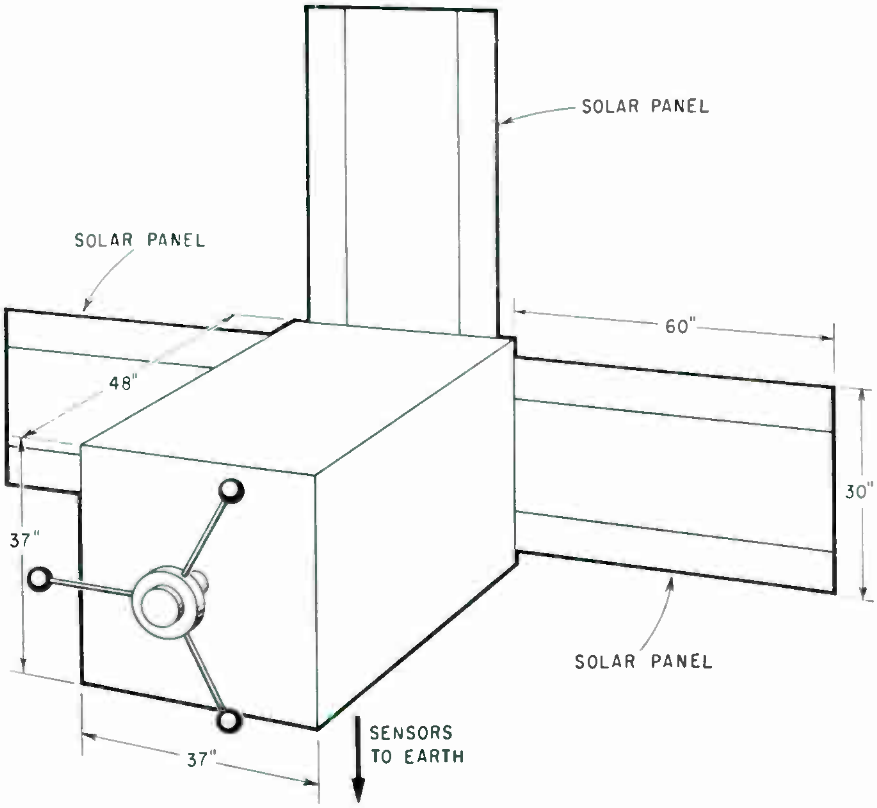
This flexibility delights the customer, the Environmental Science Services Administration (ESSA) of the Commerce Department. According to David S. Johnson, director of ESSA's National Environmental Satellite Center, Suitland, Md., Tiros-M for less cost will provide more weather information than before and with fewer satellites. Although the cost of ground support, $10 million a year, stays the same no matter how many satellites are launched, the bill for launching does not. Tiros stations have a 9- to 12-month life, which means about six have to be launched each year to provide continuous global coverage. With each Tiros costing $3 million and each launch, $4 million, it now costs about $42 million for satellites and launches plus $10 million for ground support, a total of $52 million a year.

With only two Tiros-M satellites needed a year, according to director Johnson, at $5 million a satellite and $4 million a launch, the total with ground support comes to $28 million, or $14 million less than at present.

More important than the savings, Johnson says, is the increased capability. Tiros-M will carry two advanced vidicon camera systems for high-quality weather pictures, two automatic picture transmission camera systems for broadcast to low-cost ground stations and two high-resolution infrared radiometers to collect nighttime cloud-cover data as well as a few environmental sensor experiments. Furthermore, both daylight and infrared data can be read out in real time by the small ground stations all over the globe or can be stored for playback at the two ESSA stations at Wallops Island, Va., and Fairbanks, Alaska.

By contrast, the ESSA 1 and 2 satellites launched in February and ESSA 3 scheduled to rise Sept. 21 can carry only two automatic picture transmission systems or two vidicon systems and no infrared sensors. Since ESSA demands constant global coverage on a daily basis the agency must be ready to launch a new satellite as soon as any sensor fails. All ESSA satellites are versions of the Tiros, first launched in 1960.

William Jones, who heads the



Stabilization system on the front of Tiros-M points sensors toward the earth.

. . . the old Tiros satellites will be around for at least the rest of this decade . . .

Tiros-M project at NASA's Goddard Space Flight Center, says the configuration of Tiros-M has undergone many changes since RCA was selected to make the study. Conceived originally as a 500-pound spacecraft shaped like a cylinder, 5 feet tall by 4½ feet in diameter, its weight has since shot up to around 625 pounds and a unique applecrate shape has emerged. Tiros satellites of today weigh 300 pounds. The experiment section at the bottom of the spacecraft will carry a solar proton sensor being developed by the Applied Physics Laboratory of Johns Hopkins University and a flat plate heat radiation experiment from the University of Wisconsin. Also at the bottom is the S-band antenna, although the exact arrangement is still under study.

The bus concept is something new for RCA, which has traditionally pushed its small, specialized spacecraft such as Tiros and the Space Electric Rocket Test as opposed to the big satellites such as the Orbiting Geophysical Observatory of TRW Systems Group, TRW, Inc., and the Orbiting Solar Observatory of Ball Brothers Research Corp.

More power. To make Tiros-M adaptable, NASA is imposing an 86.2-watt power requirement, or 25% more than needed. Jones believes the solar panels that RCA produced for the successful Lunar Orbiter will be used, but that a radioisotope thermoelectric generator might be substituted much later. A 30-watt unit using plutonium-238, Martin-Marietta Corp.'s Snap-19, is due to fly on the next Nimbus.

The solar array will use n-on-p cells with 9% efficiency. Total array output requirement is 186 watts based on a 70% power system efficiency and the radiation expected in a 750-nautical-mile orbit.

Stabilization will be accomplished in several steps. First a so-called Yo-Yo system consisting of two weights on the end of cables will deploy to reduce the spacecraft's spin rate to a few revolutions per minute. Then magnetic coils will orient the craft along the plane of the earth's magnetic field and further reduce spinning to 1 rpm. Finally, a new device of RCA's known as Stabilite goes into action. It consists of an external flywheel that spins in a direction opposite to the spacecraft's so that all the sensors always face the earth. Tiros-M will be the first space agency satellite to use Stabilite. The design goal of the new satellite is six months of useful life, but the agency and ESSA hope to increase that by using the superior technology that will be available in the 1970's.

II. Still has a role

For the rest of this decade, ESSA will stick with its present Tiros program. Eight more satellites each with either two advanced vidicon or two automatic picture transmission systems are being built by RCA. Also, two prototypes will be refurbished and flown to bring the total to 10. The goal is to have one of each kind of satellite in orbit and operational at all times.

The next step is to phase in the Tiros-M satellites, which ESSA calls its improved Tiros operational satellite series. The space agency hopes to fly a research version in 1969. ESSA has an option to buy three similar craft and Johnson is eager to exercise this option. Goddard is acting as ESSA's purchasing agent in dealing with RCA as it has throughout the Tiros program. Goddard has begun contract negotiations with RCA to supply the Tiros-M research and development spacecraft, the three operational versions for ESSA, ground equipment and launch support. The contract will also contain an option for an additional flight model.

Except for NASA's buying the spacecraft, ESSA's role is the same as the Communications Satellite Corp.'s: it has complete control of the satellites once they are launched by NASA.

High price. Although Nimbus will continue as a research and development platform for testing new instrumentation, it is no longer considered the ultimate operational weather satellite. Three years ago, the Weather Bureau pointed out that costs in the three-flight Nimbus program had skyrocketed to $140 million and by the time of the first launch, Aug. 28, 1964, the program was two years behind schedule. The first Nimbus operated for one month, far short of the practical minimum.

The General Accounting Office, Congress's watchdog, added its criticism in January, 1965, charging that poor management at NASA's Goddard Space Flight Center had resulted in an excessively heavy and expensive satellite.

Although ESSA demanded—and got—a refund of some $20 million from the space agency for its share of the Nimbus program, ESSA continued to be interested in the larger satellite for research purposes. In fact, ESSA is developing a satellite infrared spectrometer to measure atmospheric temperature profiles on the next Nimbus flight scheduled for late 1967. Nimbus 2 is now in orbit carrying research versions of weather instruments.

Booster. The launch vehicle for Tiros-M will be the familiar Delta used for all previous Tiros satellites but with some differences. Performance will be improved by using more fuel, adding three solid rocket motors and substituting a more powerful upper stage, perhaps the retromotor which landed the Surveyor gently on the moon. All future ESSA launches will be from the Air Force's Western Test Range in California. The orbit will carry the satellite over the poles where it will be synchronized with the sun so that about half of each orbit will be in daylight and the other half in darkness. The satellite measures 37 by 37 by 48 inches and the three solar panels are 30 by 60 inches. These fold flat against the spacecraft at launch and the entire package is housed in the protective shroud used for Nimbus satellites. According to Jones, the satellite can be unfolded to install experiments.

III. Three objectives

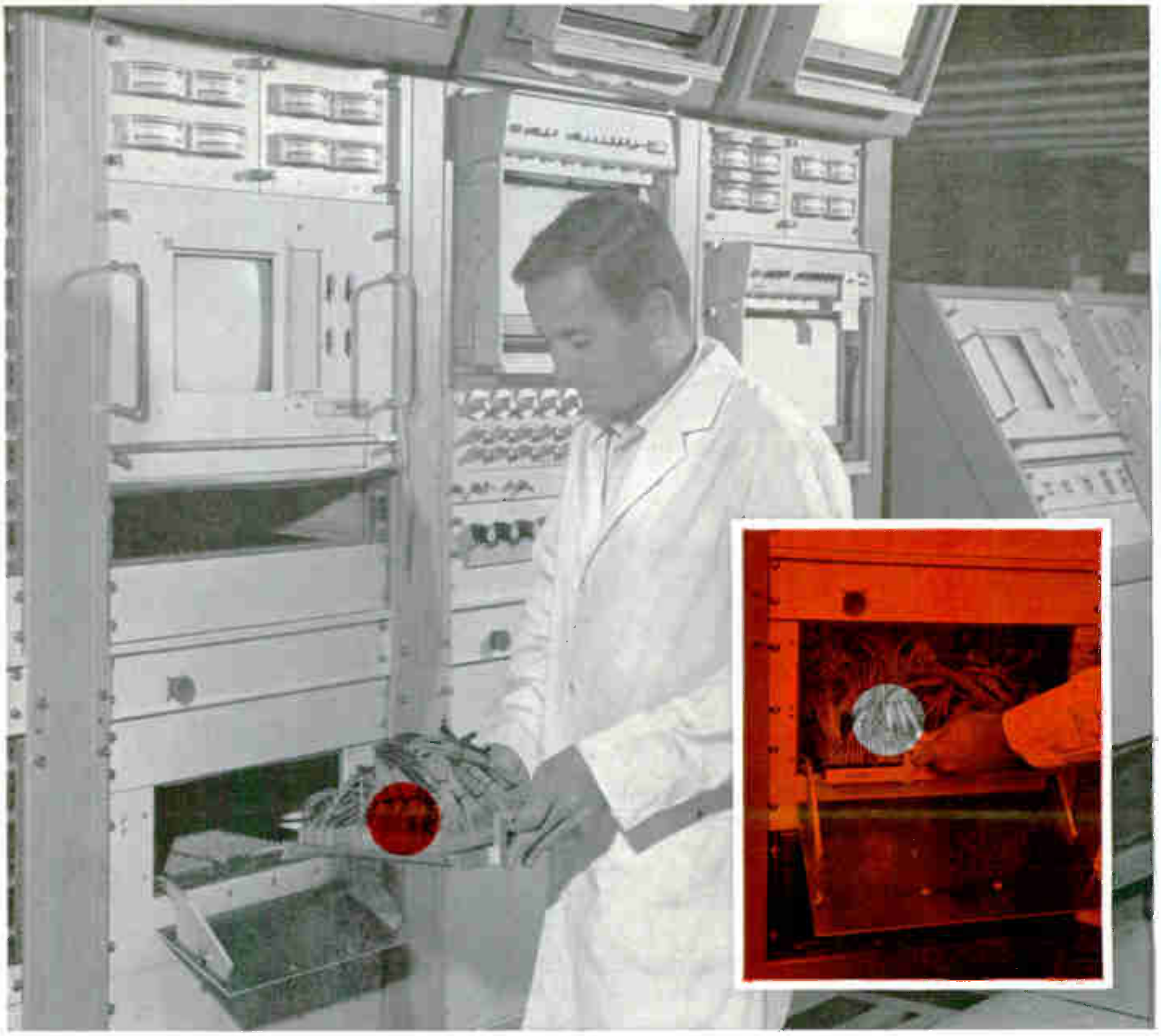
From the ESSA point of view, according to Johnson, Tiros-M represents the fulfillment of an important agency objective: uninterrupted global cloud-cover photography. Johnson spelled out two more ambitious goals before the Senate Space Committee in March, 1965.

One is constant sampling of such environmental data as wind direction and velocity, temperatures and atmospheric pressure on a global basis. Various schemes have been proposed, such as gathering data from balloons and buoys and relaying the information to satellites for playback later to ground stations. Nimbus will be the major research tool in the sampling program, Johnson believes.

The Applications Technology Satellite, scheduled by NASA for its first launch in December, will meet the other goal: continuous observation of the earth from a synchronous and stationary orbit. In this orbit 22,300 miles above the equator, a satellite's motion is synchronized with the earth's rotation so that it hovers above one spot. From this vantage, where the entire earth's disk is visible, storms could be traced from birth and data could be gathered for hurricane warnings. A special meteorological camera developed by the University of Wisconsin and the Santa Barbara, Calif., Research Center of Hughes Aircraft Co. will be tested for this purpose on the first flight.

What lies ahead? ESSA doesn't know what form the weather satellite system of the late 1970's will take, but Johnson doubts that any single satellite can do the job. He foresees a mixture of polar-orbiting, medium altitude (750 to 1,500 nautical miles) satellites and synchronous-orbit satellites ranging around the equator. Two equatorial satellites could provide satisfactory coverage of North America and nearby oceans; four satellites would cover the globe.

Also unanswered is the question of what support other countries and the World Meteorological Agency of the United Nations will provide. The Russians have already announced the launch of their first weather satellite and on Aug. 18 began sending satellite-gathered weather data to the United States through the Moscow-Washington data link. Still, in this area of space technology the United States is clearly the leader and any international system is certain to be built around the American program.



Project APOLLO . . . Shooting for the moon

With the emergence of Apollo as a full-fledged space program, Acceptance Checkout Equipment is being automated. General Electric Company has the responsibility for building a number of ACE stations, each comprising over a hundred racks used for data computation, recording, and display.

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Turning night into day

The Defense Department is pushing harder for development of low light-level television for spotting the enemy from aircraft

By Marvin Reid
Dallas News Bureau

The United States forces in South Vietnam are fighting one of the Vietcong's staunchest allies—the night—with new weapons. Reports from Vietnam tell of Army helicopters equipped with low light-level television cameras that seek out the enemy by moonlight or starlight.

The Pentagon is upset by these reports and is trying to find out how the highly classified project, called Batman, got out.

I. Batman sees all

According to the New York Times and Washington Star, there are five of the new tv systems in South Vietnam. One of them recently picked up a good picture at 2 a.m. of a couple of enemy trucks and the unloading of a Vietcong sampan. The systems, each of which costs $1 million, consist of a small tv camera mounted on the nose of the helicopter and two 8-inch tv receivers. One receiver is in front of the copilot and the other is in the rear for use by a photo interpreter. The view can also be videotaped. Although both the Air Force and the Navy are interested, the Batman systems are being flown by the Army.

The reports did not say who built Batman equipment, and the Night Vision Laboratory of the Army Electronics Command at Fort Belvoir, Va., where such work is being done, or contracted for, won't even discuss it.

Eyeglasses. One of the more interesting projects, partially sponsored by the Laboratory, is known to be a low light-level tv system being built in Hurst, Tex., by the Bell Helicopter Co., a division of Bell Aerospace Corp. The tv camera, which is installed in a three-

Pilot views on his special lenses what his low light-level tv camera picks up in the dark. He can also look through this display at the normal night scene.

axis turret on the nose of a UH-1B helicopter, is aimed by the movement of the pilot's head—up, down, left or right. The pilot's display screen is a special pair of eyeglasses. He can also look through the display on the eyeglasses at the night scene as he would normally see it.

