Electronics®

Understanding the gyrator: page 114
Measuring effects of radiation: page 122
What's new in consumer electronics: page 136

June 10, 1968
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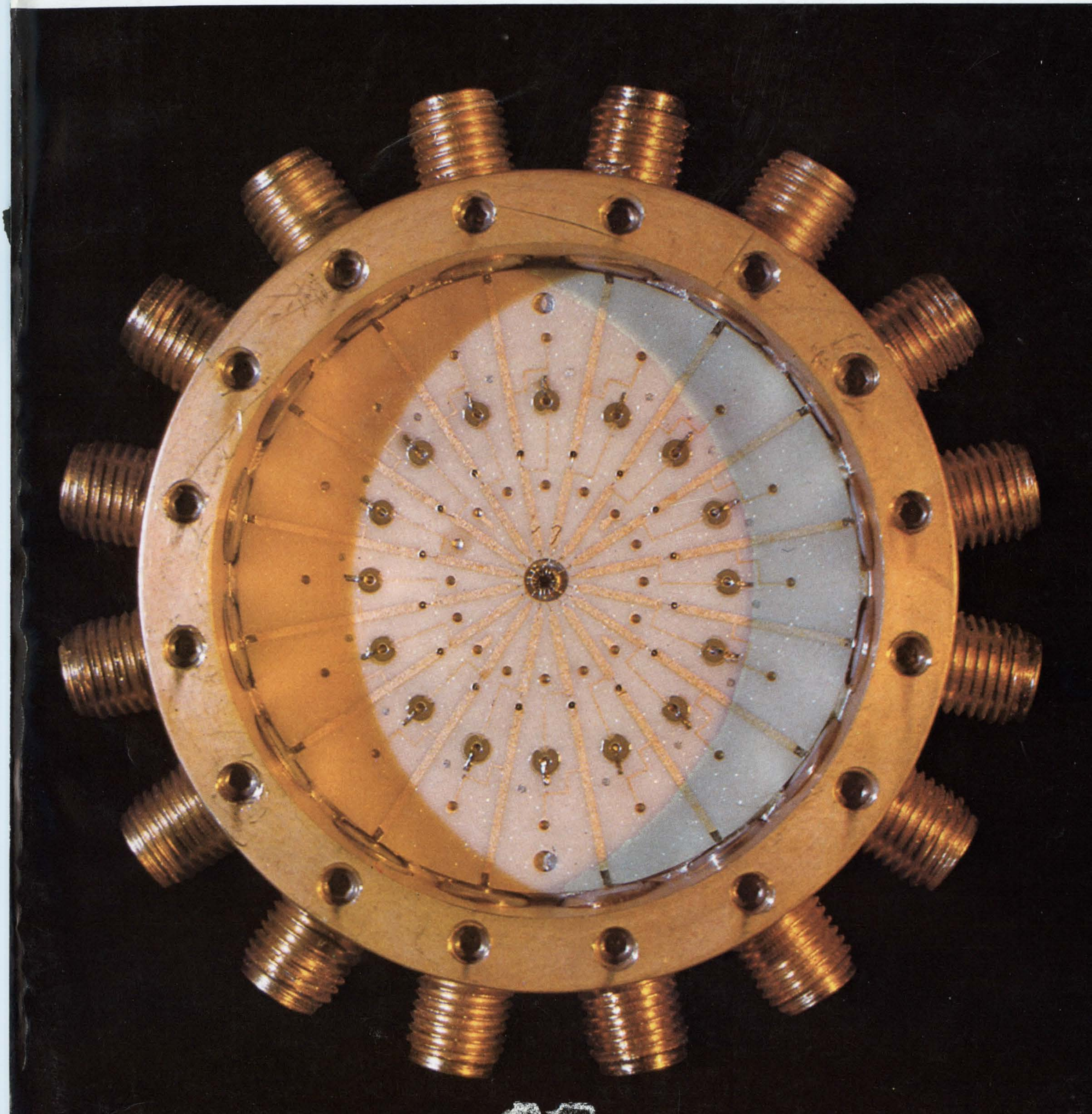
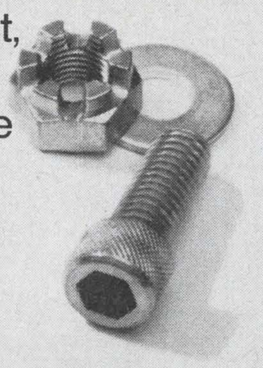
Below: New solutions to microwave IC problems, page 100



Computers are big, expensive components. Bit for bit, ounce for ounce, some are a bargain.



When you tie another man's computer into your product, you're staking your reputation on his equipment. Your reputation is worth shopping for. Naturally you want the most for your dollar. Like reliability at 130° F. Hewlett-Packard computers are designed for rugged dependability—as well as high performance. All things considered, they're something of a bargain.

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The 2114A pictured here measures 16¾"x 12¼"x 22½" including its power supply. It uses 16-bit words, operates with 4K or 8K memory, and has a two microsecond cycle time. Price: $9,950.

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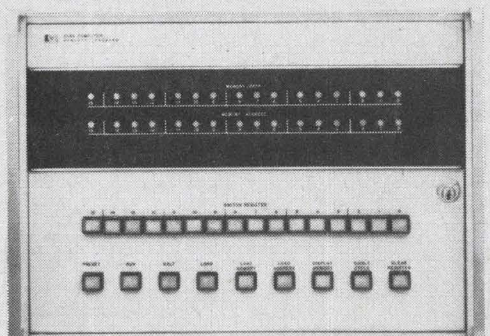

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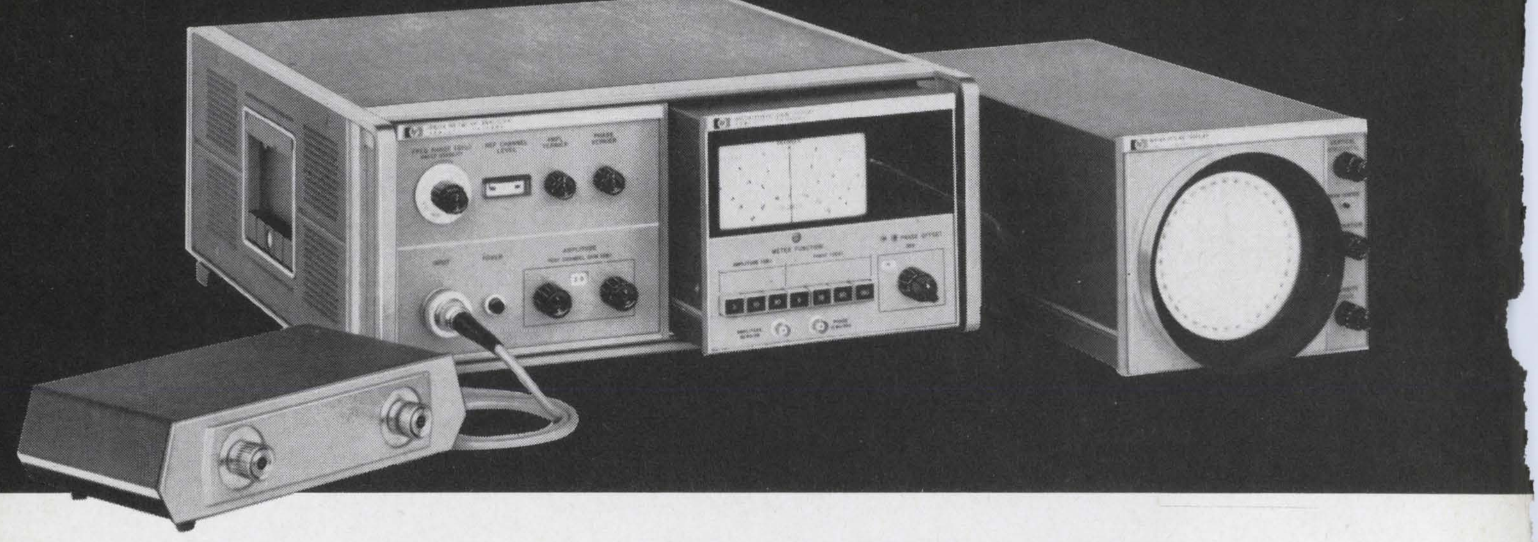
DIGITAL COMPUTERS

06818

What would *you* call this new Microwave instrument?



Our project engineer calls it a "microwave multimeter."
Our marketing people call it a "universal microwave test set."
Our catalog calls it the HP 8410A Network Analyzer.
You'll call it the answer to your measurement problems. Here's why–

First, "it" measures all these microwave parameters: gain/attenuation and phase shift, i.e., complete transmission coefficients; magnitude and angle of reflection coefficient with polar or Smith Chart plots of impedance/admittance. With "it," you can characterize active and passive components or systems at single or swept frequencies.

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"It" is actually a modular system: a signal-processing mainframe with choice of two readout plug-ins; a wideband RF converter unit; a full-range transmission test unit; and two reflection test units for 0.11 to 12.4 GHz coverage.

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The modules for transmission measurements, 0.11 to 12.4 GHz, cost $6450. Add the capability for polar and Smith Chart displays of reflection characteristics, 0.11 to 12.4 GHz, for $3985.

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MICROWAVE NETWORK ANALYZERS

04804

Electronics

Volume 41, Number 12 June 10, 1968

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Probing the News

Electronics Review

Electronics Abroad

New Products

Technical Articles

I. Design

II. Application

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Readers Comment

Punched tape

To the Editor:

The article, "Punched cards on the ropes?" [April 15, p. 193] was interesting and capably done. However, I believe that since the increasingly important roles of optical character recognition and magnetic-tape encoders were covered, the story should have discussed punched paper tape as an alternate computer input medium.

The central philosophy of punched tape is to capture data as a byproduct of some necessary operation. Thus, tape punches have been linked to many basic business machines, both for in-house processing and by companies using data centers. Almost every business machine manufacturer provides punched tape equipment, and NCR, as one example, has installed more than 10,000 tape-punching devices.

Of course, there is a break-even point of volume at which optical scanning becomes more efficient. Below this point, however, punched tape is usually the cheapest and best method of data input.

New equipment today is greatly extending the economy of direct tape-to-tape data transmission. This will undoubtedly give added impetus to an already sizable market. But the basic advantage remains the fact that punched tape (Mylar as well as paper) is able to deal with dynamic as well as static data, whereas punched cards remain as individual documents.

W.P. Keating
National Cash Register Co.
Dayton, Ohio

Microwave for Mexico

To the Editor:

We found your article "Mexico nears finish line in the first Olympic event" [April 1, p. 95] of great interest since General Telephone & Electronics International is so heavily involved in providing microwave systems for Mexico's communications system.

In addition to the temporary system of 14 antennas which you mention, we are installing a 475-mile microwave system from Ciudad Victoria to Piedras Negras in north-

True RMS—Not An Approximation. Hewlett-Packard took the standards lab technique of precision thermocouple ac to dc conversion . . . added protective amplifiers to assure fool-proof overload protection (800 Vp-p) . . . and produced a practical, true RMS voltmeter with high 1% accuracy.

With wide 10 Hz to 10 MHz frequency response, use the 3400A for all your true rms audio and many of your rf measurements. With sensitivity of 1 mV to 300 V full scale, you accurately measure anything from "down-in-the-grass" signal and noise, to transmitter and amplifier outputs.

Easy-to-read hp taut band meter is friction free and has a scale that is individually calibrated to the meter movement for unsurpassed accuracy.

High Crest Factor. Measure noise and other non-sinusoids with high 10:1 crest factor (ratio of peak to rms). Measure 100:1 crest factor at 10% of full scale. You get accurate noise and pulse measurements—without correction factors.

Three-in-one-Versatility. The 3400A is a true rms voltmeter, an ac/dc converter, and a current meter. As an ac/dc converter, typical dc output accuracy is 0.75% of full scale from 50 Hz to 1 MHz. With the hp 456A AC Current Probe, use the 3400A for quick, dependable current measurements. The 456A probe has a 1 mA to 1 mV conversion which allows direct reading up to 1 ampere rms.

Price of the hp 3400A RMS Voltmeter is $525. The hp 456A AC Current Probe is $225. Convenient, rugged, field carrying case, hp 11075A, $45. For all the facts concerning the versatility of these instruments, contact your nearest hp field engineer. Or, write to Hewlett-Packard, Palo Alto, California 94304. Europe: 54 Route des Acacias, Geneva.

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ANALOG VOLTMETERS

098/6

True RMS Measurements Come from Thermocouples!

Standards Labs Use Thermocouples for True RMS!

(So does the hp 3400A RMS Voltmeter!)

eastern Mexico and a 580-mile system in northwestern Mexico linking Hermosillo and Ensenada. Contracts for approximately $9 million were awarded by the Secretaria de Comunicaciones y Transportes for this work to our Italian subsidiary, Società Generale di Telefonia ed Elettronica S.p.A., Milan.

Edward J. Reardon
GT&E International
New York

Sour note

To the Editor:

The article "Signal gains for electronic music" [April 29, p. 93] contains misinformation about Moog electronic music instruments.

None of the Moog synthesizers sells for $1500. The device which you say . . . "can be carried around by pop music groups to augment the sound of their electric guitars and rhythm sections" is not a synthesizer, but a signal processor.

None of the Moog synthesizers employ internal interconnections in place of the facility for interconnecting modules by plugging patch cords into input and output jacks. In Moog synthesizers, some interconnections may be established with illuminated switches instead of patch cords, but this facility is in addition to frontpanel input and output jacks.

I can find no objective criterion to apply which would justify your statement that the equipment of Buchla Associates has "a greater range of sound dynamics" than Moog equipment.

Robert Moog
President
R.A. Moog Co.
Trumansburg, N.Y.

▪ The objective criterion is that the Buchla synthesizer contains programable electronic sequencing switches and the Moog doesn't. This enables the Buchla equipment to change from one frequency to another in much less time. The phrase "sound dynamics" shouldn't be confused with "dynamic range," which is ratio of the maximum sound level of a system to its background noise.

Making music

To the Editor:

Far from being a "$100,000 white elephant," the RCA synthesizer [April 29, p. 93] was the first comprehensive electronic system for synthesizing musical sounds based on post-war technology, and out of its development and application has come a wealth of knowledge which underlies virtually every aspect of electronic music today. Instead of being limited to note-by-note production as you suggest, it was actually the first means by which relatively large segments of music could be produced by programing characteristics of sounds. It is in precisely this area that its chief advantage lies.

Even today, after the development of voltage-controlled devices, the synthesizer can still hold its own with contemporary synthesizers, owing to the extreme accuracy with which the composer can control the realization of his compositions. Important compositions have been and are being produced on the synthesizer, and we expect it to be a valuable tool for many years to come.

James Seawright
Electronic Music Center
Columbia and Princeton Universities
New York

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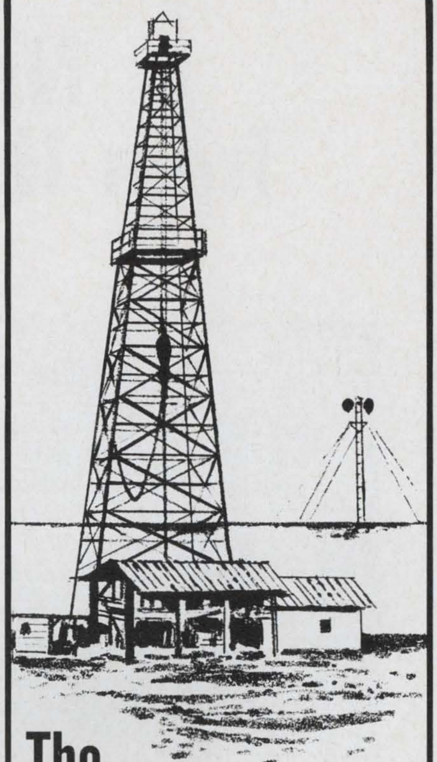


People

The new assistant to the president for microelectronics planning at Autonetics, Alvin B. Phillips, says his primary mission is to build a five-year plan for microelectronics and implement it in close cooperation with C.F. O'Donnell, senior vice president for research and engineering.

Phillips

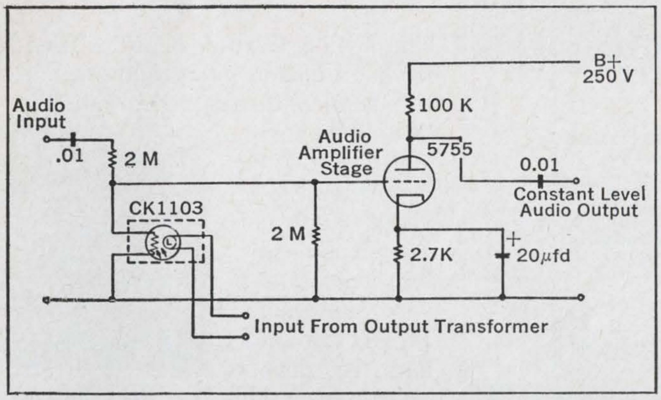
Phillips, 39, made a big move in late April—from the predominantly bipolar world of Sylvania's Semiconductor Products division in Woburn, Mass., to the large-scale integrated metal oxide semiconductor discipline of the Anaheim, Calif., division of the North American Rockwell Corp. [Electronics, April 29, p. 25].

To produce these circuits, Autonetics is building a 40,000-sq-ft. facility that's due for completion in early August. Phillips was general manager of Sylvania's integrated circuit operation before moving west. He believes the biggest problem facing Autonetics in its entry into the specialized LSI business is its marketing structure, which traditionally has been systems oriented. He says, "Autonetics is in a tremendous position in technology. Yields are surprisingly good. In production, the new building means management recognizes the need to produce—and on schedule. I think they've made fine equipment decisions."