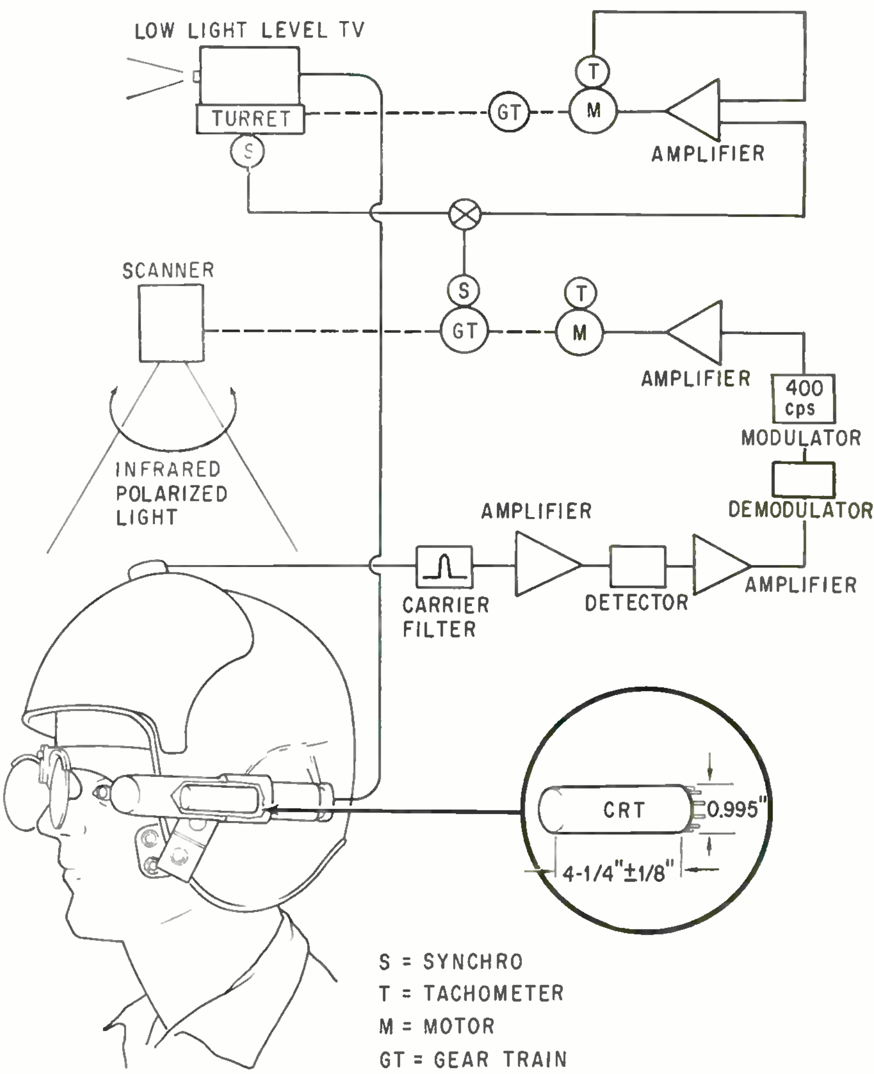
Projecting the display on the eyeglasses eliminates the need to tie up valuable instrument panel space for a conventional display system, and it gives the pilot a natural view of the direction in which he is looking.

Tiny tubes. Miniaturized cathode-ray tubes, built for Bell by Thomas Electronics, Inc. of Passaic, N.J., are on either side of the pilot's helmet. Each tube is 1 inch in diameter and projects a 1-mil electron spot beam. With an aspect ratio of 3:4, image resolution is approximately 450 horizontal tv lines per inch. Glasses and tubes weigh 15 ounces. The optics system, built by the Perkin-Elmer Corp., provides a 40° by 40° field of view.

The image on the face of the crt is reflected by a mirror through a relay lens that re-forms the rays into an aerial image. A second mirror positions the aerial image on the reflecting lens (the inside of the pilot's glasses) which also acts as a collimator. The result is that the tv image is superimposed upon the pilot's normal field of view.

II. Electro-optical headtracker

The pilot's ability to aim the camera by moving his head is accomplished through an optoelectronic servosystem. It begins with a monitor attached to the top of



Optoelectronic servosystem allows pilot to control television camera in nose of helicopter by movements of his head. Transmitter in scanner emits light in the near-infrared region that is polarized and is scanned to determine its phase and amplitude. The monitored signal is used to drive a servosystem that controls the camera's position.

the cockpit that measures the position of the pilot's head. The transmitter emits a cone-shaped (70°) beam of nonvisible light in the near-infrared region, approximately 0.9 microns. The energy is 50 milliwatts.

The emitter is a gallium-arsenide diode, made by Texas Instruments Incorporated, that is excited at carrier frequencies from 3 to 10 kilohertz. A different carrier frequency is used for each of the three axes—pitch, roll and yaw—to reduce crosstalk. The light passes through a linear polarizer, producing a reference polarizing angle. The polarizer is mounted on a torsional scanner that operates on a frequency of 100 khz and modulates the carrier signal.

A second polarizer is over the electro-optical receiver on the helmet. The receiver's output is also modulated by a 100-hz signal. The amplitude and phase of the modulated signal varies according to the angle and distance between the transmitter and the receiver. Its amplitude is inversely proportional to the square of the distance, and its phase varies according to the angle because of the polarization of the infrared light.

Filtered signal. The received carrier signal is filtered to reject spurious signals, for example, when pitch is being measured the carrier frequency for role and yaw will be rejected. The output's d-c level is detected and is used to develop an automatic gain control signal in the servo loop illustrated in the diagram on page 140, so that the servo loop gain is independent of the distance between the transmitter and the receiver.

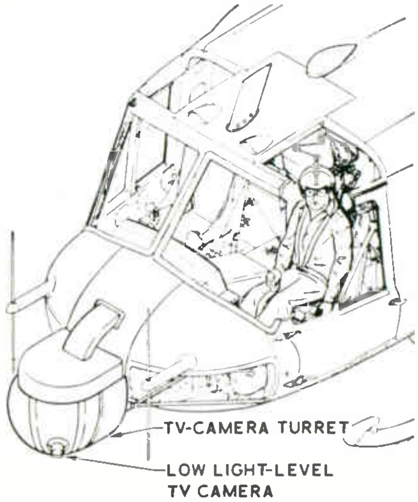
Meanwhile, a phase-sensitive demodulator develops an error signal that drives a 400-hz modulator, amplifier and servomotor. The servomotor moves the reference polarizer in the scanner to minimize the intensity of the light, thus nulling the error signal. A synchro control transmitter measures the servo position, which is proportional to head position.

The scanner system was fabricated by the American Time Products Co. at Woodside, New York. The filters were provided by the Polaroid Corp.

The only attachment to the pilot's helmet is a small flexible set of wires leading to the receiver. This connection can be quickly severed in an emergency.

III. Tested and approved

The forerunner of this electro-optical system was a mechanical headtracker that Bell tested as a possible way to use the pilot's head motions to aim a tv camera. The mechanical system consists of a set of parallelogram linkages and gimbals with associated synchros to measure head position in pitch, roll and azimuth. It was fabricated initially to permit flight testing of the entire system.



Bell envisions several uses for its tv system: pilots can fly by it, direct armament and use it for surveillance.

All the systems except the low light-level tv camera have been completed and tested in the laboratory. The tests were carried out with a regular tv camera. Flight tests have been conducted using the mechanical headtracker eyeglasses and the daylight camera, and Bell says the system feasibility has been confirmed.

The eyeglass display is being worked on now by Perkin-Elmer to improve the optical resolution. Also, the miniaturized crt's are under further development to improve brightness and resolution. Both the mechanical and the electro-optical headtrackers are being reviewed critically. Future systems will be committed to one or the other headtracker design. Bell leans at this stage to the electro-optical, saying it provides the pilot with more freedom. But, the final decision on which system wins out will have to be made by the customer.

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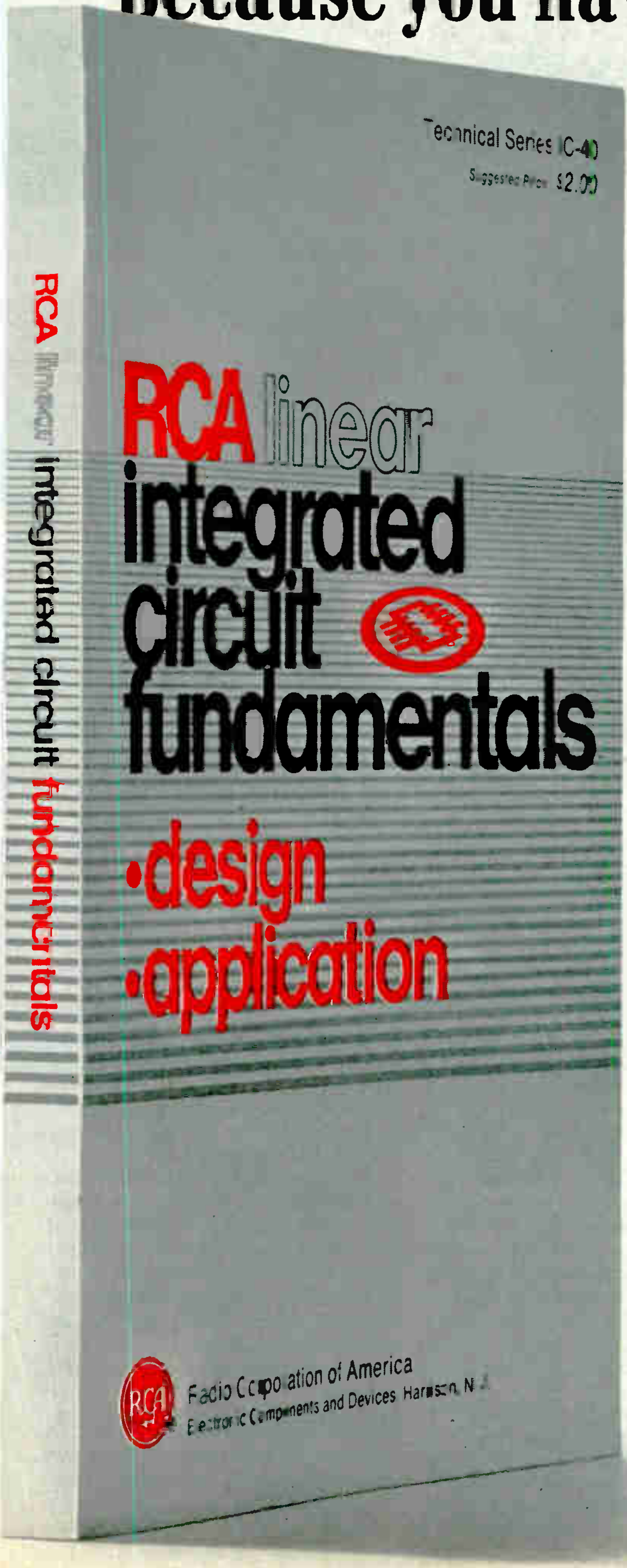

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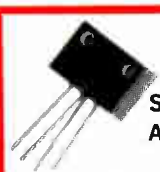

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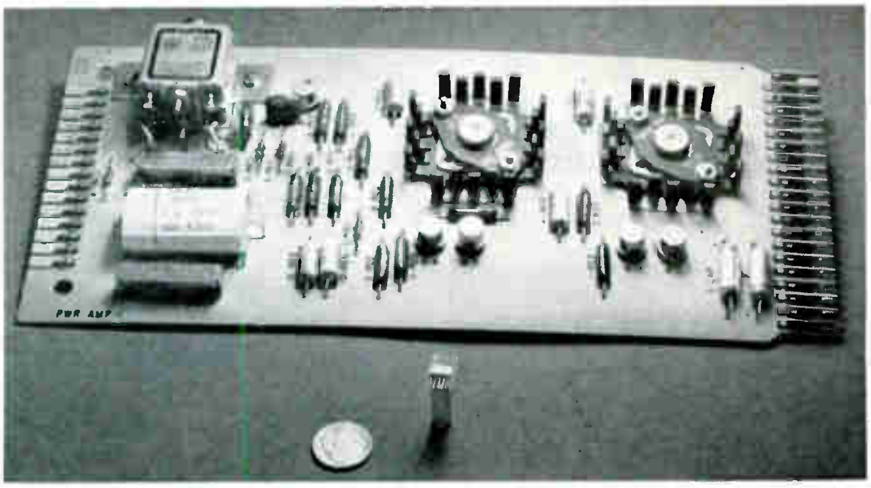
Circle 146 on reader service card

New Products

Integrated circuits shrink numerical control

First industrial product built completely with microcircuits is 10 times more reliable than former units

The first numerical control systems with all integrated circuit construction are coming down the assembly line at Cimtrol division of The Cincinnati Milling Machine Company. Although Cimtrol chose integrated circuits for reliability, the new design also cut the control unit's size to one-third that of its discrete-component predecessor.



A single integrated circuit flatback replaces an entire circuit board in Cincinnati Milling Machine's numerical control unit.

Cimtrol engineers claim that integrated circuits are responsible for a 10 to 1 improvement in the reliability of the control unit, designated Acramatic IV, making it virtually as reliable as the contouring machine it controls. To overcome doubts as to the ability of integrated circuits to stand up under rigors of industrial application, Acramatic IV was tested under actual operating conditions for more than a year without failure. During this period it was operated continuously for 2,000 hours.

Gains in reliability were primarily due to replacement of large numbers of discrete components and solder joints by microcircuits. In some instances a single microelectronic circuit supplants an entire circuit board and three circuit cards take the place of an entire drawer containing 15 larger circuit boards, as shown in the photo. Cimtrol maintains that one logic board now replaces as many as ten boards in a former system.

Improved reliability of the control means that downtime on the controlled machine is reduced substantially. The more reliable control also increases the interval during which the machine can be continuously operated without preventive maintenance.

Since the control contains fewer boards, time required for locating and repairing a defective component is considerably reduced.

Space on the factory floor is precious; thus factory planners will welcome the jukebox-size Acramatic IV which can be placed on the operator's platform of the big contouring machine it controls.

In addition to improved reliability, integrated circuits have also enhanced the performance of Acramatic IV. Previously, numerical control units were limited by cycle time or time to read and act on an instruction from punched tape. Occasionally the entire machine and control would have to pause and wait for the instruction to be read from the tape. Minimum cycle time on the new control is 100 times shorter than that offered in former systems.

Acramatic IV numerical control is housed in this jukebox sized enclosure.

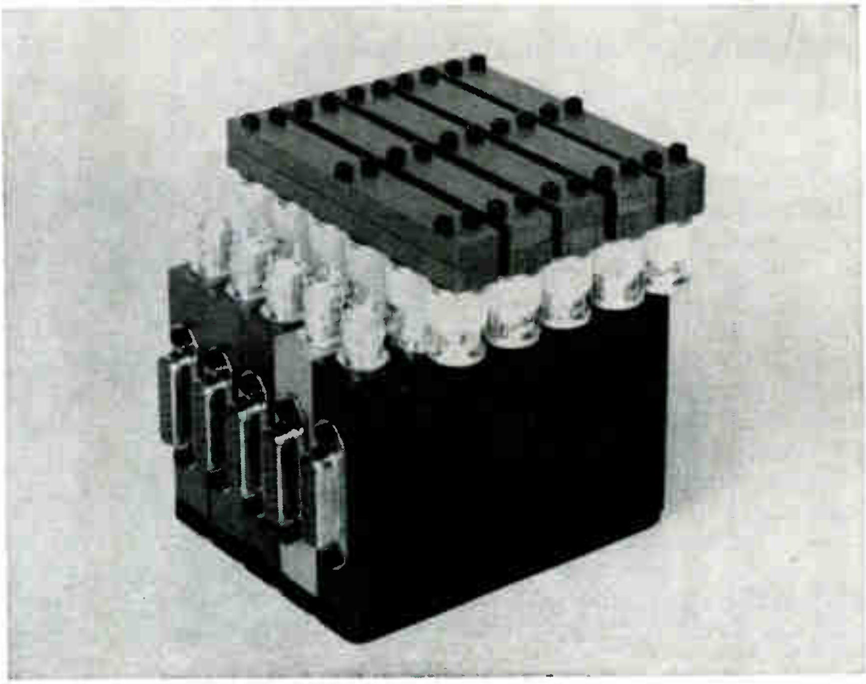
Because the integrated circuits have a lower cost per function than their discrete-component counterparts, Cimtrol can offer contouring capability (as opposed to point-to-point machining) at a price that more users can afford. Although the price for various Acramtic IV models has not been set, the company has indicated that the cost will be comparable to those on discrete-component units with some possibility of a modest reduction.

Integrated circuits in the new control were produced by Texas Instruments Incorporated. Cimtrol engineers designed all command, switching and readout logic with seven of the nine etaointaa in TI's series 73 line of saturated diode transistor logic (DTL).

The Cincinnati Milling Machine Co., Cimtrol division, Cincinnati, Ohio 45209

Circle 350 on reader service card.

Quick switch possible with modular relays



For its debut in switching, the Matrix Co. is introducing a line of modular reed-relay coaxial switches that may be assembled in a variety of configurations. Isolation is good —up to 170 decibels. Depending on the specific frequency, the switches give two to three times better isolation than any other switch, according to Matrix president John D. Williamson.

Matrix claims that its MMS series is the first modular switch that can be repaired in the field. All that is needed is a screwdriver and a soldering iron.

Matrix also has a new concept of modularity. Instead of one basic module, there are 20—ranging from a single-pole, single-throw switch to a single-pole, 20-throw switch. The modules can be assembled to form multipole, multithrow, matrix or hybrid switches. The handy thing, Williamson says, is that the user can change the size and the form of a switch as needed. The control units (the relays that operate the switches) are also modular.

The photograph shows five single-pole, 5-throw switches cross-strapped into a 5-input, 5-output matrix. The BNC connectors shown are standard equipment, but subminiature connectors can also be used. This particular 5- by 5- by 4-inch switch could link an instrumentation recorder and a readout unit or be used for low-level switching as in transducer scanning for aerospace applications.

Williamson reports that the switch is excellent for television, especially if the user doesn't want to miss a single frame (as in satellite transmission). Where unskilled personnel might damage a switch, the field-repairable feature is valuable. Other applications include antenna phasing, military-security transmission, wide-band and low-level instrumentation recording and computer interconnections.

Specifications

Frequency range	D-c to 300 Mhz
Load capacity	Up to 50 w
Isolation	Up to 170 db
Switching control voltage	20-40 v range, 28 v, d-c, nominal
Switching speed	Under 1 msec
Life	20 million operations
Switch-point spacing	⅝ in. minimum
Impedance	50 to 75 ohms
Closed-contact resistance	Less than 150 milliohms
Insulation resistance	More than 10 megohms
Average switch-point price	$20
Delivery	30 days

Matrix Co., 18075 Ventura Blvd., Encino, Calif. [351]

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4-280 LOW Z ACCELEROMETER

4-281 LOW Z ACCELEROMETER

CEC's unique solid-state design and construction (U.S. patent pending), make these low impedance instruments unequalled in performance by any other accelerometers.

The use of piezoelectric accelerometers has been traditionally complicated by special problems which have plagued even the most sophisticated user. However, by *combining* a source follower with a piezoelectric accelerometer in a *single* small package, *permanently calibrated,* with *no external pot* or other electronics—CEC has perfected instruments which offer all the advantages of the piezoelectric principle *without* the accompanying headaches of high impedance.

The reasons why low impedance units are superior:

▣ **Fixed Sensitivity.** All calculations are done by CEC at the factory—precisely and permanently. Since the source follower is an integral part of the instrument, there is *no cable* from accelerometer to follower. Therefore, total circuit capacitance remains *constant* for all applications. Even the FRC effects can be ignored as the initial calculation never varies.

▣ **Low Frequency Response Guaranteed.** The field-effect transistors give a low frequency response which is unaffected by, and independent of, the load impedance on the accelerometer output. As a result, room temperature frequency response is within ±5% from 2 Hz to 10,000 Hz, *regardless* of load impedance.

▣ **Fixed Temperature Stability.** The temperature response curves for conventional accelerometers show a varying slope as the value of load capacitance changes. This *does not occur* in a CEC Low Impedance Accelerometer. A fixed tolerance of ±5% can be assigned to temperature response over the entire range, *regardless* of output cable capacitance.

▣ **Low noise—and no cable noise.** Broad-band noise level is less than 1 mv p-p over the temperature range. Due to high sensitivities, as high as 36 mv/g, very low G-levels can be measured with excellent signal-to-noise ratios. And since there is no cable noise with a CEC Low Impedance Accelerometer, there can be *no signal deterioration,* and the need for expensive cables is eliminated.

Don't scrap it—convert it.

If you have a high impedance piezoelectric system, it is still possible to obtain state-of-the-art performance. By the simple addition of a CEC 1-304 *Source Follower*—which is adaptable to all high impedance piezoelectric accelerometers—you may convert an obsolete unit into a low impedance instrument. That way, you can always expand or replace with the new low impedance accelerometers as the need arises.

1-304 SOURCE FOLLOWER

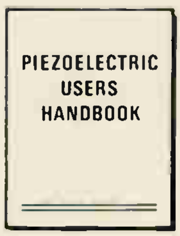
Who needs CEC Low Impedance Accelerometers?

Everyone who needs a truly precise and reliable piezoelectric accelerometer. Aerospace users would include such obvious groups as NASA, missile sites, environmental test labs and testers of airframes and aircraft engines. Industrial users—all applications where vibration monitoring and noise reduction are critical factors.

When can you expect to receive these instruments?

Whenever you need them. As the leader in data instrumentation, CEC now has 78 Field Engineers throughout the country to serve you—more than all other accelerometer manufacturers combined. Furthermore, CEC will be pleased to prepare a *comprehensive* analysis of your needs and conversion costs without obligation.

For complete information on the CEC low impedance piezoelectric line, call or write CEC for Bulletin Kit 9069-X3.



We will also include a copy of the current *"Piezoelectric Users Handbook."*

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Data Instruments Division

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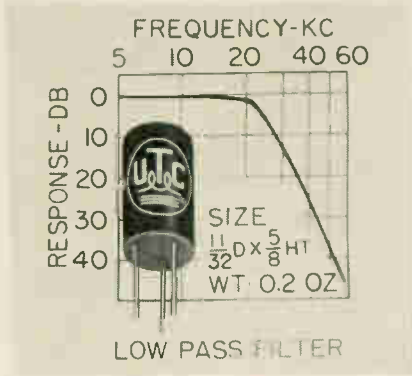
Circle 149 on reader service card

Low-pass filters ideal for IC's



Ultraminiature low-pass filters have the same physical configuration as the DO-T family of audio and power transformers, having a diameter of only $\frac{11}{32}$ in., height of ⅝ in., and weight less than 0.2 oz. Its size makes it ideal for printed-circuit applications. The metal-encased, hermetically sealed filter is designed, manufactured and tested to complete MIL-T-18327B specification.

Source and load are 10,000 ohms. Response from d-c to 22 khz is within 3 db; at 36 khz it is 20 db minimum; at 44 khz it is 30 db and above 48 khz the response is 35 db or more.

United Transformer Corp., 150 Varick St., New York, N.Y., 10013. [352]

Translational pots handle high power

A series of translational precision potentiometers has been announced. The line is designated TS or TD styles.

These compact pots can handle power levels to a maximum of 1 watt per inch of stroke. Standard resistances range from 100 ohms to 40,000 ohms per inch. This re-

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Kodak

sistance is varied as the pot's shaft is slid into or out of the unit's housing. Both linear and nonlinear outputs are available.

Translational pots are designed for both military and commercial applications where highly accurate measurement of linear motion is required, such as in a laboratory set up or for machine tool control or surveillance.

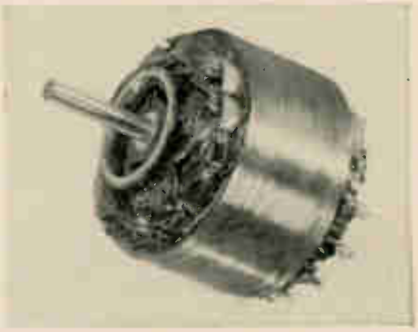
Both single (TS) or dual resistance (TD) elements with separate contact brushes and terminals are produced in a compact housing. Housings are anodized aluminum rigidly constructed to withstand vibration and shock.

The stainless steel shaft can be rotated 360° without affecting the mechanical or electrical operation. Shaft actuation for full stroke requires minimal force.

Special configurations can be provided for specific requirements. Taps are supplied as desired. Stroke lengths from ½ in. to 16 in. are standard but nonstandard lengths can be supplied. Contacting elements are precious metal throughout.

Gamewell division, E.W. Bliss Co., 1238 Chestnut St., Newton, Mass. [353]

Synchronous motor for high-volume use



The Type IC motor is available either for low-voltage square-wave transistor drive or as a single phase 115 v a-c, 60 hz unit. Torque output is 1.0 oz in. at 2 or 4 pole speeds. The unit is furnished without case to permit easy insertion in constant-speed requirement

SCIENCE/SCOPE

A "window shade" array of solar cells is being developed by Hughes for the U.S. Air Force as a power source for space. It will be designed to withstand launch requirements for a Titan III type booster in a stowed condition...will unfurl in a manner loosely comparable to unrolling a window shade. Demonstration model will have a 50-square-foot array; modular design allows larger arrays for extra solar power.

"Large array" microcircuits and high density packaging techniques are features of the HCM-205, new microminiature airborne computer designed by Hughes. It has a 4,096 18-bit word memory, expandable to 32,768 words; can perform about 125,000 operations per second; weighs 13.3 lbs. including power supply; occupies 1/5 of a cubic foot. It will be integrated into a multimode radar data processing system for flight test early next year.

A prototype radar system, most powerful ever built by Hughes, is called ADAR (Advanced Design Array Radar). The reduced-size prototype city defense system will be used to demonstrate new long-range phased-array techniques for the U.S. Air Force prior to defining the best type of full-scale system.

The first four Mark 1B satellite ground-link terminals, now on duty for the U.S. Army to communicate with the random-orbit military satellites launched in June, form the world's first global military satellite communications network. Three of the air-transportable terminals are located in Hawaii, the Philippines, and West Germany. The fourth, now being erected in Ethiopia, will soon be ready for test operations.

We have immediate openings for system-oriented engineers in a wide variety of disciplines: advanced aerospace radar, missile guidance and control, space craft electronics, command/control, communication satellites, laser systems, automatic checkout equipment. Please write: Mr. D.A. Bowdoin, Hughes Aircraft Company, Culver City, California. Hughes is an equal opportunity employer.

Surveyor 2 made the first leg of its trip to the moon aboard an out-sized "Super Guppy" aircraft, which carried it from Los Angeles to Cape Kennedy in mid-July. Scheduled to be launched this fall, its mission will be to repeat the tasks of Surveyor 1 and to perform additional experiments at a new location on the lunar surface. It is the second of seven planned lunar landings.

A new joint-venture firm called Satellite Telecommunications Company (Satelco) has been formed by Nippon Electric Company Ltd. and the Hughes Aircraft Company for worldwide marketing of satellite communications ground terminal stations and equipment. The activities will also include systems and applications engineering, site surveys, test installation, maintenance, spares provisioning of terminal stations under contract, and other field service and support functions.

Creating a new world with electronics

HUGHES

HUGHES AIRCRAFT COMPANY

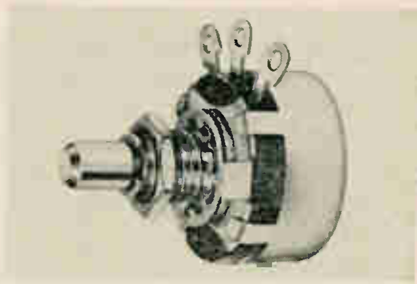
Circle 153 on reader service card

equipment, such as tape and record players. Size is 1.990 in. diameter x 2.150 in. maximum length with a weight of 10 oz.

The shaft is 0.1875/0.1870 in. diameter stainless steel and supported between two self-aligning sleeve bearings. The motor is designed to meet specific performance over a temperature range of −20°C to +140°F. Custom designed units can be made for other voltages, speeds, torques, etc., where production volume will be high.

Globe Industries, Inc., 2275 Stanley Ave., Dayton, Ohio, 45404. [354]

Hot-molded pot features reduced size



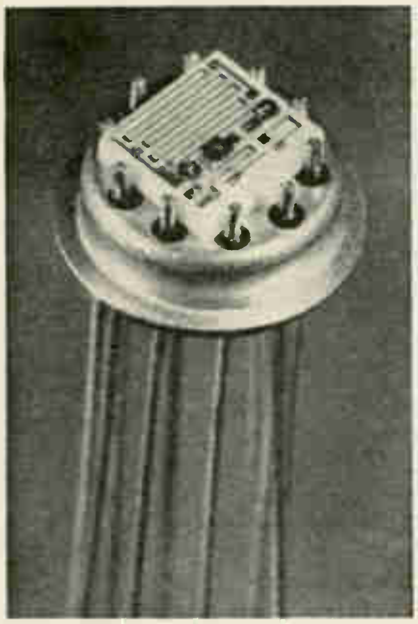
Miniature hot-molded resistive controls feature a size reduction to ⅝ in. from the earlier 1 in. as well as lower static noise levels.

Designated series 369, the controls have been designed to meet or exceed MIL-R-94B and have an RV1 envelope size. Built to the same quality specifications as the company's series 53, the units are smaller in size and operate through 50,000 rotational cycles, compared to earlier film types with an upper limit of 10,000 cycles.

The units possess low temperature coefficients and are available with a resistance range of 100 ohms to 5 megohms, with tolerances of ±10% to 100,000 ohms and ±20% above 100,000 ohms. Power rating for military units is 1 w at 70°C and 350 v d-c maximum derated to zero watts at 120°C; for commercial units, ¾ w at 40°C and 500 v d-c maximum.

Clarostat Manufacturing Co., Inc., Dover, N.H. [355]

Small amplifier packs big voltage



The Hughes Aircraft Co.'s Microelectronics division has developed a d-c amplifier with an output voltage range of ±36 volts. The company claims the hybrid integrated circuit amplifier, designated HMC 1148, outperforms any unit its size. Hughes says amplifiers with monolithic circuits usually can deliver only about ±15 volts.

Packed in a low-profile TO-5 can, the amplifier gets its performance from a hybrid circuit that has discrete silicon transistors and diode chips attached face up on an alumina substrate with deposited thin-film resistors on it. Wires are bonded to the chips by thermocompression.

The price is attractive—$28 each in quantities of 25 to 100. Other operational amplifiers with less output, Hughes reports, cost about $20 to $40 each. And the future price picture looks even better. In about 60 days, quantities over 10,000 should drop below $10 each. The key to the low price is that Hughes is planning to replace the three active-device chips with ultrasonically bonded, face-down flip chips, thus cutting assembly time by one-third.

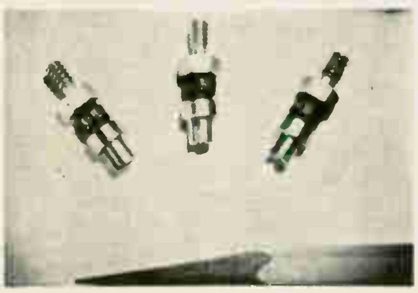
Hughes expects the HMC 1148 to be used where space is limited, such as in missiles. The amplifier is only 0.360 inch in diameter and 0.165 inch high. It is adaptable for any type of control system, such as computers, servos, filters, oscillators, voltage regulators and modulator-demodulators.

Specifications

Input offset voltage	Less than 0.2 v
Input bias current	Less than 2 μa
Input impedance	100 x 10³ ohms minimum
Input common-mode voltage	±20 v
Common-mode rejection ratio	80 db minimum
D-c open loop voltage gain	600 v minimum
Unity gain	10 Mhz minimum
Power dissipation	400 mw typical
Delivery	2 weeks

Microelectronics Div., Hughes Aircraft Co., 500 Superior Ave., Newport Beach, Calif. [360]

Stud-mount rectifier is small and light



A significant reduction in size and weight of rectifiers with a 12-amp rating is possible with this miniature stud-mount series. Only 0.187 in. in diameter and 0.46 in. long, the unit weighs less than 1.5 grams. A 4-40 stud 0.19 in. long permits mounting to a heat sink. All units feature controlled avalanche characteristics and piv ratings up to 600 v are available.

Units are made by using the manufacturer's voidless, whiskerless construction, with hard glass fused directly to the silicon and terminal pins. The 4-40 stud is brazed to one end and a turret terminal to the other.

Surge ratings are as high as 200 amps for one cycle with this series. Units are available from stock. Prices range from $5 to $11.
Unitrode Corp., 580 Pleasant St., Watertown, Mass [361]

New Semiconductors

Diode quad for high frequency

A balanced-modulator, hot-carrier quad has been introduced for high-frequency applications. Each of the four diodes is closely matched at four points on the forward curve and molded into a plastic package 0.20 x 0.200 x 0.310 in. with four leads.

Similar devices are also available in matched sets that are unmolded and also made to special matching requirements.

The MS396 is priced at $60 each in quantities of 1 to 99 with delivery from one to three weeks.
Solitron Devices, Inc., 256 Oak Tree Road, Tappan, N.Y. [362]

Integrated circuit operational amplifier

The WC-161 commercial integrated circuit operational amplifier has both single-ended and differential outputs. The unit has a Darlington input stage which permits the use of megohm-range scaling resistors. Applications include general-purpose instrumentation, integration and summation. With feedback, the amplifier can serve as a transducer amplifier, preamplifier voltage comparator and as a bandpass or buffer amplifier.

Operating parameters include: differential gain, 2,200 v/v; input impedance, 300,000 ohms; output impedance, 40 ohms; drift, 10 μv/°C and 1 na/°C.

Testing is stringent. Every unit undergoes a 24-hour bake at 150°C; three cycles of thermal shock (−55° to +150°C); 30,000-g acceleration on the centrifuge; as well as gross and helium hermeticity tests.

Price of the WC-161 is $39.50 each in quantities of 1 to 49; $29 each in quantities of 50 to 499. Availability is from distributor stock.
Westinghouse Molecular Electronics division, Westinghouse Electric Corp., Box 7377, Elkridge, Md., 21227. [363[

Only Varian delivers low-noise TWT amplifiers that have...

- lowest noise figure,
- smallest size,
- lightest weight,
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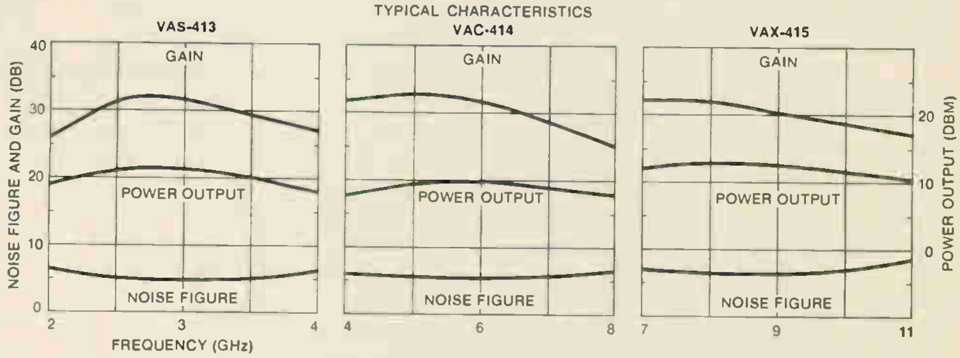
- single-reversal permanent-magnet focusing,
- integral power supply,
- broad band frequency range,
- narrow band frequency range,
- S-band performance,
- C-band performance,
- X-band performance.