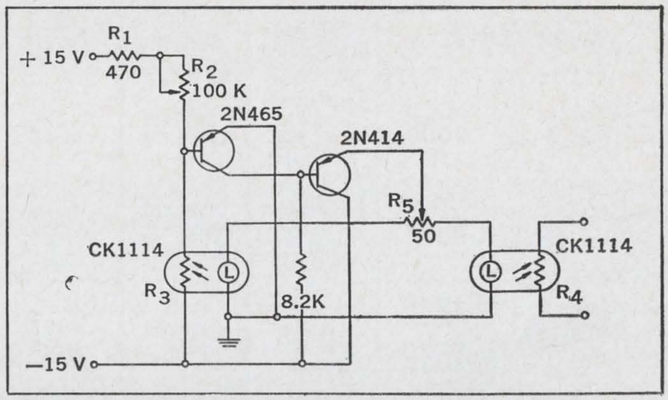
Question. But because Autonetics has been mainly systems oriented, Phillips contends, new marketing ideas will have to be introduced and the proper organization built up. "You need a highly trained marketing force to sell LSI. There are some questions to be answered, such as: Will there be standard products? Will there be a distributor organization? Do we offer systems assistance so that the customer's system can be most efficiently partitioned?

"But the marketing attitude is right. Management recognizes that changes have to be made and is asking how it can be done. And I

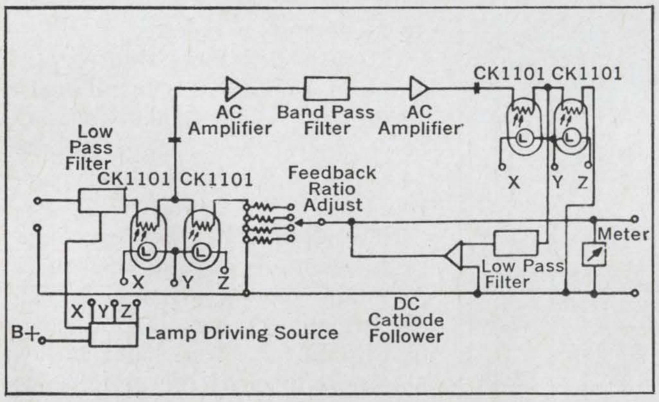
3 ways you can use the Raysistor® to improve your product, cut costs



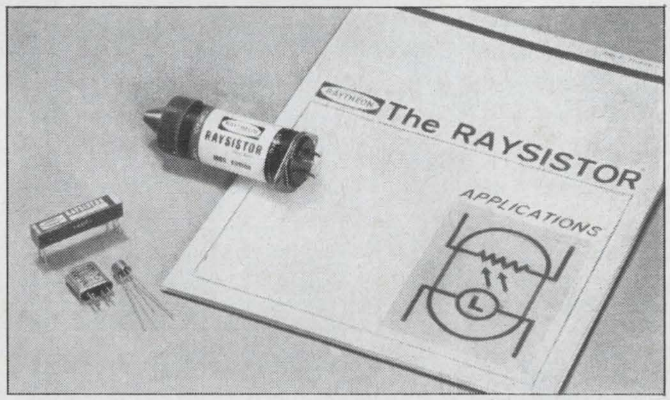
1. Use the Raysistor® as a simple remote or automatic volume control in SSB suppressed carrier receivers. Feeding part of the audio output into the control light source varies the resistance of the Raysistor's photocell, making it usable in place of a normal volume control.



2. As a remotely controlled linear potentiometer. The Raysistor can be used as a remotely controlled linear potentiometer when used in the circuit shown above. Here the Raysistor forms a voltage divider between the positive and negative voltages.



3. As a photochopper stabilized D-C microvoltmeter. Raysistors, used as photochoppers in both modulator and demodulator circuits, enable d-c levels to be measured to a fraction of a microvolt. They facilitate synchronous detection and demodulation with simple electrical coupling, have less noise than transistor choppers, while avoiding maintenance problems of mechanical choppers. Other photochopper applications: photochopper relay, series or shunt chopper, modulator circuit, and as a stabilizer to reduce long-term drift.



Many more ways you can use the Raysistor. Send for *The Raysistor Applications Manual* which describes ways you can use this unique optoelectronic component as a photochopper, variable resistor, solid-state switch, relay, voltage or signal isolator, nonlinear potentiometer, etc. For complete specifications and prices, call your Raytheon distributor or regional sales office. For a copy of this 28-page manual, circle the reader service card or write directly to *Raytheon Company, Components Division, Quincy, Massachusetts 02169.*

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think a systems house with component technology can step into LSI easier than a component house without systems experience."

The Union Carbide Corp.'s Electronics division got a late start in the semiconductor field, but the establishment of a semiconductor department 4½ years ago attracted some impressive talent—in particular, Robert Freund and the developer of the planar process, Jean Hoerni. But though strong in technology and materials, Union Carbide never became a significant semiconductor supplier—possibly because the department wasn't as strong in management and marketing.


Beadling

David A. Beadling, who recently replaced Freund as general manager of the semiconductor department, notes that Union Carbide hasn't a single direct-house account.

New approach. Beadling considers himself a marketing man. Assistant general manager of the department for less than a year, he will have a free hand in his new post to chart the unit's sales policies.

Success in any industry, says Beadling, is knowing where the future lies; in the semiconductor business, that means knowing what circuits the customer will want next year. "If we send a man into the field who, in addition to selling circuits, comes back to us with a feeling of where our customers are going, we'll be much, much better off."

Expansion. "We've chosen our sales approach and we've picked the linear and metal oxide semiconductor fields as our production areas," says Beadling. "What now stands between us and our expectations is 22 acres of relatively barren real estate around San Diego. By 1972, we'll have completed 325,000 square feet of production and development space there."

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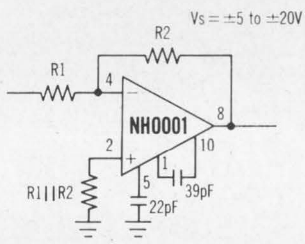
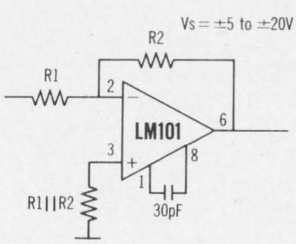
We've got op amps like nobody's got op amps.

1. VERY LOW POWER



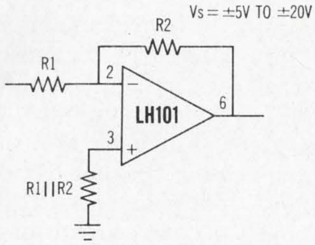
The typical dissipation of the NH0001 is but 1.8mW at Vs = ±15V and 0.6mW at Vs = ±6V. Something of a record, no? And further, the mighty NH0001 will deliver over ±10V into a 2K load from Vs = ±15V supplies. It's priced at $48.00 in 100 to 999 quantities.

2. GENERAL PURPOSE



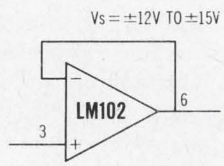
Old faithful LM101 is both general purpose and no-sweat in operation. It's short-circuit proof and has a large differential input voltage allowance. Moreover, frequency compensation is simple, and there is no latch-up problem. The price is $40.00 in 100 to 999 quantities. (There is also a commercial version, the LM201, priced at $8.80.)

3. FULLY COMPENSATED, GENERAL PURPOSE



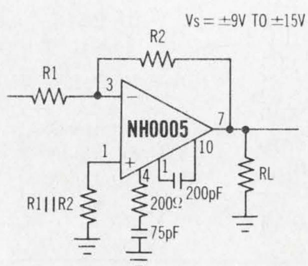
The LH101 is kin to the LM101. The essential difference is that all the required frequency compensation is *inside* the package. Current drain is low, even with the output saturated. There is no latch-up when common mode range is exceeded and there's continuous short circuit protection. Price for 100 to 999 is $48.00. The commercial version LH201 is $11.40.

4. HIGH SLEW RATE VOLTAGE FOLLOWER



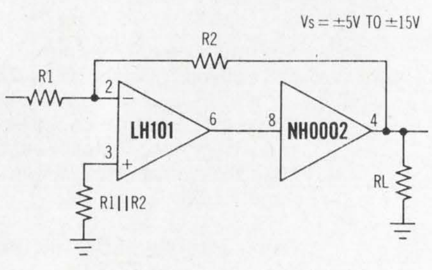
The LM102 voltage follower is the first monolithic amplifier that has combined low input current with high speed. Slew rate is 10V/μs. The maximum input current is an incredible 10nA. Input currents better than 10nA at 125°C are guaranteed. The price: $30.00 each in 100 to 999 quantities. The −25°C to +85°C LM202 is priced at $12.00, LM302 commercial at $5.40.

5. HIGH OUTPUT CURRENT



When we say high output current, we *mean* high. The output current on this, the NH0005, is ±50mA into a 100Ω load. The price in 100 to 999 quantities is $45.00. And there's a commercial version, the NH0005C, priced at $22.50.

6. VERY HIGH OUTPUT CURRENT, WITH BUFFER



The NH0002 is something else. It has an output current of ±300mA into a load of 50Ω. The NH0002 buffer is useful in the loop in all your high current op amp applications. The price is $20.00 in 100 to 999 quantities.

Meetings

LSI's impact on computers

The theme of this year's IEEE Computer Conference, scheduled for Los Angeles June 25 to 27, is the impact of large-scale integration.

The conference will be divided into six daytime sessions, plus nine "dig deeper" evening meetings that will offer an opportunity for informal discussion in specialized areas, such as design automation for LSI, testing LSI digital logic, automated mask making, ultimate limitations in computing technology, and standardization.

In the opening session, Fairchild Semiconductor's R.J. Schreiner, of the research and development laboratories, will point out that the vendor's investment in LSI will be very large in such areas as personnel, test equipment, and computer-aided design; he will also note that the return on this investment is some years away. Schreiner will then say that the system manufacturer must determine to what extent he will support LSI efforts now so that the technology will be available in the 1970's.

In another session, Wally Raisanen of Motorola Semiconductor will focus on the alternatives of custom vs. standard design and take a critical look at the advantages and limitations of monolithic vs. hybrid manufacturing. A Fairchild trio—T. Asai, J.H. Friedrich, and J.D. Schmidt—will describe their attempt to develop a hybrid LSI memory and show that storage capacities of 10^4 to 10^6 are now possible in a hybrid package that permits growth in both storage capacity and speed, with speed ranging from 250 to 500 nanoseconds.

No conference treating LSI could ignore beam-lead technology, and two representatives from Bell Telephone Laboratories—where the beam-lead technique was originated—will present a paper on an iterative arithmetic unit for highly parallel processing arrays. J.H. Huttenhoff and R.R. Shively will show that a 32-bit arithmetic unit, a 4,096-bit memory, and an input correlation unit will fit on a 3.75-by-4-inch ceramic substrate using beam-lead monolithic IC's.

Paul Baran of the Rand Corp. will discuss how LSI will revolutionize communications and warn that even the most basic design decisions made for systems of the past will have to be closely scrutinized. He will stress the need for totally new designs.

For more information write Harold Petersen, Rand Corp., 1700 Main St., Santa Monica, Calif.

Calendar

International Conference on Communications, IEEE; Sheraton Hotel, Philadelphia, **June 12-14.**

American Society for Engineering Education Meeting; University of California, Los Angeles, **June 17-20.**

Electromagnetic Compatibility Symposium, IEEE; Berkeley Cartaret Hotel, Asbury Park, N.J., **June 17-19.**

Microelectronics Symposium, IEEE; Sheraton-Jefferson Hotel, St. Louis, **June 17-19.**

Meeting of the Institute of Navigation; King Hall, U.S. Naval Postgraduate School, Monterey, Calif., **June 19-21.**

International Symposium on Optimal Systems Planning, International Federation of Automatic Control; Case Institute of Technology, Cleveland, **June 20-22.**

Summer Power Meeting, IEEE; Sheraton Dallas Hotel, Dallas, **June 22-27.**

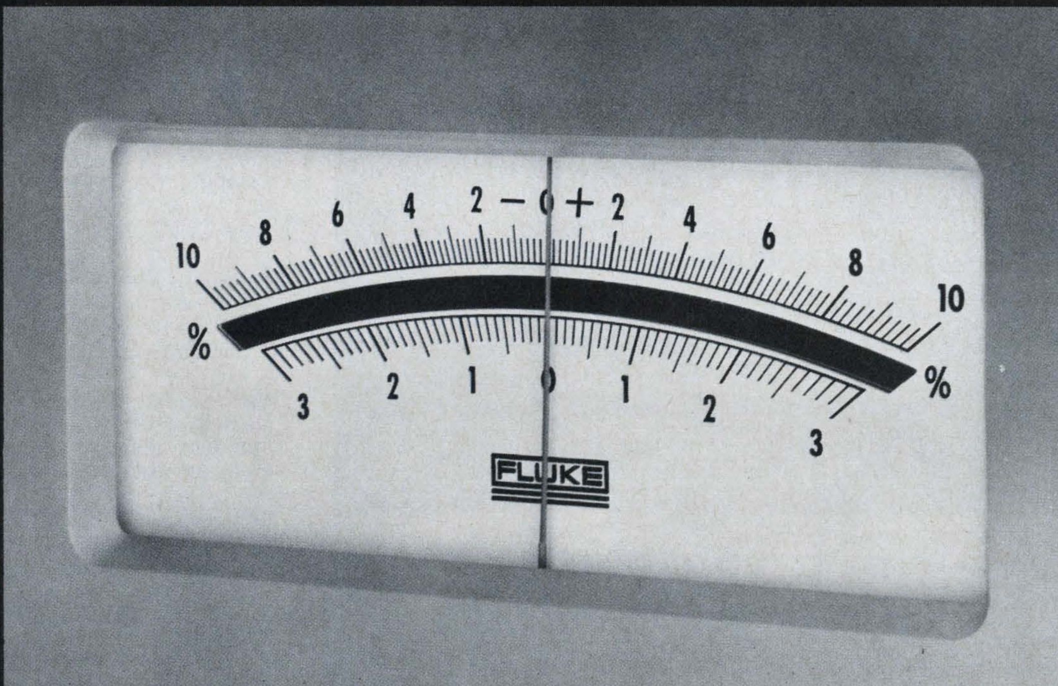
Consumer Electronics Show, Electronic Industries Association; Americana and New York Hilton Hotels, New York, **June 23-26.**

Power Meeting, IEEE; Sherman House, Chicago, **June 23-28.**

Fluid and Plasma Dynamics Conference, American Institute of Aeronautics and Astronautics; Ambassador Hotel, Los Angeles, **June 24-26.**

(Continued on p. 16)

To calibrate percent error directly on your AC/DC, volt, or ammeters of any type, read this meter.



It's on the face of the new solid state Fluke Model 760A meter calibrator.

And that's only one feature of the Fluke 760A which obsoletes all other meter calibrators. For instance, here's a calibration standards instrument guaranteed to stay within specifications for one full year over a wide range of environmental conditions. Further, the instrument is genuinely portable when compared to existing single units or groups of several instruments performing similar functions.

We've built the Model 760A with a minimum of controls and indicators so you can operate the instrument simply and quickly.

Dial up any parameter without range change or switching.

We've put in a full complement of interlocks and other safety features so neither you nor the instruments under test are in danger. The 760A can easily be used by unskilled operators to calibrate virtually all multi-range, multi-function instruments.

A stable, low distortion oscillator is used to provide either 60 Hz or 400 Hz.

DC accuracy of the 760A is ±0.1% up to 1000 volts. Current range is 1 microampere to 10 amperes with an accuracy of ±0.25%. Resistance range is 0 to 10 megohms to an accuracy of ±0.1%. AC accuracy is ±0.25% from 0.001 to 1,000 volts. And the price, $2,485, is a lot less than anything remotely comparable.

So, if meter calibration is your business, let us help make your work day shorter and easier with the new Fluke 760A Meter Calibrator. See your Fluke Sales Engineer (listed in EEM) or write or call us for full information and a demonstration.

FLUKE

Fluke, Box 7428, Seattle, Washington 98133. Phone: (206) 774-2211. TWX: (910) 449-2850.

In Europe, address Fluke International Corporation, P.O. Box 5053, Ledeboerstraat 27, Tilburg, Holland. Telex: 844-50237. In U.K., address Fluke International Corporation, P.O. Box 102, Watford Herts, England.

Circle 15 on reader service card

Meetings

(Continued from p. 14)

International Symposium on Bioastronautics and the Exploration of Space, Air Force Aerospace Medical Division; San Antonio, Texas, **June 24-27.**

Thermophysics Conference, American Institute of Aeronautics and Astronautics; Los Angeles, **June 24-26.**

Conference on Precision Electomagnetic Measurements, IEEE; National Bureau of Standards Laboratories, Boulder, Colo., **June 25-28.**

Computer Conference, IEEE; International Hotel, Los Angeles, **June 25-27.**

Automatic Control Conference, Instrument Society of America and IEEE; University of Michigan, Ann Arbor, **June 26-28.**

Management in the Fields of Aerospace Meeting, American Institute of Aeronautics and Astronautics; Montreal, **July 8-9.**

Conference and Exhibit of the Marine Technology Society; Sheraton Park Hotel, Washington, **July 8-10.**

Nuclear and Space Radiation Effects, IEEE; Missoula, Mont., **July 15-18.**

Design Automation Workshop, IEEE; Washington, **July 15-18.**

Reliability and Maintainability Conference, American Institute of Aeronautics and Astronautics; Jack Tar Hotel, San Francisco, **July 15-18.**

Call for papers

International Electron Devices Meeting, IEEE; Sheraton-Park Hotel, Washington, Oct. 23-25. **Aug. 1** is deadline for submission of abstracts to Donald A. Chisholm, program chairman, 1968 International Electron Devices Meeting, Bell Telephone Laboratories, Murray Hill, N.J. 07974.

Northeast Electronics Research and Engineering Meeting (Nerem,) IEEE; Sheraton Boston Hotel and the War Memorial Auditorium, Boston, Nov. 6-8. **July 15** is deadline for submission of abstracts to E.G. Nielsen, applications chairman, IEEE Nerem-68, 31 Channing St., Newton, Mass. 02158.