TYPICAL CHARACTERISTICS



For more information on these 3-inch TWT amplifiers, covering the complete spectrum of applications, write Palo Alto Tube Division, 601 California Avenue, Palo Alto, Calif.

In Europe: Varian A.G., Zug, Switzerland.
In Canada: Varian Associates of Canada, Ltd., Georgetown, Ontario.

varian

Circle 157 on reader service card

New Instruments

Voltage divider operates at 500 khz

The first commercially available ratio transformer capable of operating to 500 kilohertz is claimed by the Dytronics Co. The model RT-501 inductive voltage divider can resolve an a-c input voltage into more than one million parts. The accuracy of the divider's transformation ratio is within 0.0005% near the lower operating frequency limit of 4 khz and 0.09% at the upper frequency limit of 500 khz.

With the divider, many measurements not normally feasible within the ultrasonic and lower radio-frequency regions are now possible. Included are the measurement of distortion created by inverting amplifiers, calibration of attenuators and calibration and linearity tests of voltmeters; the divider provides precise control of voltage attenuation and impedance transformation with almost no power loss.

Dytronics says the device was made possible by the availability of new magnetic materials and the the development of special coil-winding techniques that permitted the company to construct almost ideal toroidal inductors. "Filling the core area of the toroid with a high-permeability material," a company spokesman says, "reduces the leakage flux to a point where the behavior of the inductor is extremely close to that of an ideal toroidal inductor. With no leakage flux, the emf generated in each turn is identical. With the new coil winders, the coils can be wound with no fractional turns. As a result, the voltage ratio between coil elements is a direct function of the turns ratio."

In addition, the model RT-501 has an output impedance which is essentially less than 1 ohm. The low output impedance eliminates almost all the circuit loading effects of conventional dividers.

Specifications

Frequency range	4 khz to 500 khz
Ratio range	0.00000 to 1.11111 in 0.000001 steps
Linearity deviation (in ppm) (= output volts/input volts—setting)	$2 + f/2 + (f/20)^2$ (f = frequency in khz)
Max input voltage	1.5f or 150v rms max
Output impedance	equivalent to 0.21 ohms in series with 1.5μh
Resolution	1 ppm below 100 khz, 10 ppm above 100 khz
Price	$350

Dytronics Company, Inc., 5566 North High St., Columbus, Ohio 43214 [370]

Portable electrometer covers 73 ranges

Model 601 is a battery-operated electrometer with off-ground operating capability. It offers 73 ranges for d-c measurements: 9 voltage ranges from 1 mv full scale to 10 v; 28 current ranges from 10^{-14} amp full scale to 0.3 amp; 23 resistance ranges from 100 ohms full scale to 10^{18} ohms; 13 coulomb ranges from 10^{-12} coulomb full scale to 10^{-6} coulomb.

Besides these ranges, the model 601 can operate up to ±1,500 v off ground. The case and all controls are at ground potential.

Price is $595; delivery, within 60 days after receipt of order.

Keithley Instruments, 12415 Euclid Ave., Cleveland 6, Ohio. [371]

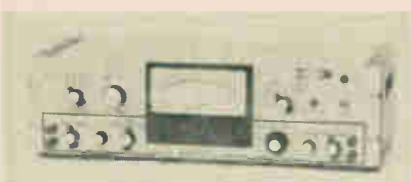
Standard oscillators are compact and light

Series 4000 RC oscillators feature transient-free tuning, exact resetting by means of rotary switches, harmonic distortion less than 0.01%, frequency response within ±0.01 db, amplitude stability of ±0.01% per hour, and voltage calibration accuracy of ±0.25% without a meter. The solid state units cover frequencies from 0.001 hz to 100 khz.

Modular plug-in construction has been used to achieve compactness and light weight, while still keeping all circuits readily accessible for easy servicing. All models provide an additional quadrature (90°) sine wave output, and all can be synchronized with an external signal. Options include a simultaneous square wave, and a pulse which is controllable in both polarity and width.

Prices range from $850 to $1,300 depending on the choice of options. Krohn-Hite Corp., 580 Massachusetts Ave., Cambridge, Mass., 02139. [372]

Phase-sensitive vtvm offers versatility



Model 240SP will operate either as a standard vacuum-tube voltmeter or as a phase-sensitive vtvm. As a standard vtvm, the instrument will measure either the total signal or the fundamental component of the signal. When operated as a phase-sensitive voltmeter, the in-phase and quadrature components as well as the phase angle may be measured at a single frequency. Isolation transformers in both signal and reference channels may be switched in or out of the circuits by means of front panel controls. Internal filters reject the influence of noise and harmonics.

Full-scale sensitivity of the model 240SP may be adjusted to any value from 300 μv to 300 v. The signal voltage is displayed directly in volts on a large taut-band with a mirrored scale panel meter. The internal calibrated phase shifter covers the full range from 0° to 360° without ambiguity.

Typical applications include the measurement of phase angle; measurement of transformation ratio at the single operating frequency; null indicator for ratiometer and synchro bridge, measurement of power factor and complex impedance and the zeroing of synchros, resolvers, and transducers.

Dytronics Co., Inc., 5566 North High St., Columbus, Ohio, 43214. **[373]**

Versatile, broadband sweep generator

A broadband sweep generator, model 900-C, is designed for sweep frequency analysis of the response of various electronic circuits. The instrument permits observation of the entire frequency response of the unit under test (up to a 400-Mhz bandwidth), or will examine a narrow 10-khz segment. It can be used to make qualitative analysis of the response of a wide range of electronic devices such as receivers, amplifiers, filters, transformers or transmission lines.

Built-in features include a plug-

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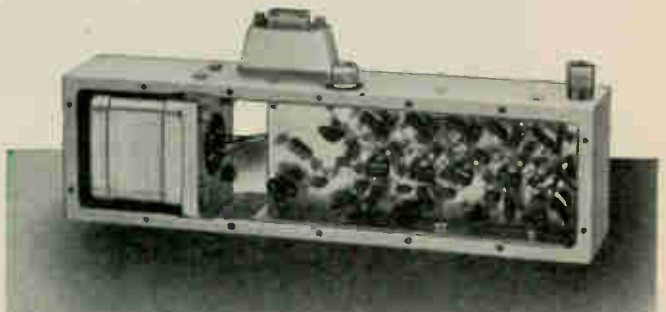

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in detector, harmonic marker system, scope preamplifier, precision turret attenuator and r-f output meter. With accessory equipment, the unit can measure by comparison methods: gain, attenuation and return loss; or measure the unloaded bandwidth and Q of cavities and resonant circuits.

Range for vhf is 50 khz to 400 Mhz; uhf, 275 Mhz to 1,200 Mhz; response is flat within ±0.5 db up to 800 Mhz. Output capability for vhf is 0.25 v rms; uhf, 0.5 v rms. Price is $2,180.

Jerrold Electronics Corp., 401 Walnut St., Philadelphia, Pa., 19105. [374]

Impedance bridge has high accuracy

The 250DE impedance bridge, a self-contained instrument can measure resistance, capacitance and inductance on-site with high accuracy, the manufacturer says. Dissipation factor and storage factor can be read out directly on capacitance and inductance measurements.

Accuracy of the 250DE is conservatively rated to within 0.1% for resistance, 0.2% for capacitance and 0.3% for inductance. Comparative measurements can be made with greater precision because the dial resolution is 12,005 divisions.

The a-c/d-c null detector allows full accuracy on all ranges with a sensitivity of better than 20 μv on d-c and 10 μv on a-c. The single front-panel meter displays both a-c and d-c null balances. Matching a-c generator features transformer output and diode rectifiers

for applications requiring d-c.

Both detector and generator are solid state throughout. Added binding posts provide for application of bias voltage to capacitors or use of external generators and detectors. The company says its precision wirewound resistors ensure accuracy and stability, and that the Dekadial coaxial main dial permits easy adjustment and reading. The cover is attached by self-locking clamps but can be detached for unencumbered use. Operation instructions are permanently affixed to the inside of the cover.

Price is $470; availability, stock to 30 days.

Electro Scientific Industries, Inc., 13900 N.W. Science Park Drive, Portland, Ore. **[375]**

Video X-Y plotter is useful in 4 modes

A video plotter has been developed to display graphic information directly on the screens of standard television monitors, with resultant increased flexibility as compared with conventional paper recorders. The traces produced by the model 401 are bright and nonfading, but can be completely erased in a fraction of a second. Signals from the 401 can be intermixed with those from tv cameras, flying spot scanners or other video sources to produce highly complex displays.

Model 401 may be used in four different modes: as an X-Y plotter writing at a rate of 60 points per second; as a low frequency storage oscilloscope by using the internal time base; as a raster display device writing at a rate of 60 lines per second; as a direct-writing device driven from an external video signal.

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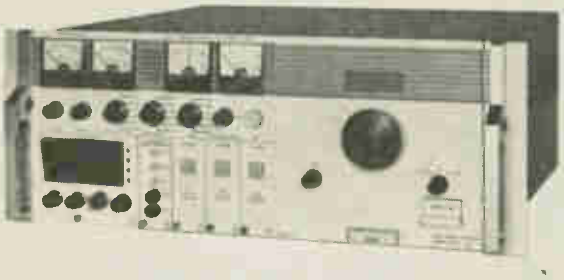

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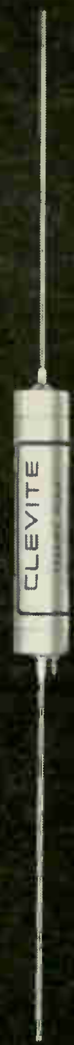

MODEL	6 db BANDWIDTH
TL-2D5A	2 kc
TL-4D8A	4 kc
TL-6D11A	6 kc
TL-8D14A	8 kc
TL-10D16A	10 kc
TL-16D25A	16 kc
TL-20D32A	20 kc
TL-30D45A	30 kc
TL-40D55A	40 kc
TL-45D65A	45 kc
TL-32E48C	32 kc
TL-50D75C	50 kc

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CLEVITE

Circle 165 on reader service card

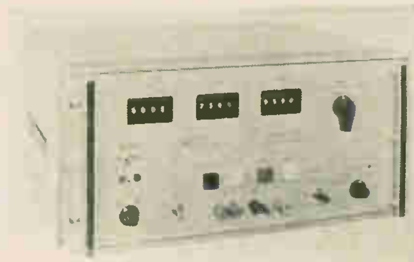
some applications is the fact that the 401 can be Z-axis modulated, and can render better than six shades of gray.

The plotter's versatility is due to its high capacity, wide band, magnetic disk memory that provides indefinite data storage.

Price of the video plotter is $4,000, and delivery is 90 days after receipt of order.

Colorado Video, Inc., Box 928, Boulder, Colo., 80302. [376]

Limit bridge tests capacitors



Limit bridge model 5350 provides simultaneous limit decisions for both series capacitance and dissipation factor at 120-hz or 1,000-hz test frequencies, and completely eliminates stray capacitance effects due to bias supplies, capacitance to ground, shielded leads, and other causes. A zero to 300-v bias supply can be used with no effect on either capacitance or dissipation factor measurements. The company claims this is the first bridge to allow this type of measurement.

The bridge operates on a go, no-go principle. It makes a limit decision in 250 msec. Accuracy is to within 0.25% on capitance and better than 1% on dissipation factor. It provides one accept and three reject categories; additional accept categories are optionally available. Output relay closures permit operation of solenoids, automatic feeders, etc. A two-, three-, four-, or five-terminal measurement allows guarding and sensing for the capacitor under test.

Capacitance ranges are from 0 to 1199.9 μf at 120 hz, and from 0 to 11.999 μf at 1,000 hz. Capacitance limits are: lower, 0 to 9.999; upper 0 to 11,999. Limits are set in

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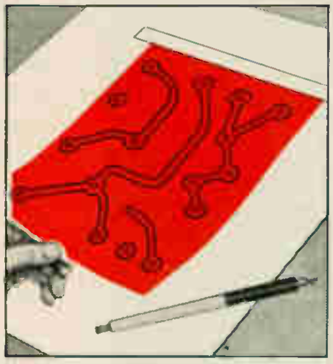
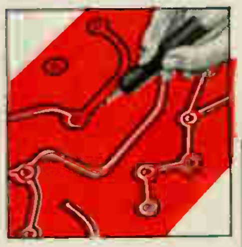
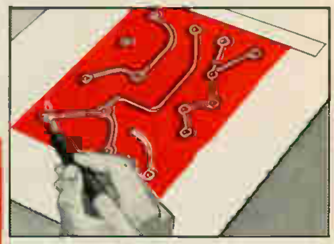


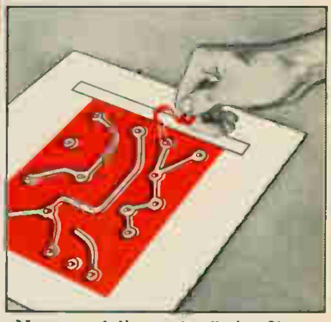
Cut a piece of the desired film large enough to cover area to be masked. Tape it down firmly at the top *with dull-side up.*



With sharp blade, outline the areas to be masked. *Do not cut through the backing sheet.* The Ulano Swivel Knife does the job quickly, easily.



Using the tip of the blade, lift up a corner of the film thus separating it from the backing sheet.



Now carefully peel off the film as outlined leaving a completed mask, positive or negative, that corresponds exactly to the desired pattern.

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with 4- and 5-digit in-line thumbwheel switches. Dissipation factor is from 0 to 0.9999, the upper limit of which is set in with a 4-digit in-line thumbwheel switch.

Model 5350 sells for $2,000 (less oscillator). Either a 120-hz or a 1,000 hz internal oscillator is available at $300. Delivery is 8 weeks from receipt of order.

Micro Instrument Co., 12901 Crenshaw Blvd., Hawthorne, Calif., 90250. **[377]**

Motor aspirated portable psychrometer

A motor aspirated portable psychrometer, model ABX-667, accurately measures the relative humidity in the air. The thermistor thermometers are carefully matched with an error of less than ½°C. A turbine fan in the interior of the instrument delivers the air stream over the sensing elements at the proper speed to insure correct and rapid reading. It covers the range of readings from 2% to 100% relative humidity and is completely portable and easy to use. All the components are built in the rugged carrying case which is equipped with a handle. Elimination of glass thermometers and slings increases the durability of the instrument while lessening potential human errors.

The portable psychrometer is powered by two flashlight batteries and one mercury cell. The unit comes ready for use except for the addition of water at the filling port at the top of the instrument. A four-position switch registers "off" when not in use. The operator then

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turns the switch to "cal" which checks the calibration of the instrument. If necessary, a small adjustment can be made with the adjusting knob. The operator then turns on the fan, flips his switch to "dry" and reads his dry bulb reading. He then takes his wet bulb reading. A slide rule is built into the instrument, and he puts his wet bulb reading over his dry bulb reading and reads his relative humidity directly as a percentage.

Price of the ABX-667 complete is $150.

Abrax Instrument Corp., 179-15 Jamaica Ave., Jamaica, N.Y., 11432. [378]

Audio flutter meter guarantees accuracy

An audio standard flutter meter is designed for production lines and laboratories of tape recorder manufacturers. This solid state instrument requires no operator calibration for full accuracy. The 8100/8100-W guarantees accurate and consistent measurement of tape recorder performance. The meter can measure both U.S. (NAB) and International (DIN) Standards.

The unit provides consistent accuracy in the simultaneous measurement of both speed and flutter. It operates from reproduce electronics output or directly from the play-back head. Options include a tunable wave analyzer (8100-W) to determine frequencies of observed flutter, thus facilitating determination of the cause of flutter.

The instrument features: full scale flutter ranges of 0.01%, 0.03%, 0.1%, 0.3%, 1%, 3% and 10%; full scale drift ranges of ±0.03%, 0.01%, 0.3%, 1%, 3% and 10%; demodulator output accuracy of ±2% on all ranges; frequency range of d-c to 200 hz; rms and peak measurements are NAB weighted or unweighted; automatic input level indication and simultaneous indication of drift and flutter.

Micom, 2570 Leghorn St., Mountain View, Calif., 94040 [379]

Fast multiplier sums logarithms

Engineers at Optical Electronics, Inc., have developed a solid-state analog multiplier which they say is five times faster than any other single-quadrant multiplier. It's priced in the range of conventional multipliers.

The high speed of the Model 519/520 is the result of a new conceptual approach to analog multiplication. In the past signals were multiplied directly in operational amplifier feedback circuits. This multiplier takes the logarithm of both signals, sums them and takes the antilogarithm of their sum to arrive at the product.

Although multiplication is done indirectly, logarithmic amplifiers in the 519/520 can process signals at 10 Mhz. The fastest previously available multiplier is an operational amplifier, with a Hall-effect device, that is limited to a 2-Mhz frequency response, according to the company.

Feedback circuits tend to be unstable, making it difficult to control and process lower-level signals which require subsequent amplification. The 519/520 can handle two input signals of 100-volt amplitude and yields a 20-volt output signal at full scale. These large signal levels bring the possibility of high-frequency wattmeters within reach.

Faster multiplication will enable real-time processing of video data from radars and video tape recorders; the company says the 10-Mhz upper frequency limit was chosen with this in mind.

The new device also opens the way to higher speeds in analog computers since multipliers are among the slowest of the computer's components. One multiplier has already been sold to an oil company for processing of instrumentation data sampled at high rates.