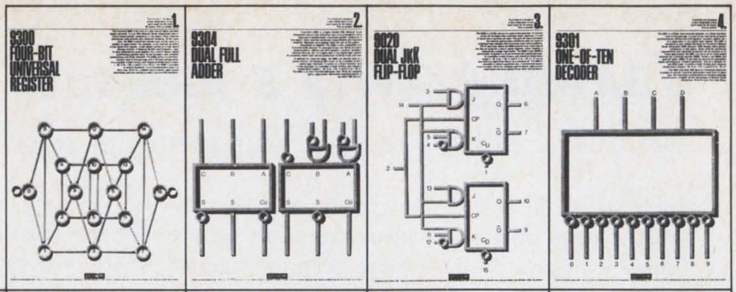
Vehicular Technology Group Conference, IEEE; San Francisco Hilton Hotel, San Francisco, Dec. 2-4. **July 1** is deadline for submission of abstracts and resumes to W.G. Chaney, Lenkurt Electric, 1105 County Rd., San Carlos, Calif. 94070.

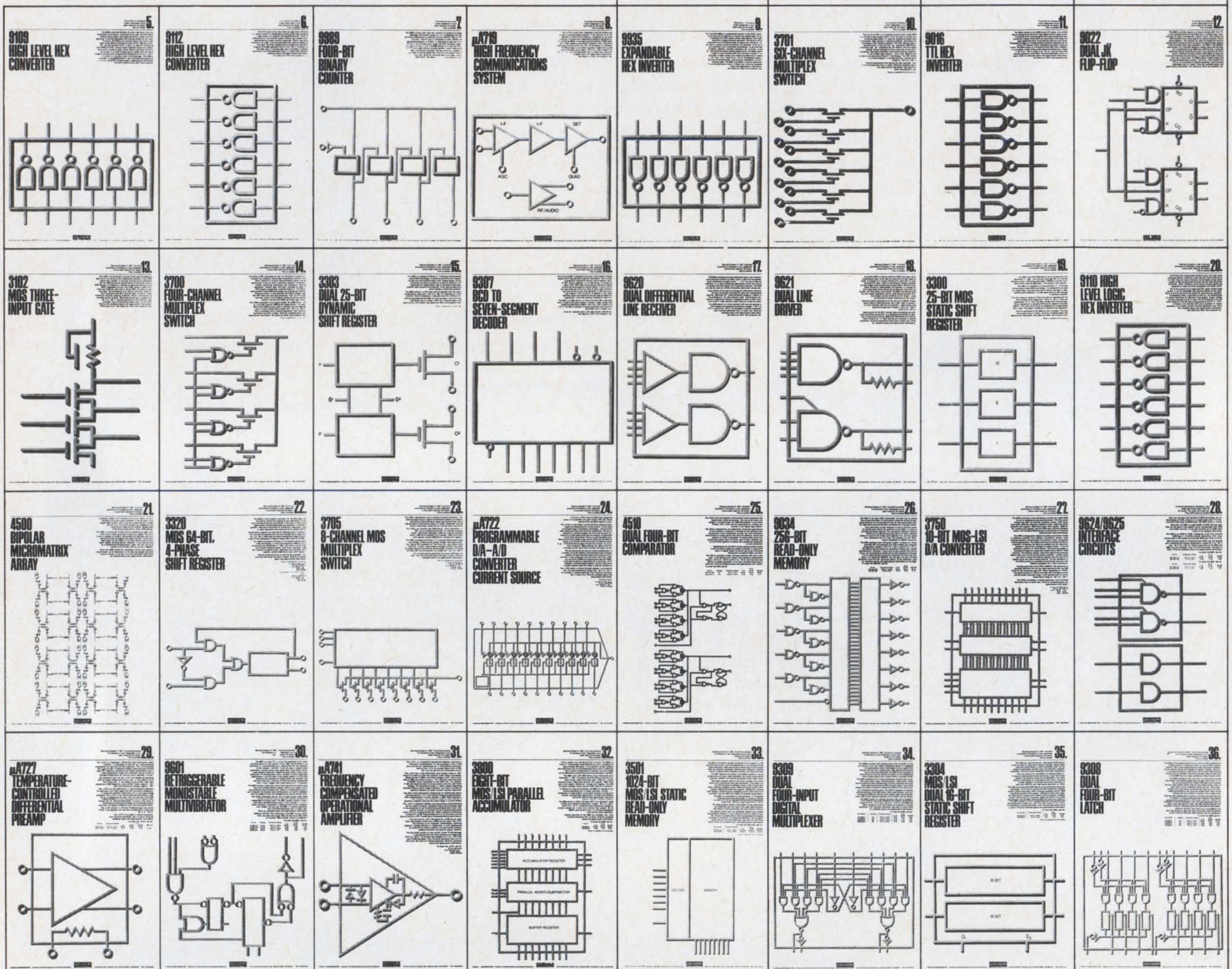
(Continued on p. 240)

Circle 17 on reader service card

Fairchild has introduced 36 new products in the last 36 weeks.

Our goal is fifty-two new integrated circuits in fifty-two weeks. To obtain the Reader Service Number for any product announcement ad, simply add 100 to the new product number. For example, New Product No. 3 is Reader Service No. 103.

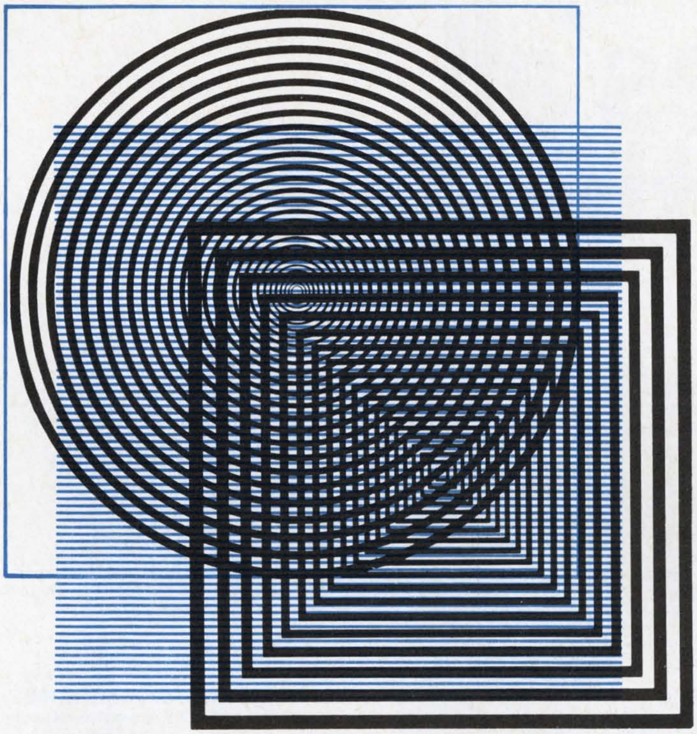




June 17, 1968	June 24, 1968	July 1, 1968	July 8, 1968	July 15, 1968	July 22, 1968	July 29, 1968	August 5, 1968
August 12, 1968	August 19, 1968	August 26, 1968	September 2, 1968	September 9, 1968	September 16, 1968	September 23, 1968	September 30, 1968

And greater strength.

Celanar is the strongest balanced biaxially oriented plastic film commercially available.



And insulation resistance.

An outstanding property of Celanar film is its high insulation resistance over a wide range of temperatures. Celanar has superior electrical properties, including excellent dielectric strength, dielectric constant and dissipation factor. Good reasons why Celanar is widely used as an insulating material in electrical insulation applications.

To bring you Celanar Film with a combination of properties unsurpassed for electrical uses.

Celanar polyester film offers a balance of electrical, mechanical, thermal and chemical properties that make it your best choice for applications from flexible circuits to wire-wrap. Want proof? Just mail the coupon.

Celanese Plastics Company
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Linden, N.J. 07036

Yes, I want all the facts about Celanar film for electrical applications. And send me a FREE set of gratings printed on Celanar. (Laying one on top of the other produces Moiré patterns that confound the eye.)

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Company__________

Address__________

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Which IC Test System does all these things?

DIAGNOSTIC COMPUTER PROGRAMS automatically check out system operation.

AUTOMATIC SELF-CHECKING assures accurate data transfer between operator, teletypewriter, computer and test instrument.

DATALOG A FORCING FUNCTION, such as the input threshold level of a flip-flop needed to produce a specified output.

VERY COMPLEX TEST SEQUENCES can be programmed, yet preparation of simple tests can be learned in two hours.

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COMPLETE FRONT PANEL DISPLAY at any desired step, simultaneously indicating all crosspoint connections, forced values, measured limits, binning decisions—everything about each test.

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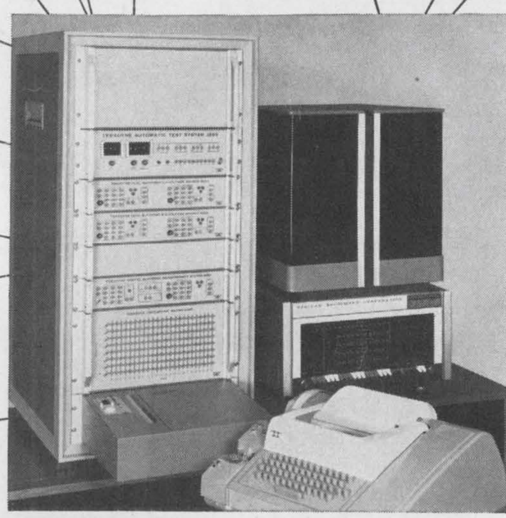


This one.

(complete for only $65,000)

This is our J259 computer-operated Automatic Circuit Test System. It includes a general-purpose digital computer, teletypewriter, test instrument (comprising modular elements: 24 x 8 crosspoint matrix, four voltage sources, measurement system, and test deck), complete software package, and courses in IC testing, system operation, and maintenance. TERADYNE, 183 Essex St., Boston, Mass. 02111 Phone (617) 426-6560.

TERADYNE

Editorial comment

Pinning the blame

Faultfinding in complex electronics equipment has become so difficult that one major systems contract offers a bonus of $19,000 for each fault that can be isolated to a single discrete part. And that's a bargain, whether the fault is in military equipment, where more than money is at stake, or in multimillion-dollar computer systems.

In military aircraft, for example, the ideal in-flight test would detect and isolate a fault and the avionics system would automatically switch the equipment to another mode of operation.

Fault detection has other important uses: it can qualify a part or system on a go/no-go basis, it can simplify maintenance procedures and minimize downtime, and it can aid in failure analysis.

In an LSI logic circuit comprising several hundred elements, the array must be tested as a functional whole. Individual elements are inaccessible to probing and there are a limited number of external pins. Since such arrays will probably have limited use, just a few of each type will be produced. The turnaround time to design and fabricate them must be kept to a minimum. The dilemma is to get rapid automatic testing of an array with the cost for the development of a test program kept low enough to make sense. The solution lies in an inexpensive computerized test program that tells designers their arrays are good—or if they are bad, why.

The development of faultfinding programs is still expensive and time consuming because of the failure to seek similarities in testing a wide range of electronics from LSI arrays to large systems. Were that done, some general-purpose computer programs or, at least, standard subroutines for fault diagnosis might be developed.

NASA is making a start in this direction at its Electronics Research Center with a study of the benefits that could accrue from NASA-wide standardization of computerized test systems for discrete components and integrated circuits. The center believes it's possible to standardize test hardware, yet keep it flexible. Furthermore, it hopes to demonstrate that test procedures can be standardized for rapid comparison of test data and that standardized software (programs for testing) is feasible.

If the NASA study proves that test hardware and software can be standardized on a component level, there's hope for standardization at a higher level.

A 'testy' attitude

Slowing the pace of developments in automating failure detection is a psychological factor—designers think of testing as the poor cousin of circuit design. They believe that designing circuits is "creative," and that designing ways to test them is neither challenging nor interesting.

The attitude stems partially from simpler times when testing was an unpleasant necessity and usually meant fixing something that probably shouldn't have gone wrong in the first place. Maintenance and repair, understandably, have never had glamorous connotations.

As a result, circuits and systems are still being designed with little concern for the way they will be tested, and with almost complete indifference to automatic self-test. The designer's attitude is reinforced by the high cost of test programs; a good one can cost as much to design as the system itself.

The designer who fails to recognize the changing scene is going to be hopelessly outdistanced. Moreover, he's ignoring one of the most exciting and challenging areas of his technology. Not only is the military aware of the need for automatic fault detection and correction but the services are beginning to write the requirements into systems specifications. The concept of integrated logistics support championed by the Defense Department includes testing.

Until now, the universities have assumed pretty much a hands-off attitude to systems testing. But that is changing, too. Bell Laboratories, for example, is supporting testing studies at Lehigh University. More should be done at the undergraduate level, where the payoff could be greatest.

Circuit designers who have been through the experience of designing a fault-detection program gain respect for the skills required. Circuits can be designed through a number of simplifying assumptions, but there's no short cut to detecting a circuit's faults, no matter how well or badly it is designed. In the end, the best way to design for fault detection is to do it along with the original system design.

Avalanche Oscillators and Diodes

One step conversion from d.c.-to-microwave. Diodes, now, as well as oscillators. Microwave Associates, who first made avalanche oscillators commercially available, now offers avalanche diodes as well — with more power than ever before.

Applications include parametric amplifier pumps, local and self-test oscillators, and transponder sources. Write or call.

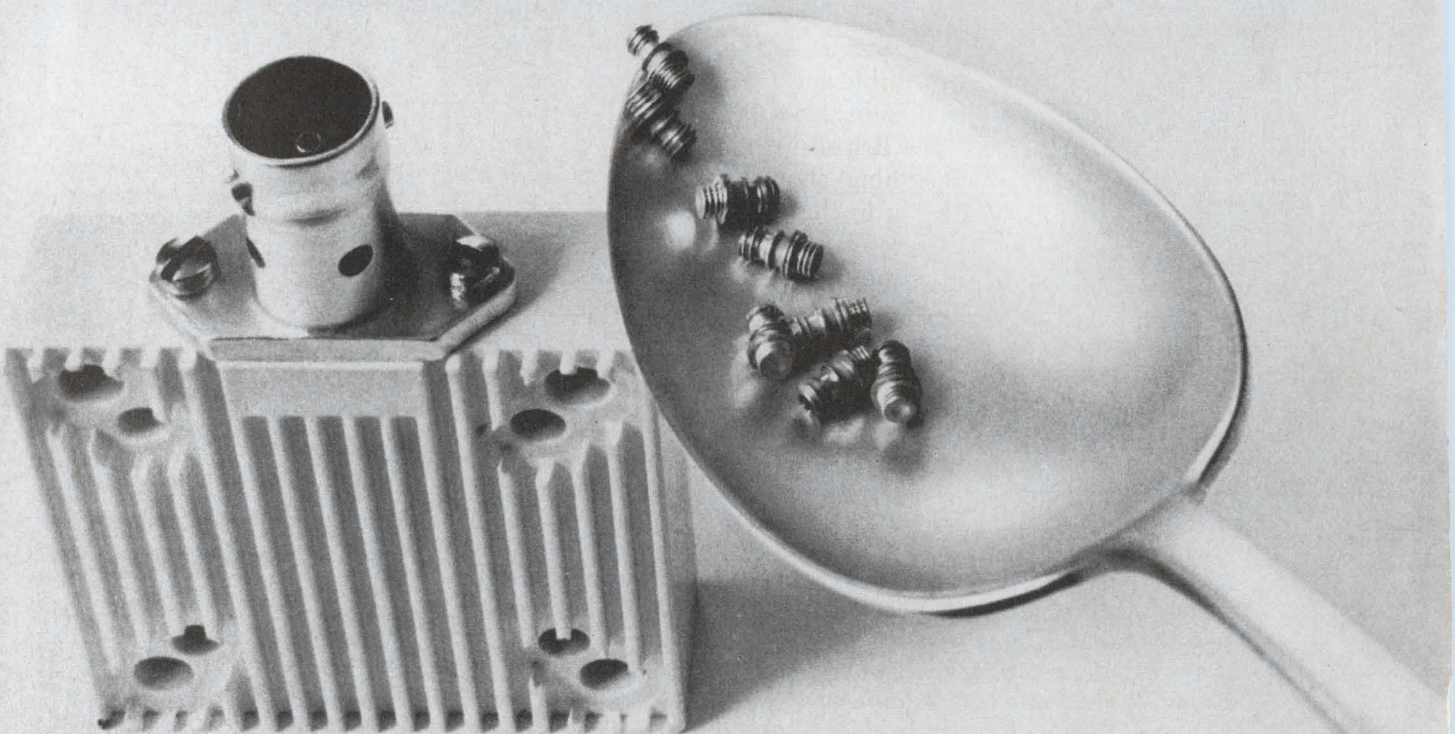
Avalanche Oscillator Diodes

Model Number	Frequency GHz	Single Freq. Min CW Output Power at 25°C mW
MA-4980	8.2 - 12.4	10
MA-4986	8.2 - 12.4	50
MA-4987	8.2 - 12.4	100
MA-4988	12.4 - 18.0	10
MA-4989	12.4 - 18.0	50
MA-4992	18.0 - 26.0	10

Avalanche Oscillators

Model Number	Frequency GHz	Single Freq. Min CW Output Power at 25°C mW	Typical d.c. Cur. mA	Typical Freq. Temp. Coef. KHz/°C
MA-8001-FC	9.0 - 12.4	100	50	−200
MA-8000-FC	9.0 - 12.4	10	30	−200

Instant Microwave...



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Electronics Newsletter

June 10, 1968

Autonetics is ready to try MOS LSI in operational gear

A general-purpose computer made up of metal oxide semiconductor large-scale integrated arrays is a high-priority goal at a good many companies. But North American Rockwell's Autonetics division, which feels it's at least a year ahead of everyone else in the development of complex MOS arrays, **is about to propose operational hardware incorporating a general-purpose computer designed almost entirely with MOS LSI for a classified Government application.**

Autonetics' confidence is such that the firm sees no need in this case for a demonstration model—usually the first step in introducing new technology. It has the MOS LSI building blocks and will suit them to the specifications worked out with system designers.

Autonetics engineers don't see as many potential applications for the MOS approach as for the faster bipolar LSI, but they are working to build more speed into their MOS design.