Specifications

Maximum input voltage	100 v
Full-scale output voltage	20 v
Input impedance	10,000 ohms
Output impedance	100 ohms
Polarities (Model 519)	x and y inputs positive
(Model 520)	x and y inputs negative
Nominal transfer equation	$E_0=kxy$ (where k is an adjustable scale factor)
Price	$140
Delivery	30 days

Optical Electronics, Inc., Tucson, Arizona, 85706. [381]

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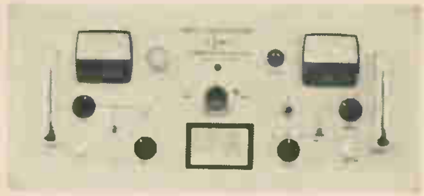
New Subassemblies

Solid state receiving system is versatile



A phase-lock receiving system, the SRA-530, features solid state construction without sacrificing the phase stability and automatic gain-control characteristics normally associated with vacuum tubes. Tetrode field effect transistors are used to provide logarithmic agc over a dynamic range of more than 100 db.

Modular design provides versatility and ease of maintenance. Change of received frequency, i-f bandwidth, or demodulator characteristics is accomplished by replacing plug-in modules or module subassemblies. Special multiple-channel receivers may also be assembled with standard modules.

R-f heads and phase-locked first local oscillators are available for any received frequency from 30 Mhz to 16 Ghz. Standard i-f bandwidths from 500 hz to 30 khz and loop noise bandwidths from 5 hz to 1 khz are available; wider i-f and loop bandwidths by special order. Automatic acquisition is standard, with switch selection of normal acquisition for use with extremely weak signals.

Smyth Research Associates, 3555 Aero Court, San Diego, Calif. 92123. [382]

Power supply adjusts output

Model RS-30—a regulated, solid state power supply—provides continuously adjustable outputs covering the range from 1.2 to 30 v at currents from 0 to 500 ma. It has a ripple level below 1 mv rms. Output voltage is monitored by a front panel meter and is isolated so that either terminal may be grounded. Short-circuit protection is provided.

The unit is laid out for easy servicing. All components are accessible for checking and replacement.

The RS-30 measures 3½ in. high, 7½ in. wide and 8 in. deep. It is priced at $45. Delivery is 30 days from receipt of order.

Aul Instruments, Inc., 24-13 Bridge Plaza North, Long Island City, N.Y., 11101. [383]

Wideband amplifier for laboratory use

Model 1202-3 wideband amplifier, which is composed of silicon planar devices, uses feedback to achieve fast response and gain stability. Gain is adjustable from 10 to 100. Frequency response is 5 hz to 10 Mhz at 20-db gain and 10 hz to 1 Mhz at 40-db gain.

Other specifications include: output voltage, 6 v peak to peak across 1,000 ohms; pulse rise time, 60 nsec at 20-db gain; input impedance, greater than 100,000 ohms shunted by 25 pf; noise, less than 15 μv rms referred to the input with the input shorted; size, 5.5 in. high x 8.5 in. wide x 7.5 in. deep; weight, 4 lbs; input and output connectors, BNC type

Designed as a general purpose laboratory instrument, the 1202-3 is suited as an oscilloscope preamplifier, tape recorder preamp, pulse amplifier, and a-c transducer amplifier.

Price is $135; delivery, 3 weeks after receipt of order.

California Electronic Manufacturing Co., Inc., P.O. Box 355, Alamo, Calif., 94507. [384]

New Step-Ahead Design Gives Big Scope Features In a Rugged, Lightweight Instrument

You get more total performance, more usability in the new hp 180A Oscilloscope—*more than any other scope on the market!* You get this greater measurement capability in a 30-pound package that goes anywhere—field, laboratory or production line. Designed from the user's viewpoint in, this new high-frequency scope is packed with new ideas and innovations to give you big picture CRT, plug-in versatility, step-ahead electrical performance, minimum weight and rugged design.

With hp's all-new CRT, you get a big picture 8 x 10 cm display in a compact 17-inch tube length to allow portability. Display area is 30% larger than on existing high-frequency scopes—and 100% larger than some portable scopes. This means that you make accurate measurements, easier!

The vertical amplifier drives the CRT vertical deflection plates directly, requiring only 3 v/cm. This allows extended bandwidth capabilities, and means the vertical amplifier is lightweight, requires low power. Solid-state amplifiers with FET input stages provide stable gain and low drift for accurate measurements. Vertical attenuation, which sets vertical deflection factor, is ahead of the amplifier. This prevents trace jumps as you change ranges; bandwidth is maintained on all ranges even when verniers are used.

For easy viewing of the leading edge of a fast pulse, a new lightweight 160 nsec, 140 MHz etched circuit delay line was developed. Wide bandwidth together with good impedance characteristics insure clean display of input signal.

A new type of horizontal amplifier has wide bandwidth with X10 magnification to provide linear 5 nsec/cm sweeps, giving you greater resolution of high frequency signals and fast pulses.

Circuitry in the new 180A is 100% solid state. Only premium quality components were used throughout. This means you have lower power requirements, lighter weight and increased reliability. This results in the utilization of convection cooling—no fans.

Circuit boards in the scope are arranged to provide easy access to all circuitry. Snap-off covers give quick access. The control panel has been "human-engineered"—control knobs and switches are "convenience-grouped" and plainly marked to make them easier to see, easier to operate. Control panel and nomenclature are selective dye anodized for permanence.

Ask your nearest hp field representative for a demonstration of the 180A Oscilloscope, and he will show how you can *see more, do more* with this new big picture, 30-pound scope! Or, write to Hewlett-Packard, Palo Alto, California 94304, Tel (415) 326-7000; Europe: 54 Route des Acacias, Geneva. Price: hp Model 180A Oscilloscope, $825.00; hp Model 180AR (rack) Oscilloscope, $900.00; hp Model 1820A Time Base, $475.00; hp Model 1821A Time Base and Delay Generator, $800.00; hp Model 1801A Dual Channel Vertical Amplifier, $650.00, f.o.b. factory.

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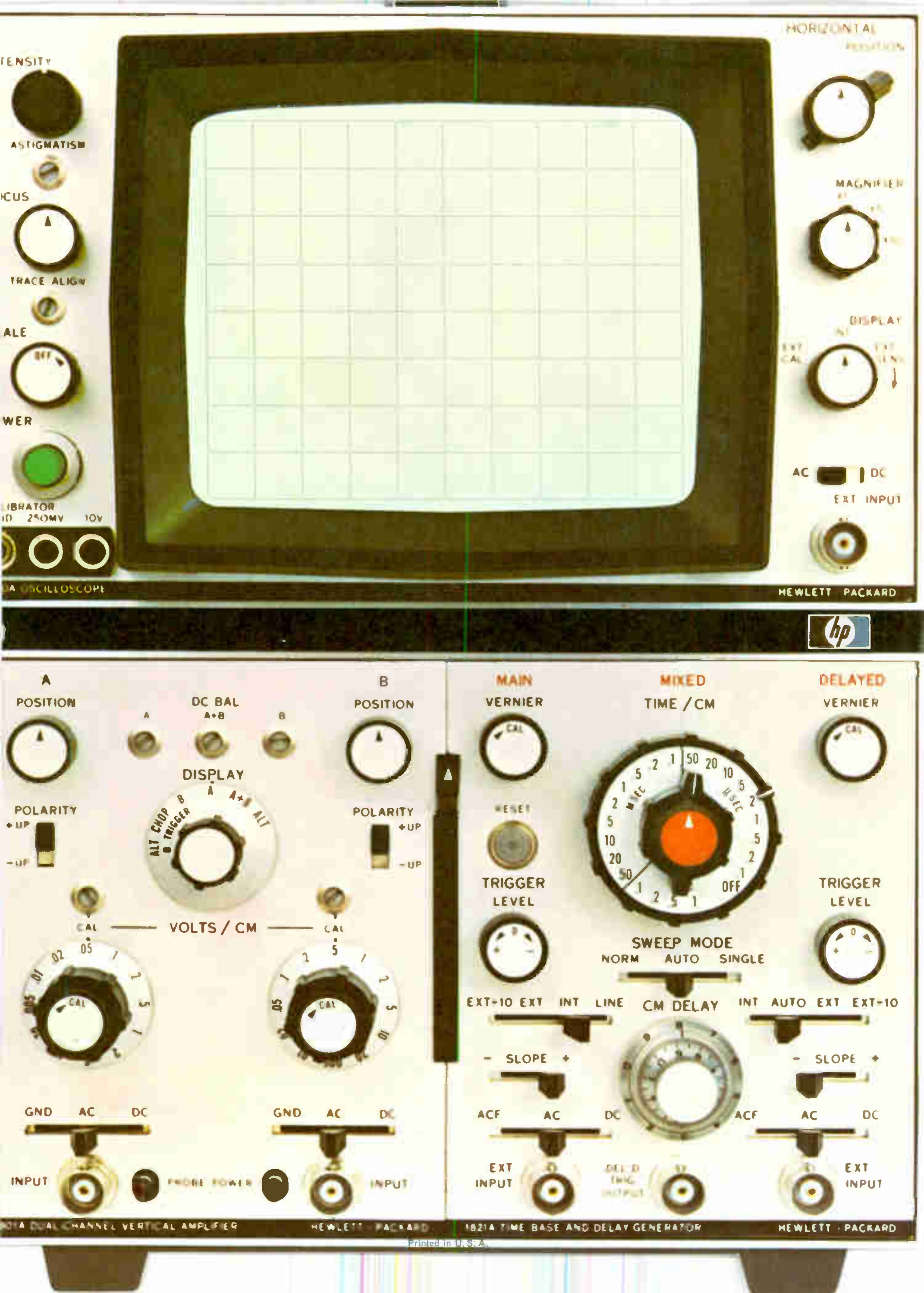

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hp 180A Oscilloscope

is shown here ACTUAL SIZE:

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See how the new 180A Big Picture Display can make it easier for you to get accurate measurements. Punch out this actual size CRT area on the perforations. Place the punched-out portion over the screen of your existing high-frequency scope. You will find the hp 180A Oscilloscope has 30% to 100% larger viewing area for easier-to-see, easier-to-read traces!

COMPARE SPECIFICATIONS! (Condensed)

180A Oscilloscope

Horizontal Amplifier:

External Input: DC coupled, dc to 5 MHz; AC coupled, 5 Hz to 5 MHz. Input RC, 1 megohm shunted by approximately 30 pf.

Sweep Magnifier: X1, X5, X10; magnified sweep accuracy ±5%.

Calibrator: 1 kHz square wave, 250 mv and 10 v p-p, ±1%.

Cathode-ray Tube: 8 x 10 cm parallax-free internal graticule marked in centimeter squares. Post-accelerator tube, 12 kv accelerating potential; aluminized P31 phosphor.

Beam Finder: Pressing Beam Finder control brings trace on CRT screen.

Intensity Modulation: Approx. +2 volts, dc to 15 MHz, will blank trace.

Active Components: All solid state, except CRT.

Environment: 180A scope with plug-ins operates within specs over the following ranges. Temperature: −28°C to +65°C. Humidity: To 95% relative humidity to 40°C. Altitude: To 15,000 ft. Vibration: Vibrated in three planes for 15 min. each with 0.010" excursion from 10 to 55 Hz.

Power: 115 or 230 volts, ±10%, 50-1000 Hz, 95 watts, convection cooled.

Dimensions: Cabinet, overall dimensions with feet and handle: 8" x 11" x 22½" deep. Rack mount: 5¼" x 19" x 19½" deep behind front panel.

Weight: With plug-ins, net 30 pounds.

Outputs: Main and delayed gates, main and delayed sweeps.

Accessories Furnished: Two 10:1 voltage divider probes, mesh contrast filter.

Price: Without plug-ins, Model 180A, $825.00; Model 180AR (rack), $900.00.

1801A Dual Channel Vertical Amplifier

Modes of Operation: Chan. A alone; Chan. B alone; Chan. A and B displayed on alternate sweeps; Chan. A and B displayed by switching at 400 kHz rate, with blanking during switching; Chan. A plus Chan. B (algebraic addition).

Deflection Factor (Sensitivity): 0.005 v/cm to 20 v/cm; attenuator accuracy, ±3%.

Bandwidth and Rise Time: DC coupled, dc to 50 MHz; AC coupled, 2Hz to 50MHz; rise time, <7 nsec.

Input RC: 1 megohm shunted by approx. 25 pf.

Polarity Presentation: + or − Up.

Triggering: Provides sufficient signal to the time base to trigger from dc to 50 MHz.

Price: Model 1801A, $650.00.

1820A Time Base

Sweep Range: 24 ranges, 0.05 μsec/cm to 2 sec/cm in a 1,2,5 sequence; accuracy, ±3%; to 5 nsec/cm with X10 magnifier. Also single sweep.

Triggering:

Internal: See vertical amplifier.

External: dc to 50 MHz from signals 0.5 v p-p, 90 MHz with 1 v p-p.

Automatic: Bright base line displayed in absence of input signal. Triggers from 40 Hz to >50 MHz.

Trigger point and slope: Controls allow selection of level and pos. or neg. slope; trigger level on external signal adjustable ±5 v, ±50 v in ÷ 10 position.

Coupling: AC, DC, ACF.

Variable Holdoff: Permits variation of time between sweeps to allow triggering on asymmetrical pulse trains

Price: Model 1820A, $475.00.

1821A Time Base and Delay Generator

Main Sweep: 22 ranges, 0.1μsec/cm to 1 sec/cm in 1,2,5 sequence; accuracy, ±3%; to 10 nsec/cm with X10 magnifier. Also single sweep.

Triggering:

Internal: See vertical amplifier. External: dc to 50 MHz from signals 0.5 v p-p, 90 MHz with 1 v p-p.

Automatic: Bright base line displayed in absence of an input signal. Triggers from 40 Hz to >50 MHz.

Trigger point and slope: Controls allow selection of level and pos. and neg. slope; trigger level on external signal adjustable ±5 v, ±50 v in ÷ 10 position. Coupling: AC, DC, ACF.

Trace Intensification: Used for setting up delayed or mixed sweep. Increases in brightness that part of main sweep to be expanded full screen in delayed sweep or made magnified part of display in mixed sweep.

Delayed Sweep: Delayed time base sweeps after time delay set by main sweep and delay controls. 18 ranges, 0.1μsec/cm to 50 msec/cm in 1,2,5 sequence; accuracy, ±3%.

Triggering: Applied to intensified Main, Delayed, and Mixed Sweep modes. Automatic: Delayed sweep starts at end of delayed period. Internal, External, Slope, Level, and Coupling: same as Main Sweep.

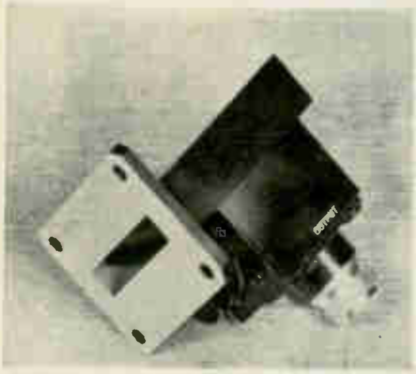
Delay Time: (before start of delayed sweep); Continuously variable from 0.1 μsec to 10 sec; accuracy, ±1%; linearity, ±0.2%; time jitter, <0.005% of maximum delay of each range.

Trigger Output: (at end of delay time): approx. 1.5 v pulse.

Mixed Sweep: Dual sweep display in which main sweep drives first portion of display and delayed sweep completes display at speeds up to 1000 times faster.

Price: Model 1821A, $800.00.

Waveguide-coaxial ferrite isolator



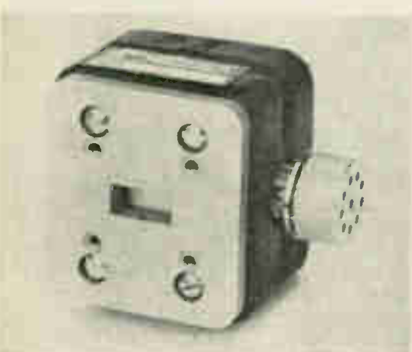
Added packaging flexibility is provided with the incorporation of integral waveguide adaptors on the company's standard coaxial ferrite circulators and isolators. A typical example is the ICC-199 isolator which covers 5.9 to 6.3 Ghz and has a waveguide input and a type N female coaxial output.

Size is approximately 2 x 2 x 2½ in. including connector, termination and waveguide flange. The unit can handle 5 watts of average power and will not be damaged if the output is inadvertently opened or shorted.

The waveguide/coaxial technique can be employed between 1 and 18 Ghz.

Western Microwave Laboratories, 1045 Di Giulio Ave., Santa Clara, Calif. [389]

Tunable magnetron operates in Ku-band



A positive-pulsed, 2.2 kw, Ku-band tunable beacon magnetron is offered. The MA-258 is a compact, rugged unit designed to tune over the 15.4 to 15.7 Ghz range with a 0.2 μsec pulse width and a duty ratio of 0.001. Peak anode voltage is 3,600 v and peak anode current is 3.1 amps.

Input connections are made through flexible leads or solder lugs and the output connector is designed to mate with a UG-541/U choke flange.

The MA-258 beacon magnetron is designed for use in beacon and navigational systems, lightweight radar systems, missile ground support equipment, transponders, and airborne radar.

Microwave Associates, Inc., Burlington, Mass. [390]

Frequency multiplier works over 6 octaves

A frequency multiplier, model N808, features high efficiency and ultra wide band operation over six octaves for extending the usable frequency range of signal generators and frequency synthesizers with minimum conversion loss. Input power up to 400 mw from 50 Mhz to 4 Ghz produces high harmonic energy in the 100 Mhz to 12 Ghz range at efficiencies approaching the theoretical 200% divided by n, where n stands for the harmonic number.

The N808 is said to be ideal from an economical viewpoint for generating a comb of harmonics from a crystal-controlled 100-Mhz source. A tunable filter, such as a cavity-type frequency meter or an electronically-tuned YIG filter, can be used to select the high-power signal that is suitable for transmitter or local-oscillator service.

The harmonic-generating device is a 100-picosecond step-recovery diode. Its bias circuit is entirely self-contained, and d-c blocking is provided at both ports allowing the maximum flexibility in external circuitry.

Model N808 measures 1.13 x 1.38 x 3.81 in. Weight is 4 oz. Price is $115; availability, 20 days from receipt of order.

Somerset Radiation Laboratory, Inc., 2060 North 14th St., Arlington, Va., 22216. [391]

New Microwave

X-band source offers low noise

Low noise and high stability characterize this X-band solid state source. The output can be remotely switched between three discrete frequencies all above 10 Ghz in a 150-Mhz bandwidth.

This source is capable of: incidental f-m noise less than 50 hz peak in the bandwidth ±150 khz from the carrier (all three channels); a-m noise 120 db below the carrier level (+20 dbm); short term power stability better than 0.1 db; power flatness between channels within 1.0 db.

Microwave Development Laboratories, Inc., 87 Crescent Road, Needham Heights, Mass. [392]

Matching tuner goes from 0.25 to 2.5 Ghz

A coaxial matching tuner is available with a frequency range from 0.25 to 2.5 Ghz. Type 900-TUB tuner is a short section of coaxial line with three lockable tuning screws, which are used to tune out small reflections in low-voltage standing-wave ratio measuring instruments and devices.

The vswr matching range of the tuner is greater than 1.02 at 0.4 Ghz and greater than 1.05 from 1 to 2.5 Ghz. An important feature is a frequency-independent neutral position, which effectively removes the tuner from the circuit.

Vswr resettability of the tuner is better than 1.001 ± 0.0003 times the frequency in Ghz and connection is repeatable to within a vswr of 1.0005. Price is $195.

General Radio Co., West Concord, Mass., 01781. [393]

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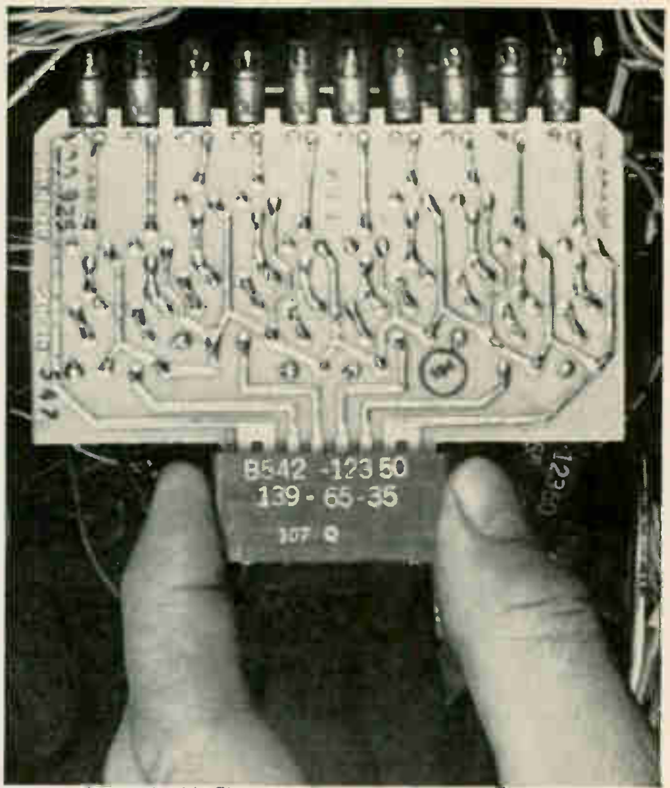


Lamps in this Electronic Associates, Inc., computer circuit board are the Tung-Sol Tu-Pin molded base types.

Computer-Inspired, Molded Base Subminiature Lamps are Self-Mounting

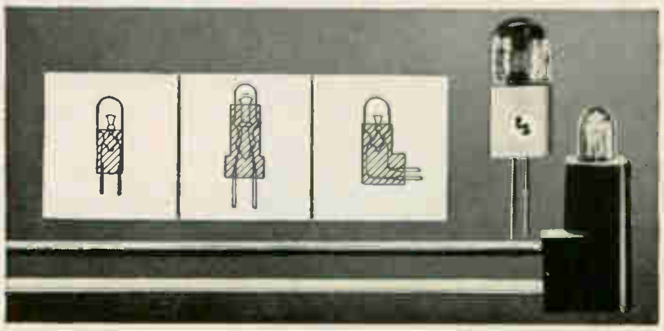
Requirements of the computer industry for a compact subminiature lamp assembly, led to the development of the Tung-Sol integrally molded base lamp.

A molded nylon encapsulation replaces the conventional cemented-on metal base. This permits direct mounting of the lamp without need for the usual mated socket. Greater reliability is achieved, with obvious simplification of installation procedures.

The molded-base lamp lends itself to automated assembly and molding permits extreme flexibility of base configuration. Bases may be color-coded for accurate identification.

Tung-Sol integrally molded base subminiature lamps are available in Tu-Pin form or with special harnessing to your specifications.

Describe your requirements for more specific information.



Molding permits extreme flexibility of base configuration.

TUNG-SOL® MOLDED BASE SUBMINIATURE LAMPS

Tung-Sol Electric Inc., Newark, N. J. 07104

Circle 181 on reader service card

Proximity sensors gauge hot glass

One of the production problems facing manufacturers of precision glass components, like television tubes, is that glass emerges hot from the production line and will crack or explode if touched by something cool. So the component has to sit in a cooling oven for about four hours before inspection. If the glass turns out to be defective, time and money have been wasted. The Phlyatron Corp. says that nondestructive testing of glass and other materials can be done with its multichannel proximity detection and sensing system. It can gauge any material, conductive or nonconductive, hot or cold, moving or stationary.

In the photograph the thickness of a glass television tube face is being gauged at nine locations. If the glass in one spot is thinner or thicker than the high and low tolerances, the appropriate light on the middle row goes on. Each sensor is connected to a potentiometer.

Phylatron claims its all solid-state instrument can give direct linear readings to 0.0001 inch. Each sensor forms a capacitor connected in parallel with a high-q inductance circuit. A change in capacitance caused by the presence of the material sensed by the probe tip shifts the resonant frequency of the circuit. A link coupling to the box converts the change in the resonant frequency to a linear voltage output. The system's output can be fed into a computer for control.

The system, dubbed PM-800, is available with from 1 to 20 sensors. It can be built to provide either parallel or serial output from the sensors. The scan rate can be set between 4 hertz and 10 khz.

Specifications

Frequency response	D-c to 1 khz, depending on switching time and No. of channels
Linearity	Within 2% ±0.05 in.
Power input	100 w
Output	500 ohms ±24 v, d-c
Drift	Less than 1%
Price	
Basic instrument	$3,166
Channels 2-10	$600 each additional
Channels 11-20	$540 each additional
Delivery time	About 6 weeks

Phylatron Corp., 1183 Chesapeake Ave., Columbus, Ohio 43212 [401]

IR oven coats p-c boards automatically

An infrared oven for p-c board coatings and metal flats automatically dips and cures photoresists in one-fifth the time taken by conventional ovens, according to the manufacturer. Besides effecting this reduction in process time and achieving a more precise temperature control with its infrared heaters, the oven offers automatic, controlled withdrawal of the p-c board out of the dip. This feature assures uniform coating and prevents edge buildup. It also eliminates the variations in coating from board to board that can happen when dipping is done manually.

Typical curing time cycles are: photoresist, 60 to 180 seconds; screened etch resist, 30 to 40 seconds; solder resist, 60 to 80 seconds; protective coatings, 30 to 40 seconds. The dip tank is used with photoresists only. Typical output is 200 10 in. x 12 in. boards per hour. Work size can go up to 18 in. x 45 in.

To load, the operator hooks the circuit boards on the chain conveyor cross rods, which takes them down through the dip at the preset speed. As they emerge from the dip at the back of the oven, they pass up between infrared heating modules where the coating is cured at a preset temperature. The conveyor moves them forward and then down to the open front of the oven for unloading. A pressurized, filtered cooling air supply keeps

Production Equipment

out lint and dust.

The infrared heaters radiate heat uniformly over their entire working faces, hence they can be mounted close to the work for highest efficiency and short time cycles. They supply instant heat, hence the oven needs no lengthy conveyor travel to warm up the work. Temperature control is ±5°F. Conveyor speed and infrared heater temperature control are infinitely variable, which allows best setting to be made for each job.

The oven occupies minimum floor space by using height instead of length. Typical oven size is 5 ft wide x 8 ft high x 3 ft deep. It operates on 230 v, 60 hz.

Infra-Red Systems, Inc., Route 23, Riverdale, N.J. [402]

Machine solders circuit assemblies

Series 4000 dual wave soldering machine has been developed for the high production and efficient soldering of circuit assemblies.

This machine features a dual cavity, dual wave solder wave generator; pyrometric control of the temperature of each solder wave and preheater; illuminated control switches; eight-foot, lift-off type conveyor; potentiometer speed control and tachometer speed indicator; dual feed foam fluxer with air regulators; Radiant-Aire preheater; eye level controls; and hinged exhaust canopy.

The machine performs three important operations in a predetermined time cycle. It fluxes the parts to be soldered, preheats and dries the flux and solders the parts

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that have already been fluxed.

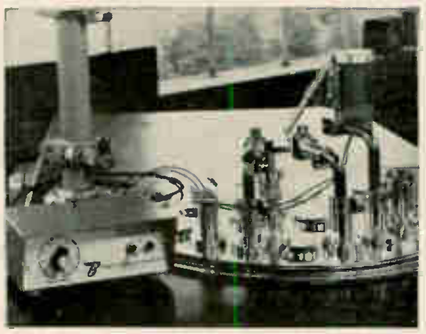
Dual air input provides a foam stability with controls for air pressure and foam height on the Foam Fluxer, with a drain valve for ease of maintenance. The Radiant-Aire preheater has a cast iron hot plate that assures long life and is practically maintenance free.

Surface temperature is accurately controlled and forced air is utilized to remove gas which forms during the preheating operation. This increases the efficiency of the preheater and accelerates the drying of the flux. The preheater has a direct readout pyrometric control.

The dual/cavity/dual wave generator has individual pumps that generate solder waves up to 2 in. in height. The temperature of each wave is independently controlled by pyrometric controllers with a sensitivity of ±2°F. Temperature range of the wave generator is 100°F to 650°F.

Dee Electric Co., 2501 North Wayne Ave., Chicago, Ill., 60614. [403]

Vibratory feeder aids film coating

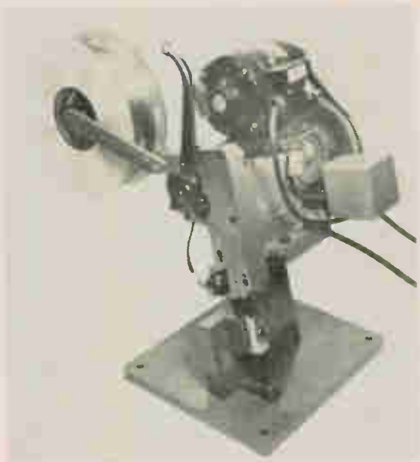


An accessory for thin-film evaporators permits continuous, controlled feeding of coating material to a hot source or an electron beam gun. Known as a vibratory feeder, the accessory makes it possible to obtain uniform, homogeneous film formation even with varying vapor pressures of coating material compositions and alloys.

The vibratory feeder consists of a container for the coating material, the interior wall of which is a conveying helical spiral. By means of vibration, initiated by a mag-

netic coil, coating material moves upward through the helical spiral to an exit channel. From the exit channel it falls into a tube positioned to permit the material to drop into the evaporation source. An electronic power control permits stepless variation of the feeding speed.
Bendix-Balzers Vacuum, Inc., 1645 St. Paul St., Rochester, N.Y. [404]

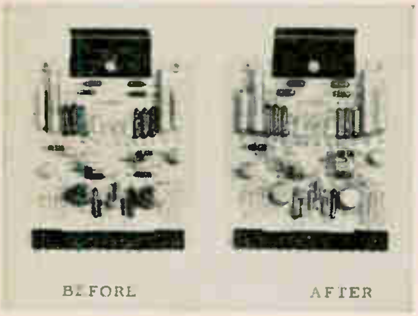
Machine splices solderless connectors



A solderless connector attaching machine has been developed for splicing leads. It utilizes a continuous spool of wire and completely eliminates the need for preformed connector strip. Connectors made from flat wire cost 80 cents per thousand as opposed to $2.50 per thousand when made from preformed connector strip. This machine can operate with copper, brass, tinned brass, silver and aluminum wire.

An operator inserts two leads, either stranded or single, into a nest on the machine, and then depresses the electric foot switch. The machine feeds a length of wire, cuts and forms the connector, then securely attaches it around the two leads. The machine will operate at speeds up to 300 cycles per minute. A non-repeat clutch is incorporated into the machine to insure operation safety.
General Staple Co., 26-28 E. 22nd St., New York, N.Y., 10010. [405]

Conformal coating for p-c boards



A conformal coating has been added to the company's line of quality resin products. TC-3050 coating was developed to give p-c boards the best environmental protection possible, while giving the applicator a broad selection of application methods and curing schedules.

The material can be applied by dip, brush, flow coating or even sprayed with standard heavy-duty paint spray equipment. The curing schedules range from overnight at room temperature to ½ hour at 300° F.

Electronic Production & Development, Inc., 11965 South Prairie Ave., Hawthorne, Calif., 90250. **[406]**

Thin copper-clad epoxy-glass laminate

Materials developed for multilayer p-c boards permit maximum design flexibility and consistent, high-quality production. The product package consists of a thin copper-clad epoxy-glass laminate, designated Textolite Grade 11685, designed for use with three new epoxy-resin impregnated glass cloth bonding sheets — Grades 11384, 11385 and 11386.

Grade 11685 copper-clad material permits the fabricating of clean circuits, according to the manufacturer. Base laminate staining, caused by oxide transfer from the copper, has been totally eliminated in the new grade because there is no copper oxide on the foil.

The material is available with 1-oz or 2-oz copper as standard, clad one or two sides, in base (etched) laminate thicknesses from 0.002 in. through 0.015 in. in 0.001-in. increments.

Another feature of Grade 11685 is a textured surface on the unclad side which makes for improved bonding between layers in the multilayer circuitry without additional processing. The textured surface almost doubles bonding area.

Textolite Grade 11685 and bonding sheets are available in packages of five 24-in. x 36-in. sheets.

General Electric Co., Laminated Products Dept., Coshocton, Ohio. **[407]**

Polyester film of corrugated Mylar

Corrugated Mylar polyester films for wire and cable applications are designated 200 WC 67 and 300 WC 67.

The corrugation of the film traps air much as crepe paper does, providing excellent thermal protection for polyethylene-insulated conductors in the cable core during the hot-melt extrusion of the cable's outer jacket.

When applied to a cable core, the corrugated film interlocks as it overlaps itself, minimizing core-wrap movement and gapping, called "shingling," at the overlap when the cable is bent. In spirally wrapped constructions, the interlocking of the corrugated grooves also increases the inherently high core-to-shield breakdown strength of Mylar polyester film. The excellent cut-through resistance of Mylar is improved by the corrugations, which act as shock absorbers to cushion the conductors in the cable core against mechanical impact.

The 200-gage film will sell at $1.85 a pound, and the 300-gage film will be $1.80.

E.I. duPont de Nemours & Co., Wilmington, Del., 19898. **[408]**

New Books

Control systems

Introduction to Variational Methods in Control Engineering
A.R.M. Noton
Pergamon Press, 122 pp., $5

A new approach to control system design has been emerging during the last ten years. The variational method, as modified by Bellman, Pontryagin and others, makes possible the consideration of economic criteria for optimization of the control system structure. Realistic constraints such as saturation are included, and the final design may contain nonlinear elements. While the method itself is not new—the calculus of variations has been used for years to find functions which optimize—its application to control engineering is new and potentially useful.

The evolution of the method has been watched with considerable interest by control engineers who are still using the classical methods of Nyquist or Evans or derivations of these methods, and to whom the subjects of synthesis, optimization, and non-linearities are to be handled (if at all) separately and academically. At the same time, high-speed computing has come into general use by control engineers, and much of the potential for the variational method awaits the establishment of theoretical guideposts for the non-trial-and-error use of computers.

Noton's book comes at a good time. It is an honest attempt to explain the theory and sort out the claims, and it largely succeeds. Noton accepts the central role of high-speed digital computers in applying the theory, and examines critically the problems inherent in aplication of variational methods—problems often buried beneath a layer of enthusiasm. At the end of the book the author answers the question of the method's utility with a very qualified yes, perhaps too qualified.