Field is narrowed for SST multiplexer

Boeing is reportedly negotiating with North American Rockwell's Autonetics division and United Aircraft's Hamilton Standard division for six-month study contracts **to develop breadboards for the supersonic transport's 2,400-channel multiplexing system.** Garrett and General Electric were also competing for the awards [Electronics, May 13, p. 25], but are now apparently out of the running.

Autonetics and Hamilton Standard won't confirm that they have won the studies, nor will they discuss details of their proposals. But a multiplexing system Autonetics has been demonstrating since the IEEE Aerospace Electronics Conference last month provides some clues to the company's SST system. **The basic building block in the Autonetics demonstration system is the Mod 2 pulse-code-modulated telemetry module** [See "Multiplexing the LSI way," p. 45].

Besides eliminating much of the weight of a hard-wire system—the joint British-French supersonic Concorde has about 150 miles of wiring weighing about 5,400 pounds—multiplexing is expected to be far less costly in the long run. The reason: **fault isolation down to the level of line-replaceable units will minimize maintenance costs over the system's lifetime.**

Meanwhile, the airbus competitors—Lockheed and McDonnell Douglas —are showing interest in the weight advantages of multiplexing for their planes' entertainment systems. Lockheed is now defining the L-1011 entertainment system and McDonnell Douglas is about ready to issue a request to industry containing performance specs for the DC-10 network.

Intelsat 4 gets nod at Vienna meeting

The unofficial word out of last month's meeting of Intelsat's interim committee in Vienna [Electronics, May 13, p. 59] is that the proposal for an Intelsat 3.5 satellite was effectively killed and that **delegates informally agreed to jump ahead with the larger-capacity Intelsat 4.** The next meeting of this panel of the International Telecommunications Satellite Consortium, in Washington next month, will vote on the Intelsat 4 satellite, and a formal go-ahead is expected. Comsat, as the consortium's manager, is now studying the proposals from Lockheed, Hughes, and TRW to build Intelsat 4, and will present its evaluation of the bids at the July meeting. **The contract winner will probably be chosen at that time, too.**

Electronics Newsletter

Panel will charge spectrum waste in communications

An influential technical panel will soon advise Federal communications authorities to ease up on notions of conserving the frequency spectrum **and to worry more about making fuller use of the available frequencies.**

The Joint Technical Advisory Committee (JTAC) will charge that much of the spectrum is being wasted by overzealous frequency conservationists **and will urge elimination of "block reservations."** JTAC is in the final stages of putting together a report that has been in the works for four years. The 1,200-page document was due in May, but editing and publishing problems have caused delays and the target date is now late July. The report is concerned mainly with the microwave bands, and only scant mention is made of the ticklish land mobile frequency-crowding problem.

The proposal is sure to bring howls from broadcasters and common carriers, which have large "blocks" of the spectrum tied up for anticipated needs.

The JTAC plan has a good chance of acceptance, however. The panel, headed by Richard P. Gifford, general manager of GE's communication products department, was organized by the EIA and the IEEE at the request of the Office of Telecommunications Management and the FCC.

The report will offer elaborate recommendations on setting up guidelines for new technical organizations to meet the frequency problems. **The panel would authorize the use of these bands by any user who would accept them with the understanding that he could be bumped off if a higher-priority user requested space on the band and none was available.**

Among these recommendations will be a **plea to increase Federal spending on research in this area to perhaps as much as $20 million annually** from the present $3 million to $4 million.

One Fairchild unit said to be under ax, but not Instruments

The recent exodus of top executives from Fairchild's Instrumentation division has stirred speculation that the firm may spin off the ailing unit. **But company insiders insist that though Fairchild is considering the sale of one of its weaker divisions, that division isn't Instrumentation.**

Other Fairchild units include Cable, Controls, Semiconductor, Graphic Equipment, Industrial Products, Space and Defense, World Magnetics, and Du Mont.

Joseph R. Spaziani, who replaced Victor H. Grinich as general manager of the Instrumentation division on June 1, points to the unit's ambitious plans as proof of its growing strength—both financial and technical. **"We'll introduce five small instruments in the next five months," he says, more products than the division's small-instrument group has unveiled in the past couple of years.** The new instruments—counters and low-cost digital voltmeters—reflect a trend that began last year toward products with more automatic controls and fewer knobs.

Merger may force FCC computer probe

The proposed merger of Western Union and the Computer Sciences Corp. will probably force the FCC to make a policy decision on common carriers' computer services. Some FCC officials say privately that **the commission will finally have to stop dragging its heels and decide whether a common carrier can offer computer services and whether computerized switching services are subject to rate regulations** [Electronics, Feb. 5, p. 60].

Component and Circuit Design IDEAS FROM SYLVANIA

IDEAS/*Color Picture Tubes*

The brightest shadow-mask picture tube...23% brighter than its nearest competitor.

Sylvania's revolutionary new rare-earth phosphor system—introduced this year—increases white-field brightness by 23% over the next brightest shadow-mask color-TV picture tube on the market.

Brighter color-TV picture tubes have become a tradition with Sylvania.

Back in 1964, we pioneered the development of the rare-earth europium phosphor screen to provide brighter, more vivid reds . . . reds that do not shift to orange. This permitted "unleashing" blues and greens which had previously been suppressed to maintain proper balance with the weaker sulfide red. The europium system at that time increased white brightness by 43% and made it possible for the first time to view color television in a lighted room.

Now in 1968, we've developed a still brighter phosphor system and coupled it with our patented dusting process for screen application, a temperature-compensated shadow mask to assure constant color purity, even at the outer edges of the screen, and an all-new electron gun mount to maximize picture resolution.

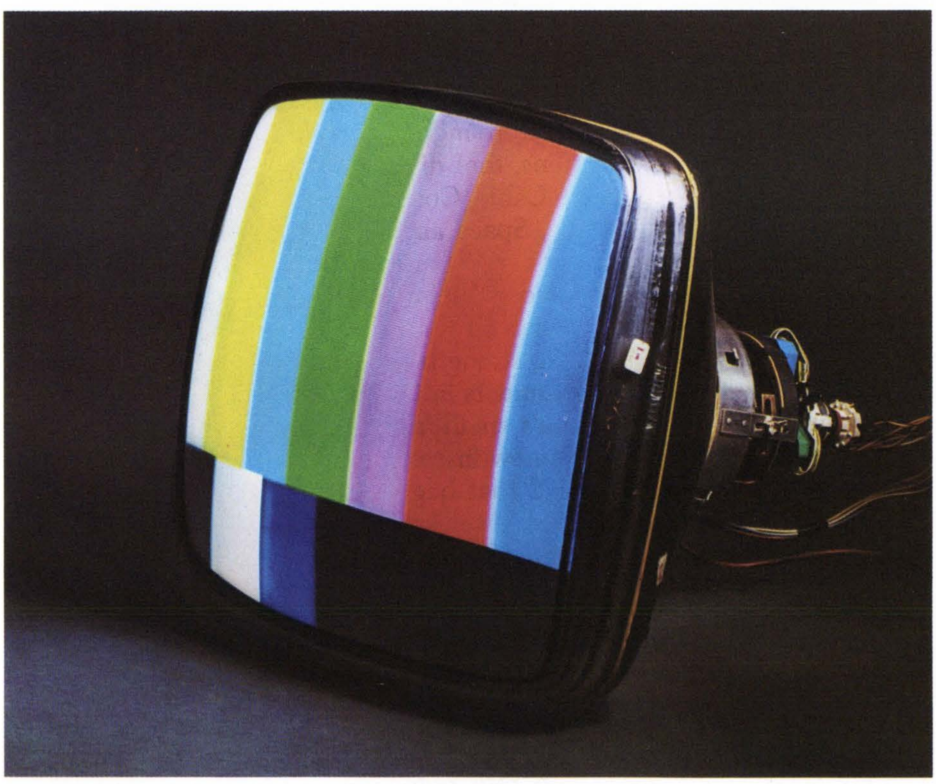
To achieve brighter reds, we used a specially developed and improved europium-activated yttrium-vanadate phosphor treated with selected activators. This permitted use of a brighter blue from a greatly improved phosphor, and a brighter green which was achieved by altering the chemical composition of the phosphor and changing phosphor particle size and distribution on the screen surface.

The result of all these developments: not only the world's brightest shadow-mask color TV picture, but also sharper, clearer and more-lifelike colors.

The patented Sylvania dusting process

Some time ago, Sylvania developed and patented a process for applying color-dot phosphors to the picture tube screen. The dusting process has several inherent benefits over the widely used slurry method, including an inherent brightness advantage.

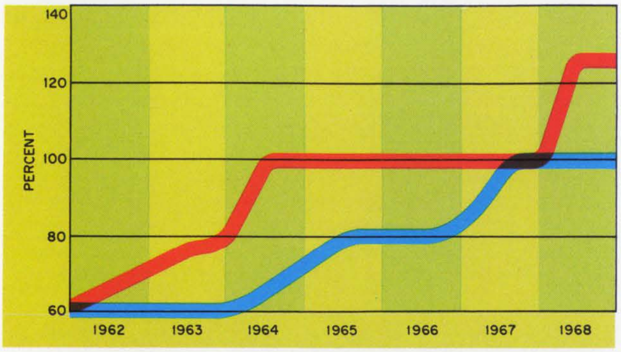
In slurry deposition used by most other manufacturers, phosphors are premixed with a photolithographic emulsion; the mixture is then poured into the glass panel and rotated to provide a dispersion. *Continued on next page*



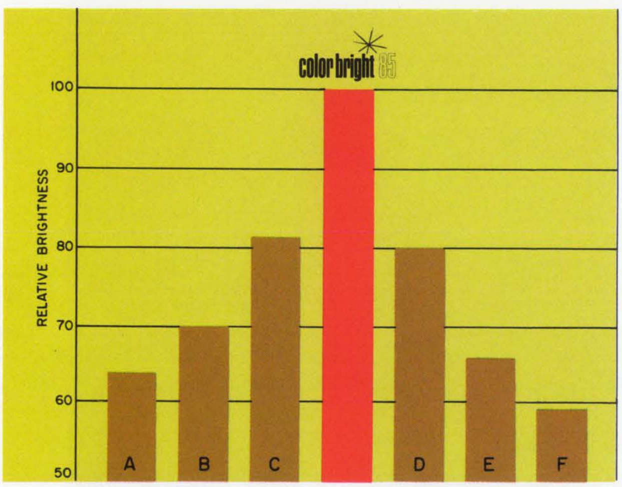
Unretouched photograph of color-bar pattern on *new* Sylvania *color bright 85®* picture tube. White-field brightness on our new tube is 23% greater than it is on the second best.

This issue in capsule

continued



We've usually been ahead, and never been behind, in color-TV picture tube brightness. Chart shows comparative white brightness levels, Sylvania *color bright 85* (red) vs major competitor (blue). Each time they've caught up with us, we've jumped ahead. Figures are based on footlambert brightness comparisons over the years.



Relative brightness comparison between new 1968 *color bright 85** and other manufacturers. Our new tube is:

23% brighter than C	51% brighter than E
25% brighter than D	54% brighter than A
44% brighter than B	69% brighter than F

*Based on average footlambert white brightness readings of competitors' color picture tubes sampled throughout 1967. Readings calculated on 25" OEM tubes—9300°K & 27MPCD—70% transmission panel —no cover glass, 800 ma beam current at 25 kV.

In the Sylvania dusting process, on the other hand, the photolithographic material is applied to the glass faceplate. Then, while it's still wet, dry phosphor powders from an air-dispersed cloud settle on the photolithographic material. The phosphor mixture does not have to be spread by physical means to attain a dispersion.

Inherent advantages of dusting

Phosphor particle deposition by dusting permits use of larger particles which produce dots of intrinsically high brightness. (The slurry method requires use of small particles to assure proper flow characteristics.) Dusting also assures more uniform registry and deposition of color phosphor dots over the screen face and eliminates the spoking effect caused by panel rotation during slurry deposition. Dusting also minimizes the possibility of contaminants entering the phosphor system and helps prevent phosphor deterioration and crystal crackup due to milling action, such as may occur in the slurry deposition method.

CIRCLE NUMBER 300

New tricolor electron gun improves spot resolution and focus in color-TV.

Our new 3-beam electron gun for color picture tubes reduces color spot size by 10 to 20% to improve focus.

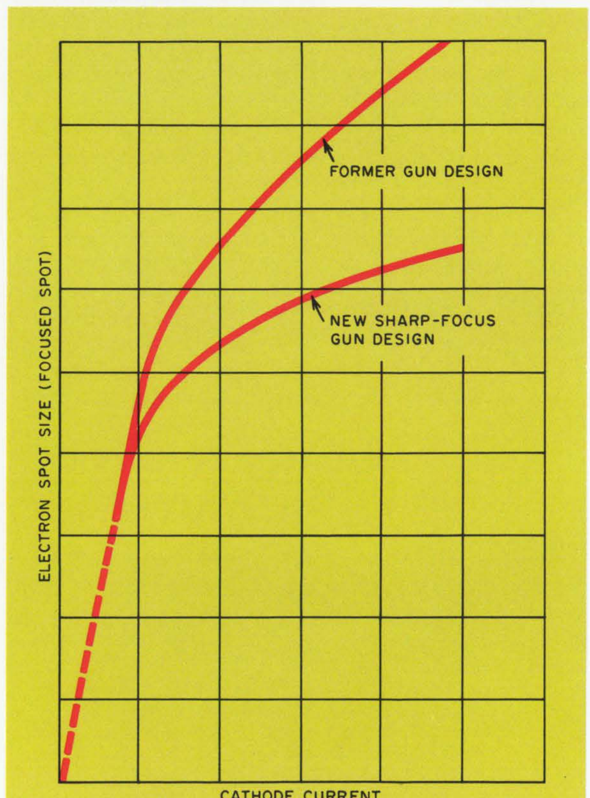
In order to improve the focus characteristics and spot quality of our high-focus 90° color picture tube electron gun mount, we changed the design of the focusing lenses. Tests showed that our new gun provides two definite advantages:

(1) Spot size is 10-20% smaller in currents above 300 μA, improving spot blooming at high brightness levels.

(2) Resolution is affected less by the purity and convergence magnets because the new gun has a sharper, smaller spot. When excessive magnetic strength is applied, a dim haze develops around the spot, rather than distinct bright "tails" growing outward from the spot. The end result is reduction of color "fringing" in the picture.

All Sylvania 90-degree color picture tubes are now being shipped with our new electron gun.

CIRCLE NUMBER 301



Spot size vs cathode current, new Sylvania electron-gun mount vs previous mount. Tests have shown that spot diameter of new gun is 10-20% smaller at currents above 300 μa . . . a very definite advantage in spot blooming at high brightness in a color scene.

Four or more colors on a CRT...from one electron gun and no shadow mask.

How many colors can you get on the face of a CRT with one electron gun and no shadow mask? Right now, Sylvania can give you four or more: any 2-color combination of red, green, blue or white.

What's the advantage of a 1-gun multicolor CRT with no shadow mask?

For one thing, the "no-shadow-mask" means that the multicolor picture has almost the brightness, purity and resolution of monochrome. The "one-gun" means your deflection circuitry is almost as simple.

Today Sylvania alone can give you a CRT display of 4 or more colors from 1 gun and no shadow mask: greater brightness and resolution, simpler back-up circuitry than a standard polychrome tube.

And on it you can display any type of information you wish: waveform, alphanumeric or pictorial . . . at the same time.

We do it by depositing phosphors of two different colors, dielectrically separated, on the CRT faceplate. (You may order almost any 2-color combination of red, green, blue or white, as you wish.) Low voltage actuates one phosphor, high voltage both phosphors. Midrange voltages mix the basic phosphor light outputs to produce colors somewhere in between. Rapid switching from one voltage to another makes all available colors appear on the screen visually simultaneously.

In the photo below we use red and green phosphor layers. Red is activated by the low (6 kV) electron-beam voltage; green and red activated by the high (12 kV). Since the green overrides the red, the resultant color is predominantly green.

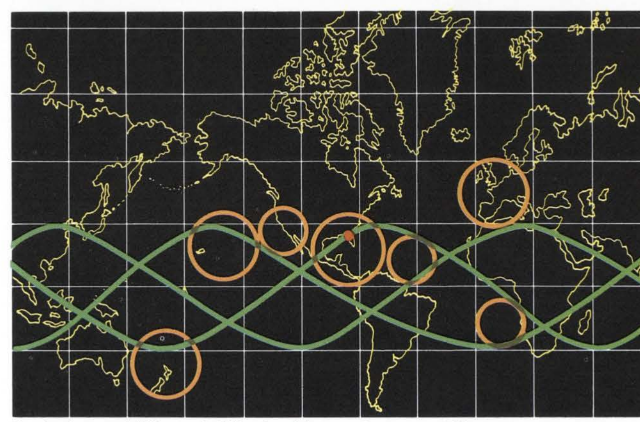
But intermediate voltages produce red-green mixtures. For example, 10 kV produces a basic green with a small red admixture . . . yellow; 8 kV produces a basic red with a small green admixture . . . orange. To produce other colors, the tube can be made with any basic 2-color phosphor combination: red-white, blue-white, red-green, red-blue, green-white, etc.

With a red-white phosphor combination, a standard B&W TV picture could be displayed—but with an "override" of red alphanumeric emergency information at the bottom.

Sylvania 19" SC-4852 displays alphanumerics in 4 colors simultaneously.

21" SC-4876 and 5" SC-4689 are typical of the range of multicolor tube types that can be made. Each is capable of displaying alphanumeric or analog information in 4 or more colors simultaneously, using a single gun.

Type No.	Screen Size	Shape	Focus Method	Deflection Method
SC-4689	5"	Round	Electro-static	Electro-static
SC-4827	10"	Round	Electro-magnetic	Electro-magnetic
SC-4852	19"	Round	Electro-static	Electro-magnetic
SC-4876	21"	Rectangular	Electro-static	Electro-magnetic



Typical capability: satellite tracking pattern on 21" screen. Coastline in yellow, orbital paths in green, tracking stations in orange, moving satellite position in red.

In air-traffic control displays, our multicolor CRTs could be used to provide quick and positive information of different altitudes, positions or stacked aircraft problems. Different colors could be used to indicate various runways, holding patterns or air traffic lanes.

In computer displays, color can be used to indicate newly changed, added, deleted or other particularly significant data.

In stock quotation displays, green could be used to indicate a stock sharply up; yellow a stock slightly up; orange a stock slightly down; and red a stock sharply down.

In electronic test equipment, different input waveforms could be displayed in different colors—all with full brightness and resolution.

In fact, just think of any information-display application where a multicolor display could facilitate comprehension. Our new 1-gun multicolor CRTs can help you.

CIRCLE NUMBER 302

Industry's broadest beamlead Schottky diode line.

In microwave integrated circuits, Sylvania's Schottky beamlead diodes give you many new and more reliable solutions to circuit design problems . . . at a price competitive with discrete components.

Now, with our newly expanded line of low frequency (UHF to L-band) and high frequency (up to X-band) Schottky diodes, Sylvania can help you solve microwave integrated circuit problems . . . with new solutions not available before.

In a line that already includes twenty devices, we can satisfy your requirements for broad frequency coverage with a variety of circuit configurations, a choice of packages and on many different substrates.

Let's take the latter two points, for instance. Our Schottky diodes are so packaged that they are readily adaptable to stripline circuits, microstrip, chip and wire . . . or for insertion in printed circuit boards. Substrate materials can be alumina, sapphire, fiberglass epoxy or other standard materials.

The D5800 series includes diodes in three forms: unmounted chips, chips that are mounted on fiberglass and chips on ceramic substrates. Fiberglass substrates are also available mounted and sealed in a TO-5 package. The unique and versatile packaging concepts make for easy insertion in stripline, microstrip, and hybrid circuits as well as in modular units using printed circuit boards. Pairs and quads are also available in the low-silhouette TO-5 package. Sylvania beamlead pairs designed as 500 MHz mixers exhibited a conversion loss of less than 6 dB.

Sylvania's D5800 series of Schottky barrier beamlead diodes can be used as mixers, detectors, modulators, low-power limiters and high-speed switches at frequencies from 1 MHz to L-band. The device is available in 15 different configurations.

Sylvania's S through X-band beamlead diodes, the D5830 series, are supplied in chip form or are mounted on alumina substrates. The device's small junctions help them to operate at these higher frequencies. For example, overall noise figures of less than 8 dB are attainable in a balanced X-band mixer fabricated on an alumina substrate.

The D5830 series is also quite versatile and can be used in such applications as mixers, detectors, modulators, low-power limiters and high-speed switches at frequencies from 2 to 12.4 GHz.

In matched pairs design flexibility is retained by having both diodes mounted separately on a common substrate. The ring configuration is especially useful as a modulator or upconverter at these higher microwave frequencies. (Both of these configurations are shown in the D5830 chart.)

Custom types available

In addition to the types in the D5800 and D5830 series, Sylvania can design and supply other custom configurations to suit your specific needs.

Another important advantage in considering beamlead Schottky barrier diodes is inherent small size . . . even smaller than conventional Schottky package sizes, making possible even more compact circuit design.

And there are two ways of considering their cost economy factors:

Price: In low volume, the beamlead Schottkys cost approximately the same as standard Schottky types. But in high volume...because of batch processing economies . . . Sylvania can pass the production savings along to you.

Handling cost: Your costs for handling and assembly are reduced when using beamlead Schottky duals and quads. The ease and simplicity of mounting means that these arrays lend themselves readily to automated and mass production processes.

While it is not possible to characterize all these Schottky devices for rf parameters at this particular time, dc characteristics can be specified that will assure you excellent operation at microwave frequencies. As for the pair and quad arrays shown in the tables, we assure close matching from unit to unit by specifying a ΔV_F at 2 mA forward current.

What is "Beamlead"?

In case you're not familiar with these devices, a beamlead diode consists of an active junction formed on a suitable substrate (silicon in the D5800 and D5830 series, shown in the tables) with metallic beam leads. The leads are grown from the junction and extend beyond the edge of the substrate. They are precisely located with respect to one another.

This process of lead attachment eliminates the problems and deficiencies normally found in devices where leads are bonded to the chip junction on an individual basis. Total height of the chip is approximately 1.5 mils. Beamlead connections to both the base and the junction are on the same side of the chip, facilitating mounting procedures.

Important to remember in using beamlead Schottky chips is the fact that, because they are extremely small, they are somewhat difficult to handle and mount unless suitable facilities are provided. Bonding to the metallized land areas of either fiberglass or alumina substrates is best accomplished with a form of thermal compression bonding. It is only necessary to apply a thin coating of epoxy over the bonded unit to assure stable operation under conditions of severe environment.

The reason Sylvania supplies beamlead devices as singles, pairs, and quads on a fiberglass substrate is to facilitate their use in stripline systems. This same wafer can also be mounted on a TO-5 header for applications using printed circuit boards.

The alumina substrate was chosen to fit in with microcircuit design techniques. A thin coating of epoxy is used for protection of the junction. This coating is kept extremely thin to allow the wafer to be inverted and bonded directly on the microstrip. This keeps circuit mismatch to a minimum by reducing lead lengths.

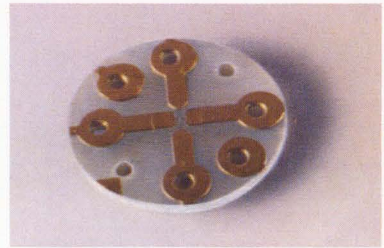
The TO-5 package was selected because, as an industry standard, it is adaptable to automatic insertion in printed boards. Sylvania makes it available in either 4- or 6-lead configurations. This hermetically sealed version is ideally suited to military equipments having high acceleration rates or high shock requirements.

The use of these devices is not limited to rf applications. They are finding increasing use in digital circuits as high speed switches and as nanosecond sampling devices for test equipment.

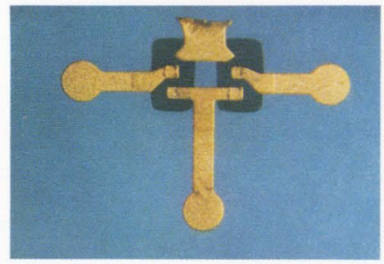
CIRCLE NUMBER 303

Up to X-Band

	CHIP	ALUMINA CERAMIC 100 MIL DIA	SCHEMATIC
SINGLE	D5830	D5836	
PAIRS	D5831	D5837	
QUADS		D5838	RING



Included in L-band beamlead packages, dual Schottky diodes on fiberglass substrate (above) and matched pair (below).



Electrical Characteristics (Typical):

Breakdown Voltage @ 10 mA	V_B 4 volts min
Forward Voltage Drop @ I_F 2.0 mA	V_F 0.55 volts max
Total Capacitance @ 0 bias	C_{TO} 0.6 pF max
Dissipation at 25°C	75 mW
Allowable Junction Temperature (max)	150°C
Series Resistance	15 ohms max

Matching Specifications:

Pairs $\Delta V_F = 15$ mV max @ $I_F = 2$mA
Quads (all four diodes matched to within these limits)
$\Delta V_F = 20$ mV max @ $I_F = 2$ mA

Suggested Mounting Methods:

1. Unmounted chips—Thermal compression bonding—Welding
2. Ceramic wafers, Fiberglass wafers } —Welding—Thermal Bonding—Soldering

L-Band devices

	CHIP	FIBERGLASS 250 MIL DIA	ALUMINA CERAMIC 100 MIL DIA	TO 5 HEADER	SCHEMATIC
SINGLE	D5800	D5802	D5810		
PAIRS	D5801	D5803	D5811	D5814	
QUADS		D5804	D5812	D5815	RING
		D5805	D5813	D5816	BRIDGE

Electrical Characteristics (Typical):

Breakdown Voltage @ 10 μA	V_B 4 volts min
Forward Voltage @ $\pm I_F = 2.0$ mA	V_F 0.5 volts max
Total Capacitance @ 0 bias	C_{TO} 1.0 pF max
Dissipation at 25°C	100 mW
Allowable Junction Temperature (max)	150°C
Series Resistance	10 ohms max

Matching Specifications:

Pairs
$\Delta V_F = 15$ mV max @ $I_F = 2$ mA
Quads (all four diodes matched to within these limits)
$\Delta V_F = 20$ mV max @ $I_F = 2$ mA

Suggested Mounting Methods:

1. Unmounted chips—Thermal compression bonding—Welding
2. Ceramic wafers, Fiberglass wafers } —Welding—Thermal Bonding—Soldering

Etched leads: a new idea for connecting high-resolution EL bar graphs.

Chemically etched connector leads provide a new, convenient way to connect high-resolution EL bar graph panels to translator-drivers, particularly on printed circuit boards.

Now Sylvania has a *new idea* for connecting EL bar graph panels.

We take a single connector strip and chemically etch it to provide extremely precise control of individual lead dimension and lead spacing. This type of connector is ideally suited for mounting an EL readout panel directly onto a printed circuit board by soldered connections.

We offer it as an alternative to the pin-type plug-in mounting configuration featured on our current EL bar graph panels.

Why EL?

After years of research and development on information display systems, we feel that EL panels—from the point of view of design, operational and human engineering considerations—are among the most useful, functional and efficient readout devices available.

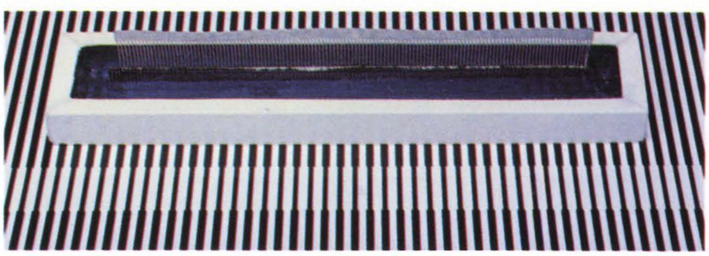
When required, they can display information faster than the human eye can respond; yet they can retain it for as long as necessary. They are highly immune to catastrophic failure. They have an extremely wide viewing angle—almost 180°—and with none of the "bloodshot-eye" look characteristic of multi-plane incandescent and gas-glow tubes. You don't have to look through nonilluminated characters to see the one that's lit.

EL panels readily display any type of information desired: letters, numbers, pictorial or analog data, quantitative comparisons—and can be designed to your specific requirements. Their soft blue-green light is very easy on the eyes and, on special order, can be adjusted to suit ambient light conditions. Spectral emission approximates that of the human eye to permit prolonged viewing without fatigue.

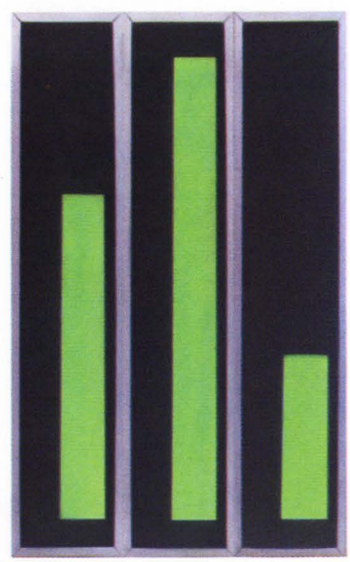
And now—with our new hermetically sealed all-glass panels—you can specify your own brightness levels up to 50 fL at 250 v, 400 Hz . . . or 25 fL at 115 v, 400 Hz. Contrast may be increased by changing the transmission characteristics of the glass faceplate. A panel with an intrinsic brightness level of 50 fL would still provide a useful light output of 30 fL with 60% transmission glass for higher contrast, and about 15 fL with 30% transmission for extremely high contrast.

Sylvania applications engineers would like the opportunity to help you develop the necessary back-up circuitry and translator-driver systems to adapt EL readouts to your specific needs.

CIRCLE NUMBER 304

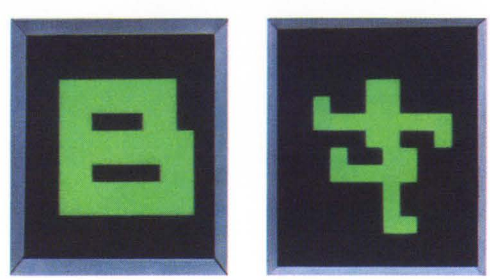


Chemical etching provides extremely precise control of lead width and inter-lead spacing. Alternate leads may be bent in opposite directions to facilitate soldered connections to a printed circuit module.



Three high-contrast bar graphs in our all-glass hermetically sealed construction. Bar graphs provide faster, more graphic evaluation of comparative data than metered displays. New chemically etched leads permit resolution up to 50 lines per inch.

Typical high-contrast digital display.



Typical random access panel. EL dots—up to 100 per square inch—may be illuminated in any combination to display virtually any type of information, digital or pictorial.

Improved color purity in TV picture tubes over full operating temperature range.

Temperature-compensated shadow mask maintains color purity and uniformity through complete cycle from "Off" to full operating temperature.

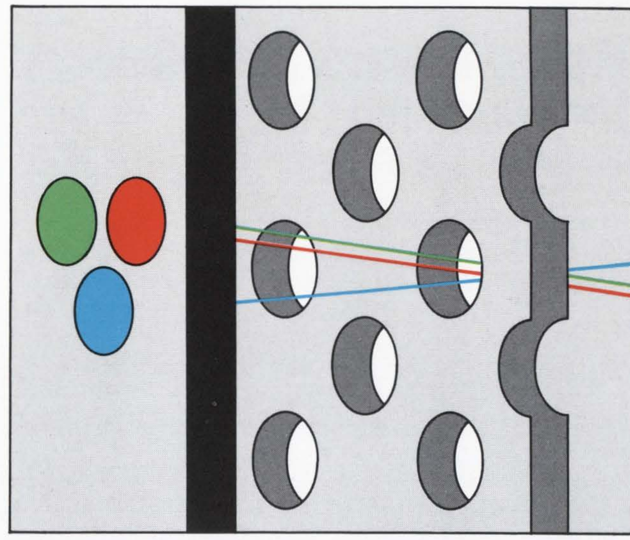
The effect of thermal expansion of the aperture mask in past color picture tubes has been such that the best tube setup is different after the tube has been run for a certain time than when it is first turned on. Thus it has been customary to set up receivers after running them for the period of time that is required to reach a typical operating temperature. While this assures color purity at standard operating temperatures, it occasionally results in blotches of improper color, particularly at the outer edges of the screen when the set is operated continuously over many hours.

This phenomenon occurs when some of the holes in the aperture mask fail to direct the electron beams precisely onto the screen phosphor dots because of lateral expansion of the mask.

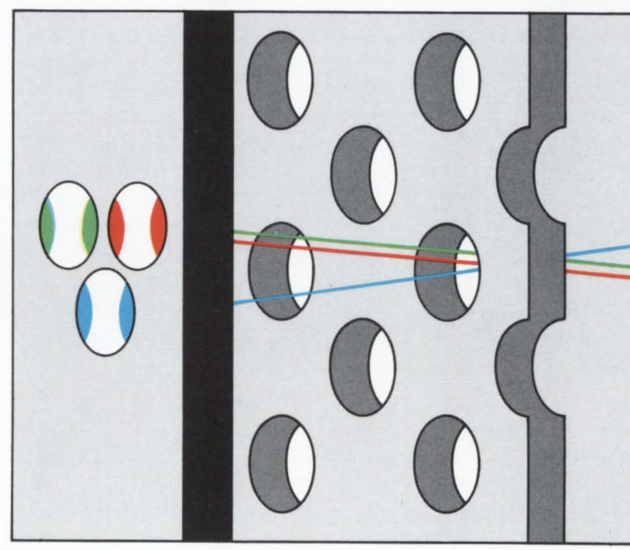
But if the aperture mask moves *toward the screen* as it expands outwardly, each hole travels essentially along the axis of its own electron path, and very little registration change occurs. Our temperature compensation system achieves this forward motion.

By utilizing a new Sylvania designed support system, the aperture mask is allowed to move toward the screen to compensate for any lateral movement in the mask caused by thermal expansion. The result is total beam-to-dot contact through each aperture mask hole and its respective dot triad. Constant color purity is assured over the full screen area at switch-on time and throughout the entire set operating period.

CIRCLE NUMBER 305



With Sylvania's temperature-compensated shadow mask, alignment between electrons and phosphor dots is maintained over the entire screen area for constant color purity. Poor color quality can result from thermal expansion of the mask (shown below).



Color TV: Out of the dark ages.

Remember the early 60's? The dark ages of color TV?

Then you'll also remember 1964 when the color TV scene changed. It was then that the rare earth europium phosphor system was applied to television screens. For the first time, bright rich reds became possible, and blues and greens were "unleashed" in a color television picture tube that was 43% brighter than any other tube on the market at the time.

And the company which first used the europium system was Sylvania.

Even before the rare earth screen, a new method called "dusting" was used for applying the phosphor dots to the color tube faceplate. Dusting was found to have an inherent brightness advantage over the still widely used slurry method. So dusting was patented.

Again, the company was Sylvania.

Other picture tube manufacturers soon caught on. Most started using rare earths within a short time, and a few even began experimenting with "dusting."

In fact, during 1967 two manufacturers caught up to us and began producing color picture tubes as bright as our *color bright 85*® tube.

But that was last year.

Today, several patents later, Sylvania has an all new *color bright 85* tube. It's by far the brightest shadow-mask tube available: 23% brighter than Number Two and a lot *more* than 23% brighter than the other brands.

In addition, our 1968 *color bright 85* has a Sylvania engineered temperature compensated shadow mask and a new electron gun for improved focus and spot resolution.

But there's more to a color set than a good picture tube, so we're backing up these advances with new designs in receiving tubes.

For example, our new 3CU3 posted filament high voltage rectifier provides less-than-a-second warm-up, eliminates shorts due to shock, vibration and high temperatures, and it's designed to last about three times longer than previous HVR's. Or take our new 6LR6 horizontal deflection amplifier tube: it provides an $\frac{I_b}{I_{c2}}$ ratio of 20 to 1, minimizes "snivets" by means of its variably spaced beam plate structure, and just about eliminates catastrophic shorts because of its internal cooling capability. Both of these tubes are designed for color sets of the future.

But why receiving tubes?