The book covers all the major methods systematically, starting with the classical calculus of variations, and introducing its shortcomings. The explanation of dynamic programing is excellent, as is the computer problems to be met when the method is applied.

In chapter 5, the derivation of the Pontryagin maximum principle by the method of characteristics is difficult to follow; an introduction via dynamic programing might have been better. Also, the method itself is left a little unclear. For example, more could have been said about the p variables which seem to arise more mysteriously than need be. However, the author's use of examples makes up for most of the obscurity, a lot of which is inherent in the method itself. At the end of the chapter the method is applied, simply and gracefully, to the design of a bang-bang system leaving the reader with a generally good feeling, marred only by the suggestion of the real problem to come.

It comes in the next chapter—the two-point boundary value problem. Because boundary values must be satisfied simultaneously at "both ends" of the solution, serious computational problems arise. The author's treatment of this is good. The choice of methods is adequate, although including some material on invariant imbedding would have been appropriate.

If prospects are grim by the end of Chapter 5, they improve considerably in Chapter 6 where the intriguing possibilities raised by the problem of inaccessible state variables are discussed. Treatment of the problem of process identification could have been included to advantage; the variational approach may lead to difficult (or impractical) computational problems, but it does much to unify control theory.

Throughout the book, real though simple problems are used as examples, and solutions are sought on a large, high-speed digital computer. No special knowledge of computers is assumed or needed. On the other hand, the book shouldn't be undertaken without some mathematical sophistication. Prior exposure to the calculus of variations would be a minimum, although the book might provide motivation for mathematical study to make up deficiencies.

The author sums up by mentioning very briefly some possible future applications. The picture he presents is not encouraging, especially since the reader is referred elsewhere for aerospace applications. This is unfortunate, first, because many of the best current examples of the application of variational theory lie in that area; and second, because the reference (G. Leitman's 1962 book, "Optimization Techniques") doesn't cover the subject with anything approaching Noton's brevity and candor.

The book is what it claims to be—a short monograph intended to help the control engineer close the gap in his knowledge of new developments in his field. Control engineers should find it valuable as an introduction to an important design approach and as a reference for further study; students may find it a guide for things to come.

John A. Aseltine

TRW Systems
Houston, Texas

Recently published

Atomic Transistion Probabilities—Hydrogen through Neon, W.L. Wiese, M.W. Smith and B.M. Glennon, National Bureau of Standards, U.S. Government Printing Office, 153 pp., $2.50

Basic Matrix Analysis and Synthesis, G. Zelinger, Pergamon Press, 228 pp., $7.50

Electronic Digital Systems, R.K. Richards, John Wiley & Sons, Inc., 637 pp., $15.00

Modulation, Resolution and Signal Processing in Radar, Sonar and Related Systems, R. Benjamin, Pergamon Press, 184 pp., $8.50

Topics in Advanced Mathematics for Electronics Technology, Stephen Paull, John Wiley & Sons, Inc., 420 pp., $4.95

Semiconductor Circuits: Theory, Design and Experiment, J.R. Abrahams and G.J. Pridham, Pergamon Press, 310 pp., $4.95

Electronic Properties, Robert M. Rose, Lawrence A. Shepard and John Wulff, John Wiley & Sons, Inc., 306 pp., $3.50

Audio Systems, Julian L. Bernstein, John Wiley & Sons, Inc., 409 pp., $4.50

Network Analysis and Synthesis, second edition, Franklin F. Kuo, John Wiley & Sons, Inc., 515 pp., $11.95

Transform and State Variable Methods in Linear Systems, Someshwar C. Gupta, John Wiley & Sons, Inc., 426 pp., $12.75

Marketing Guide to U.S. Government Research and Development, Robert Rickles, Noyes Development Corp., 229 pp., $20

Electronic Troubleshooting: A self-instructional Programed Manual, staff members of the Philco Technical Institute, Prentice-Hall, Inc. 274 pp., $12.50

Electrical Fundamentals and Circuit Analysis, H. Alex Romanowitz, John Wiley & Sons, Inc., 715 pp., $8.95

Technical Abstracts

Planetary processor

On batch processing of evaporated thin-film microelectronics

Noel W. Scott, Naval Avionics Facility, Indianapolis, Ind.

Evaporated thin films are widely used in integrated circuit manufacture to produce passive components and conductive interconnections on circuit substrates. The method usually entails placing substrates in a vacuum chamber and depositing the film selectively in controlled amounts with a series of sequential material depositions and mask changes.

According to the author, many thin-film applications do not require sequential depositions, but lend themselves better to batch processing, in which a large number of substrates are exposed to a "one-shot" deposition. This approach is particularly successful when there is a wide disparity in the required evaporation time for various film materials. In many cases, mask alignment for high-density circuits cannot be accomplished within the required tolerances by automatic techniques used in sequential systems. Furthermore, an in-atmosphere process is sometimes required between depositions.

The author bases his case for batch processing on 10 years of experience at the Naval Avionics Facility laboratory with a planetary coater that permits uniform deposition of thin films over relatively large substrate areas.

In the planetary coater, the substrate wafers and their masks are mounted on one of four disks attached to a wheel that rotates horizontally at 60 times a minute. The four disks rotate one to four times a second depending on the selected gear ratio. The substrate movement describes epicyclical paths during the coating cycle, which assures a high degree of film uniformity.

The system has been used with both 18-in. and 32-in. diameter bell jars. Complex 11- and 13-layer circuits have been successfully fabricated and reproduced in a single planetary coater by batch operations.

One of the chief advantages of the coater's planetary motion is that the vapor stream's deposition angle constantly changes. Consequently, the walls and edges of the many plateaus on the substrate are covered from many angles. Sharp corners with their attendant stresses are reduced.

Presented at the Fifth Annual Microelectronics Symposium, St. Louis, July 18-20.

Bodily harm

The effects of microwaves on biological systems

Joseph H. Vogelman
Chromalloy American Corporation
West Nyack, N.Y.

Since the introduction of high-power radar and communication equipment, there has been a growing fear of potential damage to human biological systems. The major impetus to an investigation of the effects of microwave energy has been provided by the Air Force in an attempt to establish a safe level of exposure for military personnel required to work on radar.

All experimental and statistical results can be grouped in three categories—thermal, peak thermal and nonthermal. Microwave energy that duplicates the radiant effects of infrared energy and the conductive effects of continuous heat exposure are thermal effects and are related to average microwave power. Peak thermal effects are produced by peak microwave power. Nonthermal effects include all that cannot be explained in terms of thermal or peak thermal effects, such as resonance phenomena that affect the molecular structure of a biological material.

Experiments demonstrated the damaging effects of exposure to continuous microwave radiation. Cataracts were produced in the eyes of rabbits as a result of exposure to 2.45 Ghz of microwave energy. Humans who worked with radar for a long time developed eye opacities. Dogs exposed to radiation suffered nerve irritation identical to that resulting from excessive heat exposure. The animal generally felt uncomfortable and began to pant or chase its tail. The symptoms are dependent on frequency. They are less evident, for example at 1.285 Ghz. The animal's peripheral nerve endings were not excited as much by the longer wavelengths because they penetrate deeper into the body.

In addition to the neurological effects, many investigators found considerable changes in blood chemistry and a significant loss of body water. In animal organ studies exposure produced considerable ovary and testicular damage as well as injury to other internal organs including the heart and liver.

Exposure of living tissue to peak thermal radiation resulted in another series of effects. Pulse energy excites peripheral nerves more markedly than continuous energy at the same wavelength.

Exposing living tissue and organs to microwave radiation of low intensity produced no thermal burden but resulted in important biological effects that cannot be categorized in terms of thermal and peak thermal phenomena.

In France, microwaves reduced the size of cancerous tumors. In Russia, chronic exposure to low-intensity microwaves produced changes in the brain function of dogs, exciting the animal and modifying his inhibition. In the United States, levels of exposure led to chemical changes in dogs' blood. Other exposure experiments caused a drop in the dogs' blood pressure and a significant loss of body water. In other experiments, rats, mice and dogs pretreated with microwaves, exhibited increased resistance to radiation after a long latency period following exposure. During this time the microwaves' thermal burden dissipates.

There is need for more controlled experimentation to define peak thermal more accurately as well as certain nonthermal effects of microwave radiation. The ability to produce stable, single frequencies of polarized microwave energy is important in these investigations.

The power of microwaves to act as a source of thermal energy at certain internal body depths, produces localized internal heating in cold environments. It opens the way for use of the energy as a diagnostic tool in medical therapy.

Presented at the Bio-Medical Engineering Conference, Marquette University, Milwaukee, Wisconsin, June 24-25.

New Literature

Mutlilayer printed wiring. Wabash Metal Products Co., Inc., 1588 Morris St., Wabash, Ind., 46992, has available sixteen pages of current information on multilayer printed wiring, titled "Symposium In Print".
Circle 420 on reader service card.

Microelectronic interconnections. ITT Cannon Electric, a division of International Telephone and Telegraph Corp., 3208 Humboldt St., Los Angeles, Calif., 90031. Handbook MMH-1A discusses microelectronic interconnections. [421]

Education-type meter. The Triplett Electrical Instrument Co., Bluffton, Ohio, 45817, offers a data sheet on the educational a-c/d-c measuring instrument, model 820-U, which is used with an overhead projector for dynamic classroom display. [422]

IRIG bandswitching discriminators. Airpax Electronics Inc., P.O. Box 8488, Fort Lauderdale, Fla., 33310. Bulletin TM-6 describes a line of high accuracy demodulators of frequency-modulated telemetry subcarrier signals having IRIG or similar characteristics. [423]

Circuit-card mounting. Scanbe Manufacturing Corp., 1161 Monterey Pass Road, Monterey Park, Calif., 91754. The mounting and packaging of electronic circuit cards is described in comprehensive text-and-photo detail in brochure 205. [424]

Fluorocarbon solvents. Olefins division, Union Carbide Corp., 270 Park Ave., New York, N.Y., 10017. A 16-page brochure contains specifications and test methods for Ucon fluorocarbon solvents 113-LR1 and 113-LR2, used in critical cleaning applications, particularly in the aerospace and electronics equipment fields. [425]

High-vacuum components. Ultek Corp., Box 10920, Palo Alto, Calif., 94303. Bulletin A-1355 offers condensed specifications and new pricing information on all of the company's high-vacuum components. [426]

Microwave absorbing materials. Emerson & Cuming, Inc., Canton, Mass. A quick-reference brochure describes the complete line of Eccosorb microwave absorbers for free space, waveguide and high temperature applications. [427]

Vibration and shock mountings. Lord Manufacturing Co., division of Lord Corp., Erie, Pa., 16512. The J-4624 series Flex-Bolt mountings for control of vibration and shock are described in bulletin D-944. [428]

Dual-slope digital meters. Fairchild Instrumentation, a division of Fairchild Camera and Instrument Corp., 475 Ellis St., Mountain View, Calif., offers an eight-page brochure detailing specifications, accessories, dimensions and prices for the series 7100 dual-slope, integrating digital meters for the measurement of voltage, resistance and ratio. [429]

Microwave energy sources. Trak Microwave Corp., 4726 Kennedy Road, Tampa, Fla., 33614, has available a 56-page catalog and technical manual on microwave energy sources. [430]

Frequency counters. Northeastern Engineering, Inc., 130 Silver St., Manchester, N.H., 03103. An eight-page fold-out catalog describes in detail a complete line of solid state frequency/time interval meters. [431]

Laminated wire and cable. Inso Electronic Products Inc., Nutley, N.J., 07110, announces a 20-page booklet describing its line of fused, high temperature, Teflon laminated wire and cable. [432]

Printed-circuit soldering. Electrovert Inc., 86 Hartford Ave., Mt. Vernon, N.Y., 10553, offers a four-page brochure on its most recent wave-soldering developments—the 346 and 364—both of which are said to represent a significant advance in the automation of printed-circuit soldering. [433]

Wire and cable. Super Temp Wire division, Haveg Industries, Inc., Winooski, Vt., 05404, has available an eight-page brochure explaining the weight and space saving advantages of Spacewrap wire and cable for aircraft, aerospace, and electronic equipment designed to withstand environmental extremes. [434]

Subcarrier discriminators. Airpax Electronics Inc., P.O. Box 8488, Fort Lauderdale, Fla., 33310. Bulletin TM-7 describes a low cost, high performance and miniaturized discriminator that yields superior dynamic response and low harmonic distortion. [435]

Digital-to-synchro converter. North Atlantic Industries, Inc., Terminal Drive, Plainview, N.Y., has published a two-page data sheet on the series 537 modular digital-to-resolver/synchro converters. [436]

Electrometer operational amplifier. Keithley Instruments, Inc., 12415 Euclid Ave., Cleveland 6, Ohio, offers a four-page engineering note covering the model 300 true electrometer operational amplifier. [437]

Rectifier modules. Unitrode Corp., 580 Pleasant St., Watertown, Mass., announces bulletin T-118 covering its expanded line of "doorbell" rectifier modules. [438]

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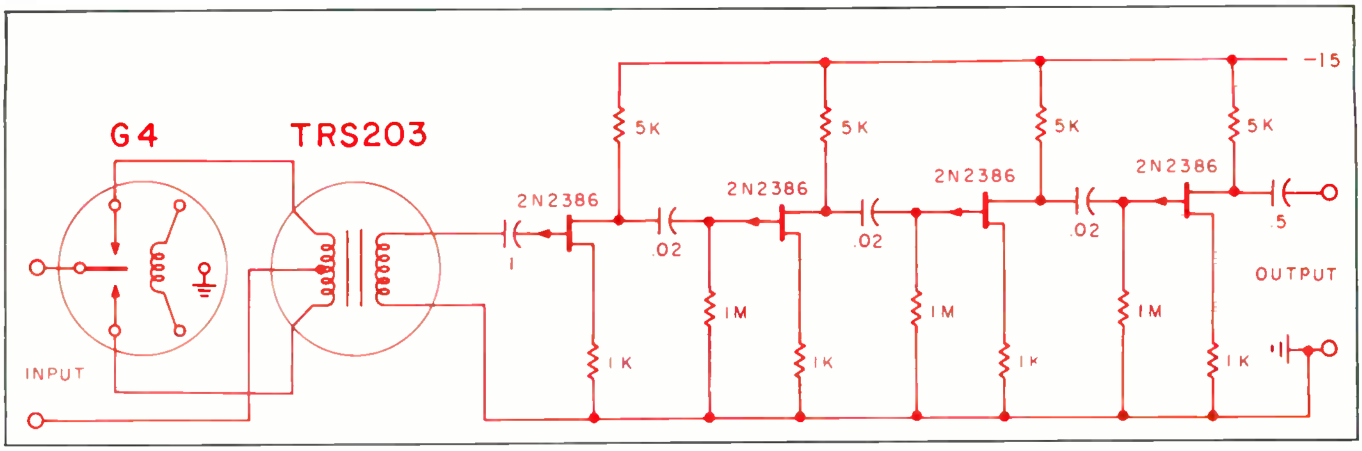

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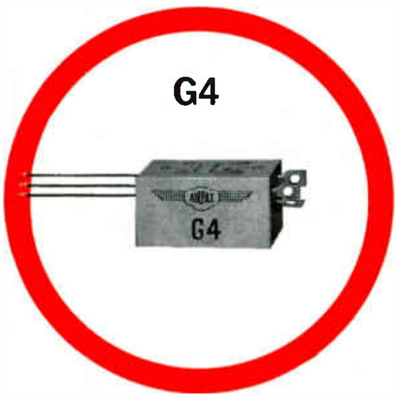

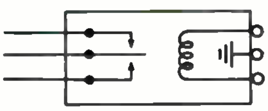

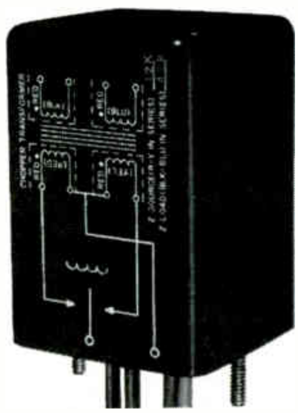

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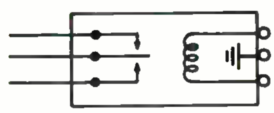

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September 5, 1966

Electronics Abroad

Volume 39
Number 18

International

Pulse-train lullaby

A white-jacketed therapist straps a padded electrode band around a patient's head, sets a couple of dials and flicks a switch on a small control panel. Soon the patient becomes drowsy, most often he falls asleep.

The scene has become routine in Russian hospitals, where "electrosleep" therapy has been used for several years to treat a variety of illnesses including high blood pressure, insomnia, ulcers, even epilepsy [Electronics, May 24, 1963, p. 20]. Now the technique seems on the verge of catching on around the world. In the United States, Great Britain and in Austria sleep-inducing instruments are either on the market or close to it. And next week, some 300 medical researchers from around the world will turn up at Graz, Austria, to attend the First International Symposium on Electrosleep and Electroanesthesia, which will run from September 12 to 17.

Questions. One question sure to keep the doctors awake at Graz is what exactly happens to a patient when he's subjected to the square-wave pulses of an electrosleep instrument. Despite Russian successes with the technique, medical researchers still aren't sure what causes the feeling of well-being, followed by drowsiness and often sleep when the pulses are applied.

One explanation is that the low-level electric currents paralyze a sleep-inhibiting center in the brain. Another explanation is that the effect comes from an electrical potential set up in the casing of the brain. Dr. Sigmund Forster, who heads the physical medicine and rehabilitation service at a Brooklyn, N.Y., hospital, maintains that no one has shown that the pulses actually pass through the brain.