This year only about 1.5 per cent of color sets will be solid state, 20 per cent will be hybrid, and 78.5 per cent will be tubed. And the industry is looking forward to 6.3 million color set sales by the year's end.

Even by 1970 we predict that 30 per cent of color sets will still be completely tubed, with 58 per cent hybrid and 12 per cent completely solid state.

Both our 3CU3 and 6LR6 are designed for high voltage and high power sections of the color receiver—sections which are not apt to be converted to solid state in the near future.

As proud as we are of these contributions to the state of the art, we have no intention of coasting on our reputation.

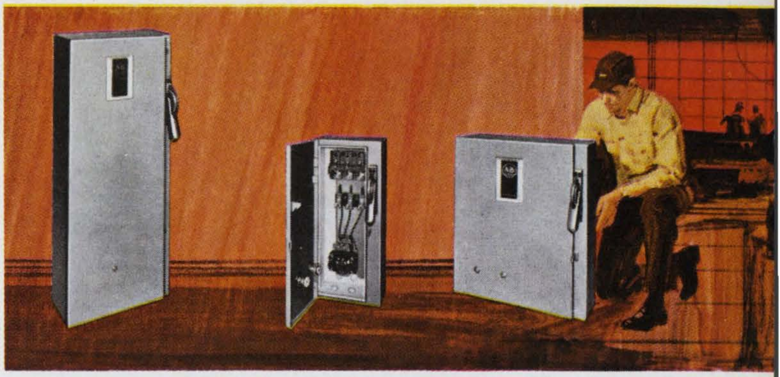
The next time you hear of a new idea in color TV components, chances are it will have come from Sylvania—the company that brought color TV out of the dark ages.

J. W. Ritter
Marketing Manager, O.E.M.

your local Allen-Bradley distributor has the components for this

AB Modular Control Center in stock– installation can start as soon as tomorrow!

Keep one or more of the A-B modular frames in your stockroom—and you can start the assembly of your control center immediately that its need is discovered. Don't wait weeks and months for a factory designed and built motor control center. It has virtually nothing of value to offer which is not represented by greater value in the A-B modular design—and the latter is vastly more flexible.



All modular mounting racks will accept A-B disconnect switch or circuit breaker combination starters—also in the reversing, and multi-speed construction. There are also various size enclosures equipped with universal mounting plates for mounting contactors, relays, timers, terminal blocks, etc.

Here's a radically new idea in motor control that greatly simplifies the installation of a multi-unit control center. It is now a job your electrical contractor—or your own plant's electrical department—can handle just as easily as a Harvard graduate.

The basic purpose of the new AB Modular Control Center idea was to save you lots of time and lots of money—providing all costs are taken into account that you have to reckon with when you buy a factory designed and factory assembled control center. For instance, how about the "rigger's" bill for getting the heavy and awkward assembled control center to that one particular place where it is to be installed.

The Allen-Bradley modular control can be located anywhere—in fact, it can be assembled in several sections—to fit any space that you have available—it can be *installed around corners!*

With each starter self-contained in its own enclosure, this is a safety feature not inherent in factory built control centers. In the event of a short circuit, the same would be confined to the one starter enclosure. In the factory built control center, such a short circuit would usually have "the run" of one entire section of the control center containing six to eight—or more starter units.

Modern as is this A-B control center concept, it is distinguished by the convenience in "laying out" and assembling even a very large job, and it has the important advantage that all components and starters are produced in the Allen-Bradley plant and tested under the usual Allen-Bradley "quality" specifications. You cannot buy anything but "A-B quality" from the appointed A-B quality distributor.

Your local Allen-Bradley appointed distributor will be pleased to demonstrate to you the easy assembly of an AB Modular Control Center. Please contact him today. Or write for Bulletin 797: Allen-Bradley Co., 110 West Greenfield Ave., Milwaukee, Wis. 53204. Export Office: 630 Third Ave., New York, N. Y., U.S.A. 10017.

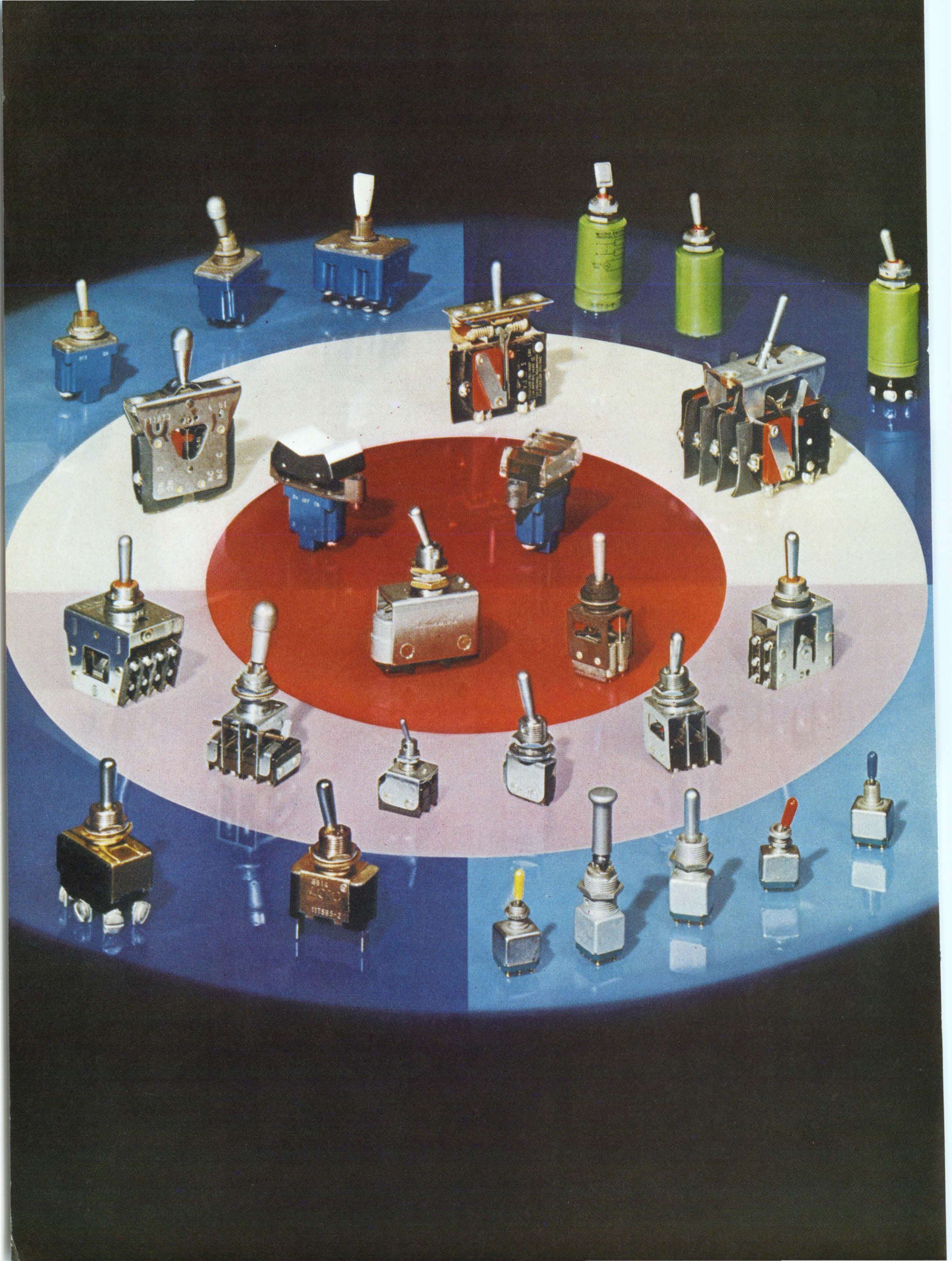
A-B QUALITY

ALLEN-BRADLEY

QUALITY MOTOR CONTROL

467M-1

Circle 35 on reader service card



Sure way to target in on all your toggle needs. Call MICRO SWITCH!

You'll score every time, no matter what combination of features you require. MICRO SWITCH offers the world's broadest line of toggle switches with an almost limitless selection of specifications. Such as size, circuitry, capacity and toggle action.

You can select special features, too, and get them right off the shelf. For example, environment-proof construction, magnetic hold-in, electric memory, and dry circuit capabilities.

Many in the MICRO SWITCH line are designed to meet military specifications. What's more, quality is assured by a program that is the model of the industry.

Maybe you can use some new design ideas—ways to simplify circuit design, combine functions in fewer controls, improve operator efficiency. The most extensive field engineering staff in the industry is available to offer you help and suggestions whenever you need them.

A sampling of our thousands of toggle switches are shown at left and described below. For more details, call a Branch Office or an Authorized Distributor (Yellow Pages, "Switches, Electric"). Or write for Catalogs 51 and 52.

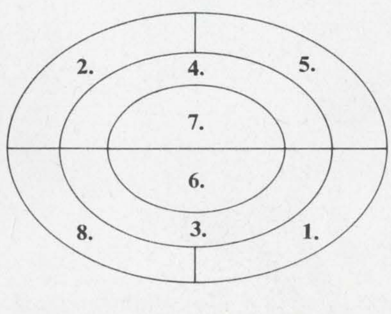
1. Miniature toggle switches, Type TW—Weight and space savers (extend only $\frac{5}{8}$" behind panel), yet they provide good operating feel and 35° toggle travel. Molded-in terminals. Lever seal and optional panel seal. Versatility, too: $\frac{1}{4}$ or $\frac{15}{32}$ inch bushings. 1 or 2 pole. Small, standard or large pull-to-unlock levers with 2 or 3 positions. Colored lever caps.

2. Environment-proof toggle switches, Type TL—Only switch of its kind which meets the complete environmental sealing requirements of MIL-S-3950. Case is of high impact, arc-resistant material. Rugged, molded-in, stepped terminals. 1, 2 or 4 pole. 2 or 3 position with momentary or maintained action, and special "on-on-on" circuitry. Standard or pull-to-unlock levers. 15 amps 115 vac, 20 amps 28 vdc.

3. Assemblies with subminiature basic switches, Type AT—Versatility is the keyword for these compact assemblies. Miniature, standard, or pull-to-unlock levers. Momentary or maintained contact action 2 or 3 position levers. $\frac{1}{4}$ or $\frac{1}{2}$ inch bushings. Up to a dozen or more precision snap-acting Type SM basic switches, each SPDT. Silver contacts for 5 amp. rating or gold contacts for low energy reliability. Solder post, or single or double turret terminals.

4. Assemblies with high-capacity basic switches, Type AT—Precision snap-acting Type V3 basic switches are UL and CSA listed for 15 amps and $\frac{1}{3}$ hp at 125-250 vac. Up to 10 individual SPDT switches can be ganged in one assembly. Rugged construction, positive 3-hole mounting. Two lever lengths. Convenient screw terminals.

5. Magnetically-held toggle switches, Type ET—Two or three position levers, magnetically maintained, manual or remote electrical release. Environment-proof construction. MIL-S-3950 (immersion-proof). MIL-S-5272 (explosion-proof). SPDT or DPDT. Turret, screw or leadwire terminals. Standard, flat tab, or pull-to-unlock levers.



6. Assemblies with hermetically sealed basic switches, Type AT—Maximum protection for switch contacts with hermetically sealed (MIL-S-8805, Class 5) subminiature or standard size precision basic switches. MIL-S-5272 (explosion-proof). MIL-S-6743 (corrosion-resistant). For temperature extremes from —300° to +500° F.

7. Rocker button toggle switches, Type TP—Pushbutton operation with toggle switch versatility. Translucent button for edge-lighting and engraved legends, or transparent button for removable legends. Above-panel or flush-panel mounting. Same circuitry and rating as Type TL.

8. Panel sealed toggle switches, Type TS—Rugged construction, vibration and shock resistant. Sealed lever, plus panel seal (MIL-S-3950B). 1 or 2 pole, 2 or 3 position. UL and CSA listing: 15 amp. 125-250 vac, $\frac{1}{2}$ hp 125 vac, 1 hp 250 vac. Solder, screw, or quick-connect terminals.

MICRO SWITCH

FREEPORT, ILLINOIS 61032

A DIVISION OF HONEYWELL

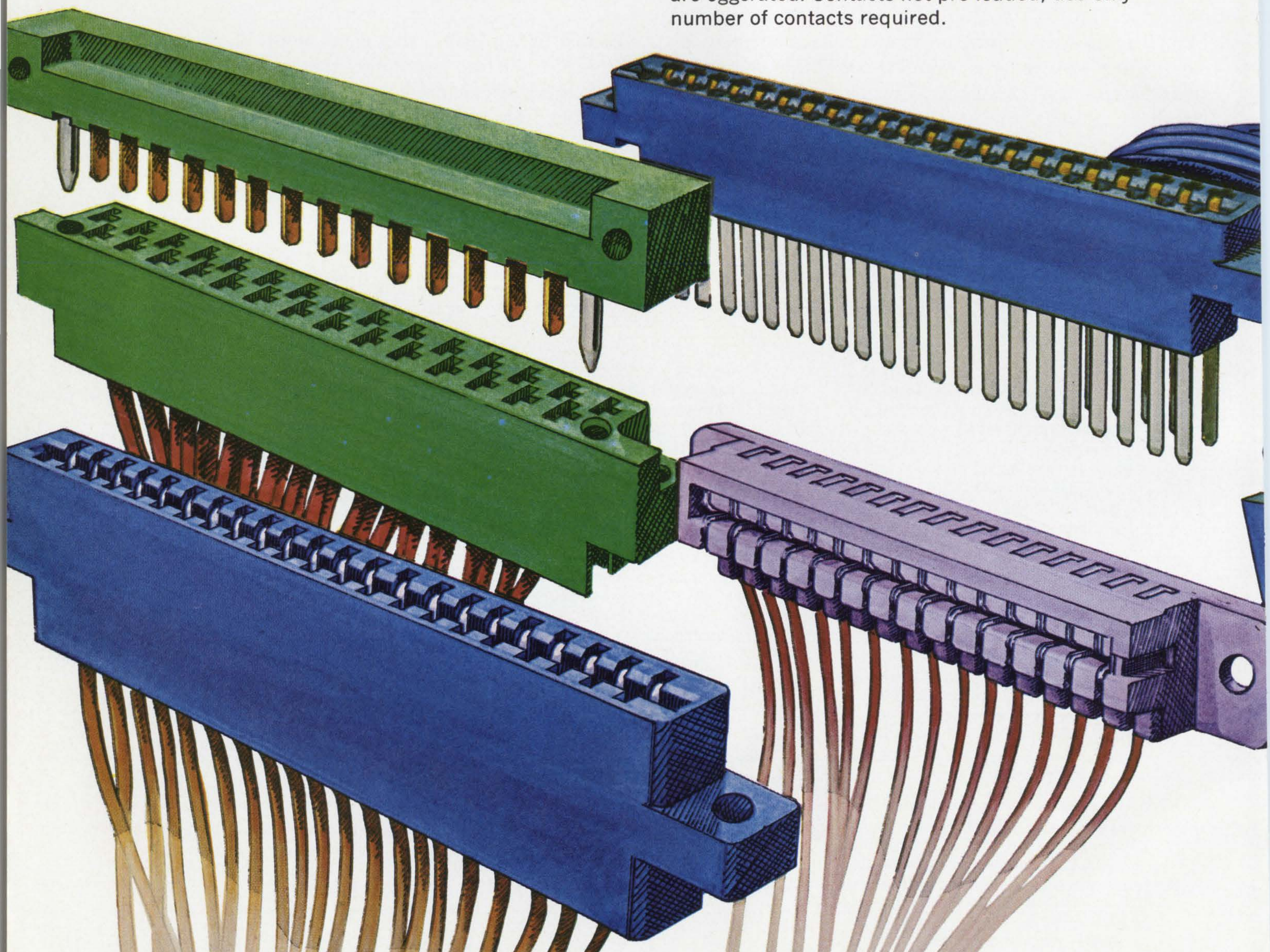
HONEYWELL INTERNATIONAL • Sales and service offices in all principal cities of the world. Manufacturing in United States, United Kingdom, Canada, Netherlands, Germany, France, Japan

Circle 37 on reader service card

Best connectors on

Blade-type connector. A rugged two-piece printed circuit connector that meets MIL-C-21097B. Tab housing of diallyl phthalate or phenolic is clinched and soldered to the daughter board. Receptacle contacts are crimp, snap-in type. Contact options include wrap posts or solder tabs.

Leaf-type connector. A one-piece connector for single or double-sided printed circuit boards. Snap-in leaf contacts lock in place on .156″ centers, maintain constant pressure on circuit paths. Contact tail end options include crimp-to-wire, wrap post or solder tab. Housings of diallyl phthalate or phenolic are eggcrated. Contacts not pre-loaded; use only number of contacts required.



Fork-contact connector. A one-piece polysulfone connector with eggcrated contact cavities: up to 33 positions. Capability for .100″ center spacing. Improved fork contact design with large curved contact surfaces for smooth insertion and excellent conductivity. Crimp, snap-in contacts.

Right-angle connector. Compact one-piece connector saves space in sub-assemblies on vending machines, appliances, etc. Right-angle board entry facilitates compact cabling. Housing may be keyed; slips on board edge. Recessed snap-in fork type contacts: available in 3 to 22 positions.