Forster is one of the pioneer U.S. experimenters in the technique. It was he whom the U.S. government tapped to send to the Soviet Union two years ago to look into the Russian work in electrosleep. Forster was sent because both the Air Force and the National Aeronautics and Space Administration wanted to find out if a few hours of induced sleep could replace eight hours of natural sleep for bomber pilots and astronauts. After Forster's report, government officials decided not to follow through with a special program although the possibility still has not been ruled out.

Forster returned from Russia convinced that the pulse-therapy technique had produced impressive results in treating some ills but that it did not necessarily induce sleep. He currently is directing a clinical experiment aimed at getting an idea of how often autosuggestion plays a role in the cures or improvements in health credited to pulse-wave therapy. Forster also suspects that what appears to be induced sleep might actually be a hypnotic state brought on by periodic pulsing. Because the action of low-level pulse trains on the brain is not yet fully understood, Forster will plead at next week's meeting at Graz that researchers in the field shy away from the term "electrosleep" and instead use something like "cranial application of low-level currents."

Hardware. The worldwide exchange of information on experiments and clinical trials at Graz should speed the widespread use of pulse-train therapy in countries besides Russia. For medical electronics equipment makers, it could turn into an important new market. The Russians now produce 5,000 electrosleep units a year.

In the United States, the National Patent Development Corp. has readied, under a license arrangement, a transistorized version of the original vacuum-tube Russian equipment. The U. S. unit puts out pulses 1.8 to 2.0 milliseconds long at rates from 27½ to 40 pulses a second. Amplitude is 18 to 24 volts and the current passed is 1.4 milliamperes. National Patent has under way extensive clinical trials of its instrument and expects to have it on the market—for professional use only—early next year. The price will be around $300. National Patent is keeping the Food and Drug Administration informed of its plans. FDA a few years ago banned a cheap Japanese-made unit that was sold "across the counter" to all comers.

In Great Britain, D.R. Garner & Co. recently put a sleep-inducing

Transistorized sleep-inducing unit recently put on the market in Great Britain is used in a London hospital to treat insomnia and anxiety states.

unit on the market after successful clinical trials in a London hospital. Physicians use it to treat insomnia, anxiety states and other conditions in which sleeplessness occurs.

The patient wears two bands, which apply electrodes to the forehead and the back of the head just above the neck. The square-wave pulses fed to the electrodes are generated by a transistorized astable multivibrator. Frequency can be adjusted from 7 to 140 pulses per second and pulse width from 1 to 4 milliseconds. Maximum amplitude is 27 volts. The Garner unit sells in Britain for $340.

Space team

Although United States electronics companies have cornered substantial markets in Western Europe, essentially they've been shut out of the space hardware business there.

Determined not to let America and the Soviet Union wind up with a monopoly in communications satellites, European countries have made it a policy not to use American hardware in their national space programs and in joint efforts. They aim to build a purely European space capability and with it pick up a piece of the lucrative business in communications satellites that's in sight. What's more, the European countries fear their cultural images would be tarnished if the Americans and Russians controlled tv broadcasting by satellite.

Cashing in. Up against a hopeless situation in hardware, U. S. companies are tapping the market as best they can by selling know-how to Europe. Many companies have set up advisory arms—a new phenomena—and through them worked out consulting agreements with European companies bidding for hardware contracts.

Thus, the Hughes Aircraft Co. has become an almost constant partner of the British Aircraft Corp. The TRW Systems Group of TRW, Inc., works with Britain's Hawker Siddeley Dynamics Ltd. and with France's Engins Matra. The Ball Brothers Research Corp. has collaborated with Sud-Aviation of France. The Philco Corp., a subsidiary of the Ford Motor Co., often advises Nord-Aviation, like Sud a French government-controlled aerospace firm. Because of tie-ups like these, Yankee advisors have a key technical say-so for most of the satellite projects of the European Space Research Organization (ESRO).

Binding. So far, though, there's been a costly drawback for American companies looking for profits in the space know-how business. A group forms around a U.S. consultant to bid on a satellite and then usually falls apart if a competing group wins the award. When the next project goes up for grabs, the expensive effort to put together a bidding consortium has to start practically from scratch.

To get around this drawback, the General Electric Co. has lined up what it hopes will be a durable consortium, the European Satellite Team. Along with GE's Technical Services Co., a subsidiary set up to handle overseas sales of know-how, the team includes Elliott-Automation Ltd. of Britain, Compagnie Française Thomson Houston-Hotchkiss Brandt, Fabbrica Italiana Apparecchi Radio (FIAR), the Royal Netherlands Aircraft Factories (Fokker), and Allmanna Svenska Elektriska AB (ASEA) of Sweden.

The team already has launched an effort to capture a big chunk of space business. Last month, it bid along with four other competing groups for an $18-million contract to build a pair of 800-pound scientific satellites for ESRO. If the team gets the job, GE stands to collect a $1-million fee for consulting and a part of the hardware money as well since it owns 75% of FIAR.

Togetherness. The team also has submitted a proposal to the International Telecommunications Satellite Consortium (Intelsat) for a development study on a multipurpose communications satellite. R.C. McBride, who heads Technical Services' operation in Paris, says the team plans to stay together for bids on future ESRO satellites, hardware for European Launcher Development Organization projects and for the first Intelsat satellite.

Other U.S. companies to date haven't followed GE's lead in knitting together durable space-business consortiums with European hardware producers. Many feel the best way to pick up know-how fees is to form one-shot groups tailored for specific projects. But if the European Satellite Team wins the ESRO contracts for the two 800-pound scientific satellites this fall, the scramble will be on to put together long-lasting consortiums.

Japan

Characters galore

In addition to the same sort of problems their Occidental counterparts run up against, Japanese computer makers face a harrowing situation when it comes to printout—it takes nearly 2,500 different characters to get ordinary Japanese down on paper.

So far, Japanese computer makers have sidestepped the printout problem rather than tackle it head on. They've limited printout to the so-called katakana syllabary, a set of 48 phonetic symbols used in normal Japanese for emphasis and for words taken over from foreign languages. Anyone who can read Japanese can puzzle out the words from the phonetic symbols, so katakana works well enough for computer-prepared inventories, invoices, brief explanations on business forms and the like. But in long prose passages, katakana becomes unintelligible.

Pointing toward the day when widespread use of computers in Japan will make easily readable printouts necessary, Hitachi Ltd. has developed an electrostatic printer that can cope with 1,200 different characters and grind out 40-character lines at 225 lines per minute. The variety of characters is sufficient to turn out texts in normal Japanese prose, a combination of kanji—Chinese characters—and a phonetic syllabary for inflection.

At 150 characters per second,

Hitachi's kanji printer doesn't come close to the speed of the fastest katakana printer, which whirls out nearly 20,000 characters per second [Electronics, Dec. 13, 1965, p. 239]. Still, the Hitachi unit operates 75 times faster than previous kanji printers, the best of which pokes along at two characters per second. What's more, unlike its predecessors the Hitachi printer can be run directly off a computer. First production models will be on the market late this year.

Kanji store. The 1,200 characters that the printer can reproduce are stored on a photographic film belt, the equivalent of the row of type wheels in a mechanical line printer. The film belt runs over a bank of 40 optical fiber tubes, each illuminated by a xenon lamp. Control circuits in the printer flash the lamps to match the input from a computer or a paper tape reader.

As the lamps flash, the optical fiber tubes project the 40 characters for each line onto coated paper that can hold an electrostatic charge. The paper first passes a plate that charges it. Then it is discharged line-by-line—except where characters are flashed onto it—as it passes by an exposure plate. Continuing its pass through the printer, the paper picks up a charged toner where light has hit it. The toner is developed to form legible characters by xerographic techniques.

Typhoon chaser

Getting warnings out to the public well before hurricanes hit is no longer much of a problem for the United States Weather Bureau. It has a battery of weather satellites and far-ranging military patrol planes at its disposal to track hurricanes from Amy to Zelda.

For its typhoon warning system, though, the Japan Meteorological Agency can't afford a panoply of satellites and aircraft. Fuel bills for the planes alone would be more than the agency's entire operating budget. So the agency has put a typhoon-chasing weather-radar ship to sea.

The ship will back up the existing—but sometimes inadequate—network of weather-radar stations strung out along the Japanese coast, including one atop Mt. Fuji. In recent years, the agency has been caught short several times by typhoons that have veered out to sea beyond the range of the network and then changed course to batter the coast with little warning.

Defiant. The Japanese christened their 2,000-ton weather ship the Ryofu Maru, which translates into "wind-defying ship." The ship herself and the 16-foot-diameter radome amidships were designed to withstand winds up to 133 miles an hour. All the same, the agency doesn't plan to send the vessel right into the eye of a typhoon. She can stand off and track storms up to 250 miles away with her radar, which puts out 300 kilowatts of peak power at a frequency of 5,300 megahertz. The resolution in range is better than 600 feet, in azimuth better than 3°.

Circuit design of the Ryofu Maru's radar is similar to that of other high-power radars but the 8.2-foot-diameter dish antenna is far and away the largest yet built in Japan with a stabilized platform. The stabilization system can cope with roll up to 30° on either side and pitch of 10° up or down. Along with the mechanical antenna platform stabilization, there are electronic circuits that keep the radar display oriented "North up."

In addition to the $180,000 weather-radar system, which was built by Tokyo Shibaura Electric Co. (Toshiba), the Ryofu Maru has been outfitted with an extensive kit of oceanographic gear so she won't be idle between typhoon seasons.

Ryofu Maru's radar can track typhoons up to 250 miles away.

Great Britain

Heads up

Prime Minister Harold Wilson's decision last spring to buy 50 F-111 intercontinental fighter bombers from the United States provoked dismay in the British airframe industry, but electronics manufacturers reckoned the overseas plane buy might turn out to be a good thing for them in the long run.

To clinch the deal, the Pentagon agreed to buy enough British defense gear to offset the cost of the planes—some $300 million. For this business, the usual 50% "buy American" price differential doesn't apply and British suppliers bid on the same footing as U.S. suppliers. The British electronics industry has long maintained it could compete in the U.S. military market if it weren't for "buy American" protection.

Now it looks as if the British electronics industry had the situation sized up right. Last month, Elliott-Automation Ltd. picked up a $600,000 initial contract to develop the "head-up" system and a digital computer for the U.S. Navy's Integrated Light Attack Avionics System (Ilaas).

The award came officially from the Sperry Gyroscope division of the Sperry Rand Corp., prime contractor for Ilaas. The Navy has earmarked $23.9 million to develop and test four Ilaas prototypes for the A-7 Corsair-2 carrier aircraft. Sperry Gyroscope itself was the other main contender for the head-up part of the system, but Elliott got the nod from the Navy. Said Commander H. Pasley-Tyler, who directed Elliott's negotiations with the Navy, "This shows we can compete on equal terms, and we're jolly proud of it."

In view. The Ilaas head-up display allows pilots to see both instrument information and the outside world at the same time. The instrument information is projected from a cathode-ray tube onto a viewer in the pilot's line of sight. All the pilot has to do to stay on course, for example, is keep a dot projected onto the viewer in the center of a circle. One feature of Elliott's display is a ceramic cathode-ray tube, with the electrode structure deposited directly on the ceramic, much as in printed circuits. Elliott head-up displays using the special tube already are standard equipment in some British military attack and transport planes.

Another kingpin element in the Ilaas hardware Elliott will develop is a digital computer that weighs only 90 pounds, including the interface and power supply. The standard model of this computer, which translates flight information so that it can be displayed as a dot on a viewer, has a memory with a capacity of 12,000 words. Elliott will expand the memory for Ilaas.

More to come? For Elliott-Automation, the $600,000 development contract may be just the beginning. If the Navy decides to put Ilaas into production, Elliott almost certainly stands to get a production contract worth several million dollars. And Pasley-Tyler says that Elliott is negotiating with U.S. officials for a contract of "quasi-military" nature, but won't let on exactly what Elliott is trying to sell.

Red China

No threat yet

For electronics companies eyeing markets in Southeast Asia, one big question is when will the People's Republic of China start looking seriously for customers on the other side of the Great Wall.

The answer, apparently, is not soon. Judging by the Chinese Machinery and Electronics Exhibition mounted a fortnight ago by 14 Hong Kong companies that handle Red Chinese goods, the People's Republic still has little to offer to neighboring countries.

To be sure, the emphasis at the exhibition was on heavy machinery —textile and printing equipment along with a variety of high-precision machine tools, all rated as well-made by Western observers. But the Reds also showed what electronics gear they have to sell now in export markets.

Little. It isn't much—a few measuring instruments and some vacuum-tube radios. The instruments included a signal generator, an oscilloscope, a low-frequency analyzer, a voltmeter, and a pH meter. Few were transistorized and none could handle high frequencies. The electronic computers over which the Red Chinese have made much ado were conspicuously absent.

As for radios, only vacuum-tube sets were shown. Some had as many as five medium- and short-wave bands, but none had frequency modulation. Although it's known the Red Chinese produce transistor sets, apparently they can't spare any now for export markets. With nothing but line-operated sets to sell, they won't stack up as serious competitors in consumer markets for a long time.

Along with instruments and radios, the Hong Kong fair also brought forth a display of components that include variable condensers, fixed capacitors, resistors, ferrite antennas, transformers, loudspeakers and microphones. But there was no miniaturization, a drawback in Asian markets where the transistor radio is king.

Profile. It's a reasonably safe bet that the Hong Kong exhibition mirrors the makeup of the Red Chinese electronics industry. The main effort, then, seems directed toward manufacture of instruments for industrial and scientific uses. In consumer electronics, the emphasis is on radios, presumably to keep the population well primed with propaganda. Western observers estimate that in 1965 there were some 6.3-million radio receivers and communal radio relay loudspeakers in use in the People's Republic, but only 100,000 tv receivers.

The Hong Kong show made it clear that Red China still is a sleeping giant as far as electronics exports go. But a long-range threat lurks. Although the range of items was limited, prices quoted at the show were highly competitive.

Around the world

India. Practically all the instrumentation for India's massive long-range nuclear power program will be produced domestically. By 1970, the Indians plan to be building one nuclear reactor a year and each will require some $1.3 million worth of electronic monitoring and control gear. To handle the job, the government plans to transform the electronics production division of the Indian Atomic Energy Dept. into a commercial corporation.

South Korea. With the labor market in Hong Kong beginning to tighten up, United States semiconductor manufacturers are turning to South Korea. The first U.S. company to go into semiconductor production there will be the Fairchild Camera & Instrument Corp., which recently received government approval to build a plant. Signetics Corp., a subsidiary of the Corning Glass Works, also plans a South Korean semiconductor plant.

Western Europe. Two NATO countries are buying low light-level television cameras from the Admiral Corp. in Chicago to install aboard Navy ships to augment radar. The tv will take over the job of tracking low-flying aircraft when clutter from the sea's surface obscures the target on radar.

Thailand. The Thai police department is evaluating bids for a $5-million "hot line" telephone system to link Bangkok with 107 towns in the northeastern provinces where Communist activity is rife. The trunk line will be paralleled by microwave links to keep the system operating should the Communist insurgents cut the cable. Six countries are competing for the contract.

Japan. The Nippon Electric Co. has started taking orders for the first small Japanese computer with integrated circuits. NEC calls the computer the NEAC Series 2200 Model 50, says it bridges the gap between the low end of the line of computers it builds under license from Honeywell Inc. and its small parametron computer [Electronics, Sept. 6, 1965, p. 155].

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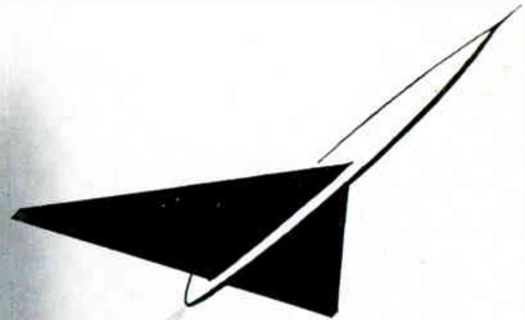

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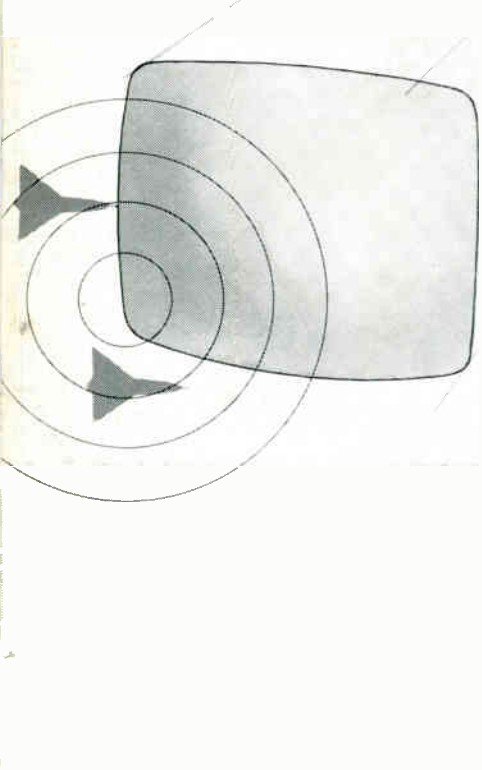

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