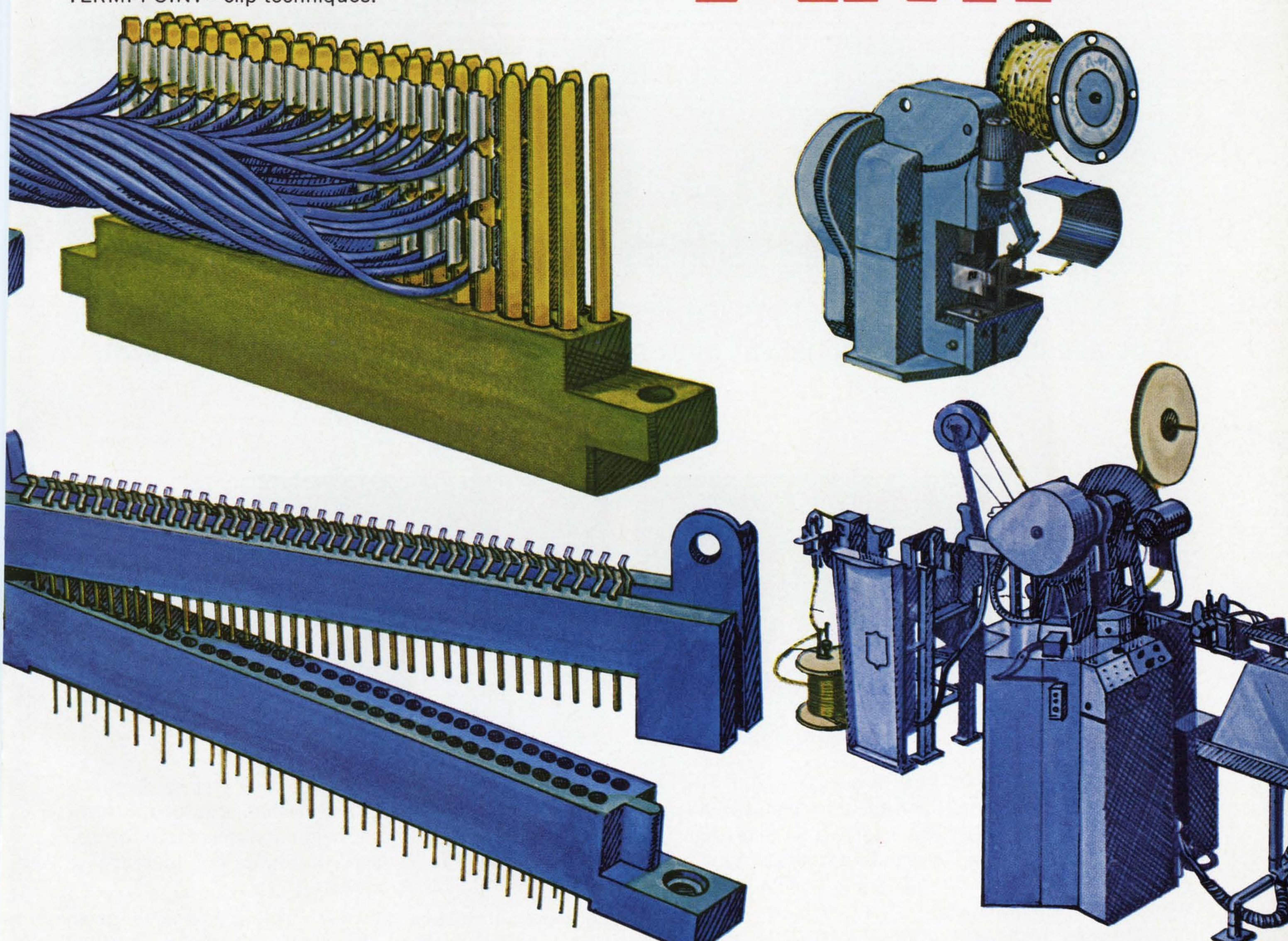
the printed circuit.

TERMI-TWIST★ Connector. This connector combines economy and reliability with highly efficient application tooling techniques. Closed entry diallyl phthalate or phenolic housings accept boards from .054″ to .071″ thick. Snap-in, bifurcated contacts adaptable for a wide variety of wire attachment methods. Can be used with solder, weld, wrap or TERMI-POINT★ clip techniques.

Part of a complete line of AMP-UNYT printed circuit connectors available from AMP . . . Worldwide.*

*Trademark of AMP Incorporated

AMP



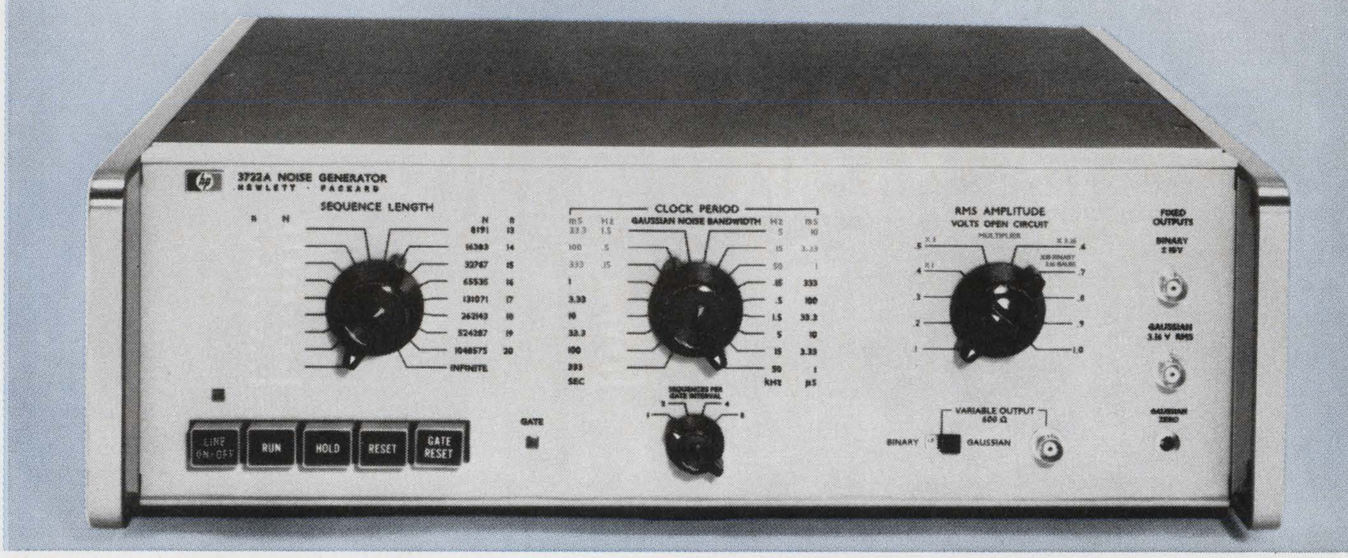
Box-contact connector. A superior two-piece board-to-board or board-to-wire connector provides high density with low insertion and extraction forces. Unique contact design allows wide mismating tolerances. Ten to 180 contacts on .075″ centers. For black-box, computer and other high reliability applications. Exceptional low cost for exclusive features incorporated.

A full range of semi-automatic and fully automatic machinery is available for high-volume production and lower installed cost. AMP's large assortment of printed circuit connectors permits proper selection of the best connector for any requirement. Matched tooling plus advanced engineering give you unsurpassed performance, economy and reliability.

For detailed catalog information on these products, contact **AMP Incorporated, Harrisburg, Pa. 17105**

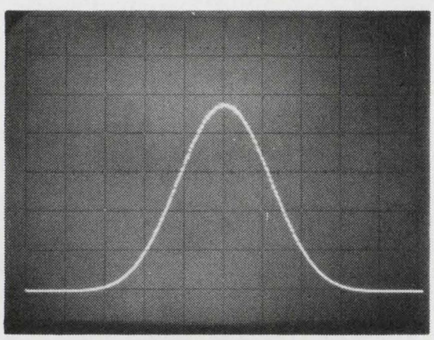
Circle 39 on reader service card

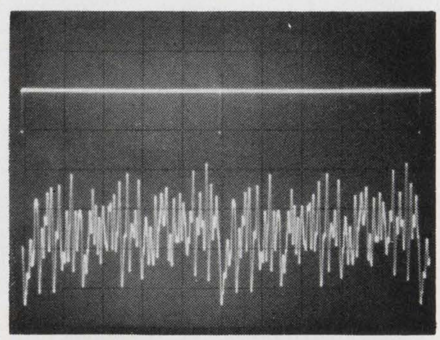
Put noise to work



DC to 50 kHz, HP now offers calibrated, repeatable noise patterns, random or pseudo-random, constant power and excellent Gaussian distribution.

EXCELLENT GAUSSIAN DISTRIBUTION
Using HP 5400A Multi-Channel Pulse Height Analyzer, ±250 mw; 1024 channels; Noise Generator: sequence length, 1,048,575; clock period, 3.33 μsec.





REPEATABLE
Sweep time of oscilloscope, 0.2 millisec/cm; Noise Generator: sequence length, 1023; clock period, 1 μsec.

The Hewlett-Packard 3722A Noise Generator now lets you harness noise so that it becomes a defined and calibrated input to your system. It allows you to synthesize and reproduce at will noise signals of constant noise power with a probability density function (pdf) in the classical Gaussian construction. This unique new instrument uses computer techniques to synthesize noise patterns of selectable length that are thoroughly defined and repeatable.

Because the 3722A employs a unique combination of digital and analog filtering, it is able to produce usable controllable power at low frequencies not previously possible. And, too, the digital nature of noise generation enables exact repetition of noise patterns of selectable length. This can save you hours of testing time, and you can test circuits, components or systems with confidence. System responses can be completely defined.

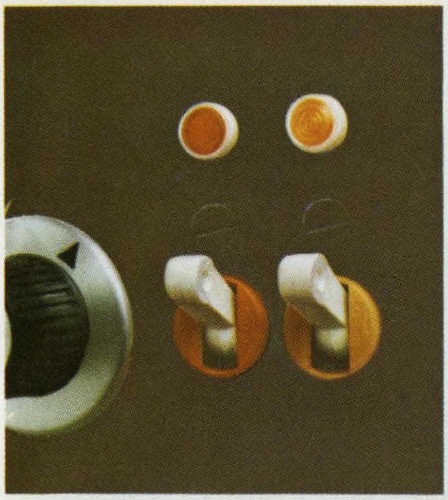
Ideal for such applications as control system response measurements, communications testing, acoustic measurements, temperature and flow fluctuations, study of air, water and earth turbulence—and other real-time analog simulation. HP 3722A, $2650.

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

18703

HEWLETT hp PACKARD

SIGNAL SOURCES



The Heinemann Series JA circuit breaker

Legend has it that the equipment that wears one is forever safe from harm. (Although our claims for it are considerably more modest.)

We do believe, however, that a bouquet of color-coded JA's on your equipment panel will give you a distinct feeling of well-being.

For one thing, those bright JA color caps make your panel look better. (They also make faults easier to find and correct.) There are nine happy colors to choose from.

For another, you have all the advantages of Heinemann's kind of hydraulic-magnetic protection working for you.

What advantages?

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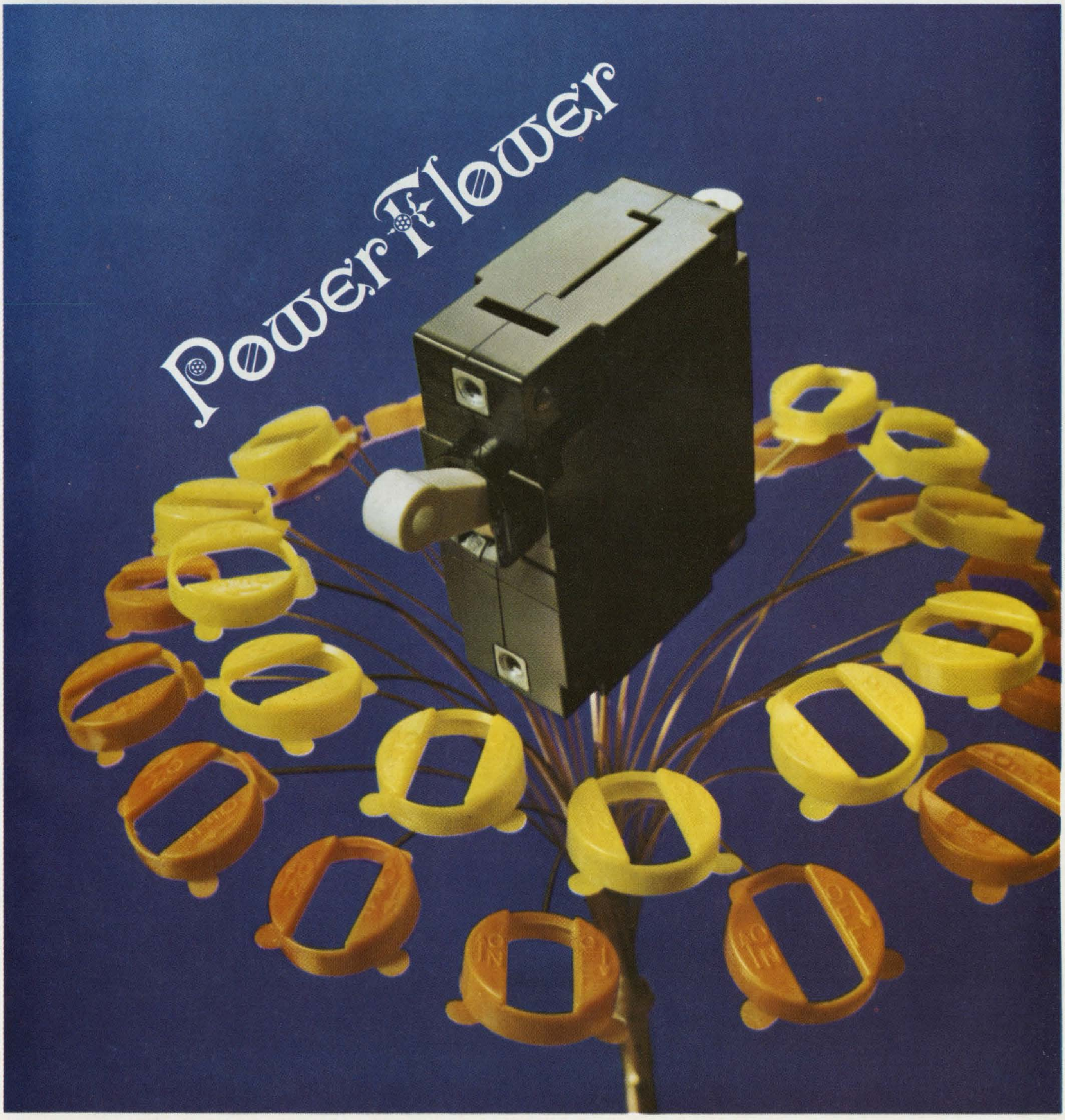

Circle 41 on reader service card

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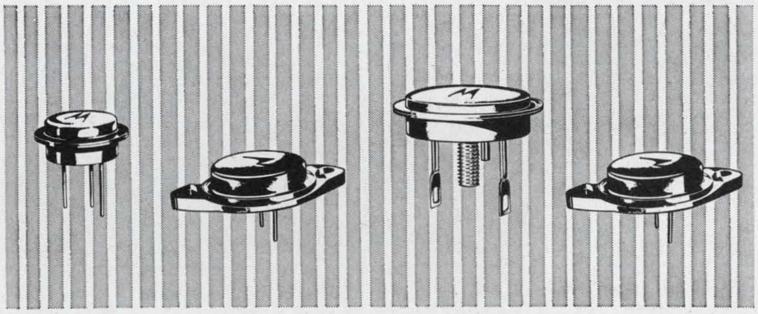

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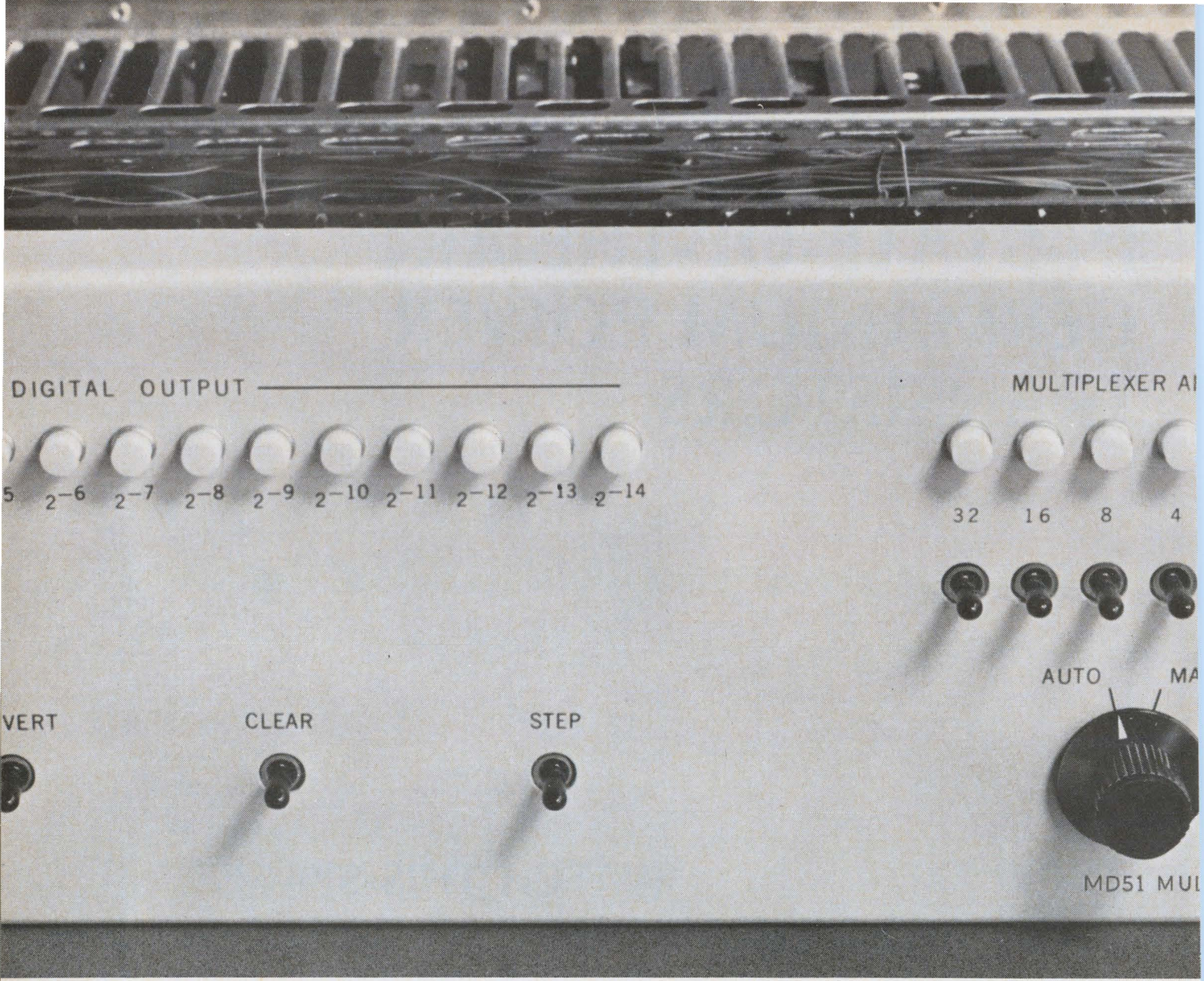

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Electronics Review

Volume 41
Number 12

Oceanography

Underwater eyes

Oceanographers have long considered lasers as potential tools for illuminating the murky deep. This potential appears to be headed towards reality with a laser-television system developed by the Kollsman Instrument Corp.

Called Udacs, for underwater detection and classification system, the laser can sight objects eight times farther away than can the naked eye.

Although developed specifically for the Navy, Udacs' potential applications go well beyond the military's undersea detection and surveillance. They include navigation in uncharted waters, recovery and salvage operations, detection and classifications of fish, inspection of underwater structures and cables, and mining and farming on the ocean bottom.

Off and on. The Syosset, N.Y., firm based Udacs on laser range-gating, which minimizes glare and backscatter immediately in front of the tv camera. Laser bursts are synchronized with the camera's on-off switching—when the laser is on, the camera is off. After the beam of coherent light has traveled to its target and back—usually in nanoseconds—the camera turns on to pick up the target's image, but none of the backscatter. This process is repeated at conventional tv scan rates, thereby creating a continuous image on the tv receiver on board a surface vessel.

Udacs, which has a resolution of 450 lines and a range of 90 feet, is currently undergoing tests at the David Taylor Model Basin in Carder Rock, Md.

An image intensifier is used as a high-speed shutter. At 10-nsec intervals, the transmitter emits a laser pulse with a 500-kilowatt peak power at 5,300 angstroms. The receiver modulator, which produces an 8-kilovolt pulse that is applied to the image intensifier, obtains an absolute time reference from a photodiode that is energized by the laser itself.

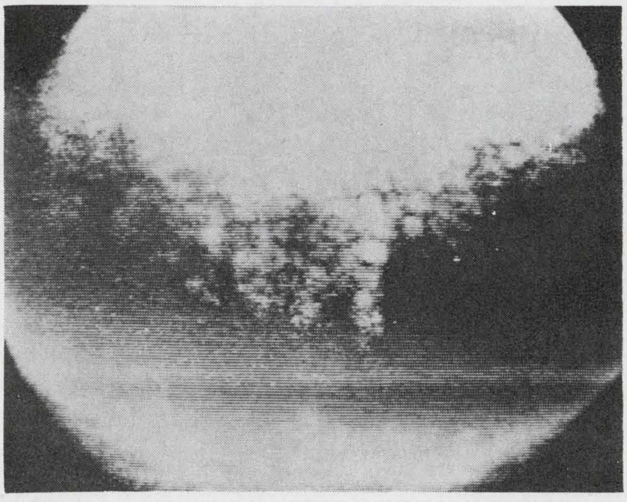
Kollsman is now working on modifications that will enable Udacs to sight objects that are 200 feet from the camera.

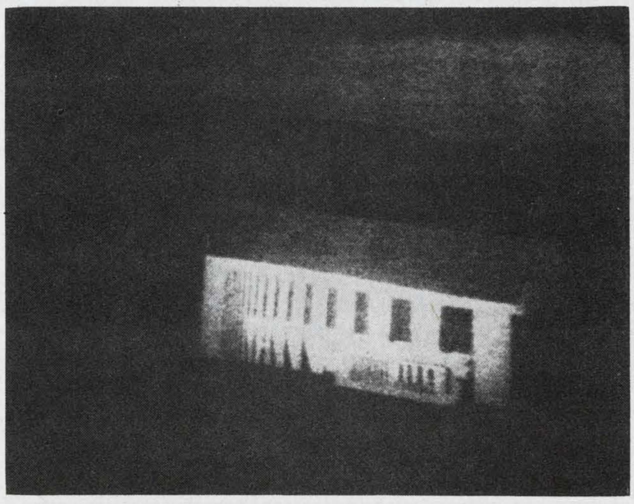
Avionics

Multiplexing the LSI way

Large-scale integration has made its way into a pulse-code modulation telemetry system. At the North American Rockwell Corp.'s Autonetics division, Duane Fox, supervisor of multiplexing technology for the data systems unit, says the telemetry module represents a technological advance that will make multiplexing more attractive than it already is. [For more on multiplexing in airplanes, see p. 25].

"There have been small telemetry systems that use microelectronics," says Fox, "but I don't think there have been any that use metal oxide semiconductor IC's." The most sophisticated chip in the Autonetics system, the Mod 2, is a monolithic 110-by-116-mil MOS de-





Night and day. The Kollsman underwater laser-television system illuminates an underwater target, which to the unaided eye (left) was only a blur. The system's resolution is based on a range-gating technique, in which laser bursts are synchronized with on-off operation of a tv camera, minimizing backscatter.

vice that contains 300 field effect transistors in a hybrid thin-film package 1.78 inches long and 0.95 inch wide. The same package contains all the logic for the telemetry system and does all the digital-to-analog and analog-to-digital conversion. Mod 2 is made up of three hybrid thin-film packages and five metal flatpacks—each flatpack containing the monolithic MOS chip.

The entire module fits on a 5½-by-3½-inch board. Fox says a single Mod 2 can do the work of six modules in today's most advanced telemetry systems, which are made with discrete devices and bipolar integrated circuits. Autonetics uses bipolars and discretes in its module, too.

Random access. The Mod 2 can multiplex 64 single-ended or 32 differential channels, or any combination of the two. It can handle one data channel at a time sequentially, or function as a random-access multiplexer using the same MOS chip.

Says Fox: "You won't find any analog-to-digital converters this small with this accuracy. Nor is it likely that you will find MOS logic in a-d conversion." Successive approximation with voltage summation is used in the conversion.

Of the three 40-lead thin-film packages, one contains the logic, level translators, 22 bipolar IC's—diode-transistor-logic NAND gates and flip-flops—four discrete transistors, two discrete capacitor chips, and several nichrome resistors. A second package contains ladder switches and ladders with a 10-bit accuracy. The other package is partitioned into two parts—a comparator and an analog differential amplifier. The system itself has a resolution of one part in 1,024 bits.

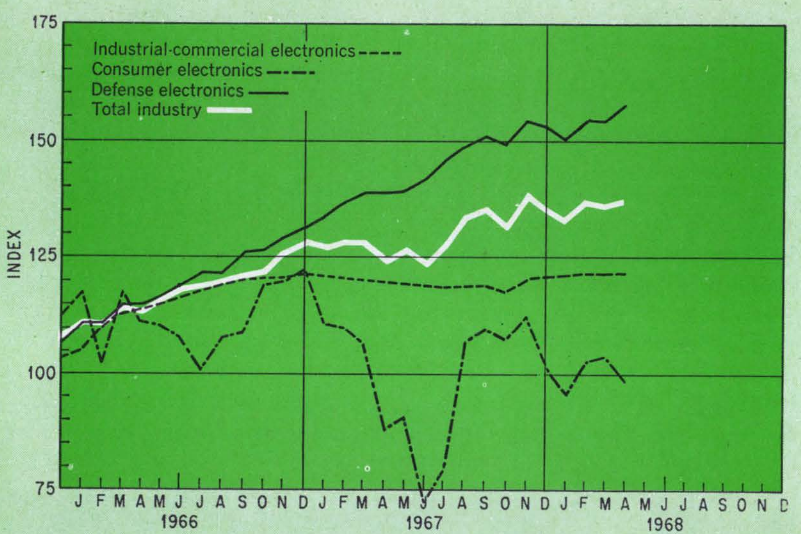
"The output of the comparators, which compare the analog input with the voltage generated by the ladder and logic, peaks the logic in a successive approximation scheme," Fox explains. Sequential commutation of 16 single-ended channels or eight differential channels is provided in the monolithic MOS IC's.

Versatile. "Besides multiplexing analog signals," says Fox, "the MOS chip can operate as a function generator—generating 2^{16} functions—as a parallel-to-serial converter, a code generator, a four-bit binary decoder, or a four-bit storage register. We found out after we built it that it serves as a universal building block. It has storage and decision capabilities, and that's all you need for all the logic of a computer."

Autonetics completed Mod 2's development just two months ago. And the company's engineers are already at work on a new MOS chip that Fox says is even better than the one used in the Mod 2. It will dissipate just 50 milliwatts vs. the Mod 2 chip's 250 mw.

Electronics Index of Activity

June 10, 1968



Segment of industry	April 1968	March 1968*	April 1967
Consumer electronics	**98.4**	104.3	87.3
Defense electronics	**157.3**	154.1	138.1
Industrial-commercial electronics	**121.7**	121.6	120.2
Total industry	**136.8**	136.1	124.1

Electronics production inched up 0.7 point in April to 136.8, 12.7 index points above the year-earlier level. Consumer output declined 5.9 points from March, but was still 11 points ahead of the April 1967 figure. Defense electronics production rose 3.2 points in the month, while a 0.1 gain was posted in the industrial-commercial area.

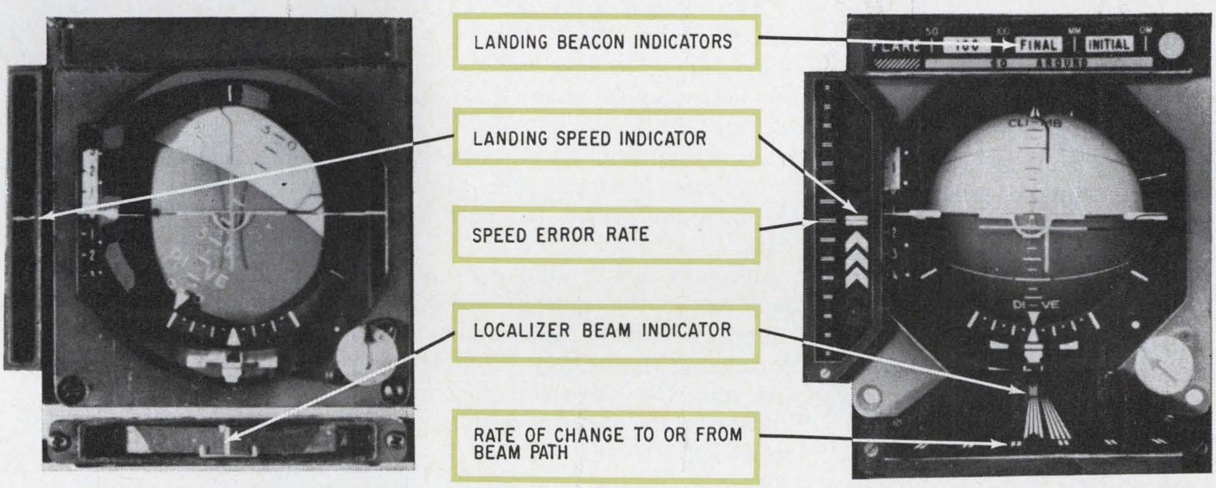
Indexes chart pace of production volume for total industry and each segment. The base period, equal to 100, is the average of 1965 monthly output for each of the three parts of the industry. Index numbers are expressed as a percentage of the base period. Data is seasonally adjusted.
* Revised

High lighting

Lear Siegler Inc. was awarded a contract by the Air Force last year to reduce the power requirements of the instrument panel on a T-39 jet trainer. Not only did the company succeed in cutting the power in half by using electroluminescent panels, but it also made the panel easier to read and got more displays in the same space.

In addition, the heat produced by the indicators was reduced by about 50°F. In the old panel, the instruments were lighted by incandescent bulbs and the moving displays were operated by a maze of servomotors, gears, tapes, and pulleys.

Shadowy. A major problem in using electroluminescent panels in aircraft is that sunlight tends to wash them out. Lear Siegler wasn't particularly stumped by this, though; the firm had been working for several years on methods of increasing the contrast between lighted and unlighted areas. According to Leroy Addis, a project engineer, "We have developed a coating that cuts down on reflected light by 60%." The coating is applied to the entire face of the panel, covering lighted and unlighted areas. The effects of ambient light are reduced 30% going into the panel and 30% coming out, while the light emitted from the panel is cut by the coating by only 30%.



Easy on the eyes. Electroluminescent instrument panel (on right) is easier to read and supplies more information than conventional panel. Moving lights indicate landing beacon position and landing speed and their rate of change.

Another problem with electroluminescent panels is moisture. "If you look at the electroluminescent night-light that you may have at home," explains Addis, "you may notice that after a while a small dark area appears on the face of the panel. This spot is caused by moisture, and it grows until it covers almost the entire face." To protect against this, Lear Siegler has developed a hermetic seal that envelops the entire panel.

High temperature is another factor to be reckoned with. The ambient temperature behind the instrument panel is about 160°F, and though the incandescent bulbs that were to be replaced produced some of this heat, there were other sources. The attitude direction indicator (ADI), a unit (below) that shows the pilot his position with respect to the ground, consists of a sphere representing the earth with two degrees of movement, and two movable crossbars whose intersection represents the plane. The servomotors and gear trains needed to position these parts generate considerable heat.

Beat the heat. Since the ADI is manufactured by Lear Siegler, it was up to its engineers to redesign the unit. The new ADI employs a d-c torquer with an integrated-circuit drive system. The use of this unit, plus the elimination of the bulbs, has cut the temperature to about 110°F.

Three types of electroluminescent lighting are used in the instrument panel—edge, back, and direct.

On the original T-39 panel, engine conditions such as speed, temperature, pressure, fuel flow, and fuel quantity were indicated by circular analog meters. On the new panel, bar graphs composed of electroluminescent segments make it easier to compare the operation of the engines, besides being easier for the pilot to read. An added advantage is that limits can be set on the indicator. If, for example, engine speed shouldn't exceed 100 rpm, the segment next to 100 on the scale can be lighted. As a further warning, the panel can be flashed on and off when the 100 mark is reached.

Rear view. Electroluminescent panels are also used for back lighting and edge lighting. Cutouts are made in the instrument panel and a panel placed behind it, or a panel is mounted on the instrument panel and the background is blacked out.

Edge lighting involves a system similar to that employed with incandescent bulbs. After a glass wedge has been placed behind the faceplate of the instrument, electroluminescent strips are mounted along the edges of this wedge and their light is directed onto the meter's surface.

But one area where electroluminescent panels really shine is in the implementing of new types of displays. Along the bottom and left side of the ADI on conventional panels are two landing indicators, one showing the plane's position in relation to a landing beacon and the other indicating whether the plane is coming in too fast or too slow. These indicators consist of a fixed pointer and a moving tape controlled by a servomotor. When electroluminescent segments are used, the pilot not only knows he's coming in too fast and to the left, but how far to the left and how fast. Segments are positioned alongside the position and speed indicators to indicate rates of change. The effect is that of a strobe, with the segments moving along the edge.

Making a point

Small digital airborne computers may be moving up in class. Until now, all machines of this type employed fixed-point arithmetic. But IBM's Federal Systems division has changed this with its 4 Pi Model CP computer that will now use floating-point arithmetic—a technique common in larger systems.

With the fixed-point technique, whereby decimal points are given fixed location, scaling is difficult. And this placement of decimal points is often imprecise. In some cases, the user has to bypass the computer and turn to that old-fashioned engineering tool, the slide rule. Even programing is difficult. Such common computer languages as Fortran and PL-1 can't be used because they are intended for processors with floating-point arithmetic only.

Time saver. Gilbert C. Vandling, an advisory engineer at IBM, sees the floating point as a major development for airborne computers. He believes that computers can be readied for operation faster with the floating point than with the fixed point.

"The time between a computer buy and its readiness in a system can be reduced by 50%," says Vandling. The new 4 Pi modification, he points out, makes the airborne computer compatible with the IBM 360 computer. And this, he says, means additional time can be saved because program work can start on the 360 before the 4 Pi's are delivered; fewer program interactions are required. Moreover, testing and verification of programs are simplified—fixed-point computers must now be checked against floating-point machines.

Vandling credits plug-in microprograming for the CP's success. The complex floating-point instruction set is microprogramed in the read-only storage.

More to come. Vandling says the new processor was inevitable and that IBM is expecting others to come up with floating-point processors in the future. But, he points out, they may have to make major hardware changes to accommodate floating point, since other airborne computers do not have the microprograming available in the 4 Pi.

"The writing is on the wall," he says, "because the Government is looking ahead to developing a common aerospace language that won't be for fixed-point computers." He believes that requests for proposals for military systems will specify floating point within the next two years.

Although IBM is aiming its new machine at the general airborne computer market, the company is also eyeing the airborne command post and the advanced Airborne Warning and Control System as potential applications.

Meanwhile, the 4 Pi family has just chalked up another win—this time, as the computer for the Navy's A-NEW integrated avionics system. Vandling sees the new CP as a natural for A-NEW follow-on contracts.

Military electronics

Where am I?

The Army has long wanted a miniature loran-C navigator for foot soldiers [Electronics, Oct. 31, 1966, p. 48], and now it may finally have one. Laboratory for Electronics Inc., Boston, has begun delivering 18 prototype loran-C navigation sets suited for riflemen. Such systems could be used to locate ground troops more precisely and to better coordinate artillery and air support.

The units result from six months of work under a half-million-dollar contract, which grew out of an unsolicited proposal to the Army's Electronics Command, Ft. Monmouth, N.J. With the first of the sets, designated PSN-2, shipped the second week in May, lab trials are just about complete, and field tests will start soon.

Tune in. Backpack loran tells a rifleman where he is.

Weighing about 20 pounds, including a six-hour battery pack, the PSN-2 comes in two main parts: a rectangular receiver to be carried on a soldier's back, and a control module about 8-by-2-by-2 inches to be mounted on his pistol belt. Erwin M. Allen, the product manager, says the PSN-2 can locate its operator to within ±100 feet. And the user can be moving as fast as 150 miles per hour when he takes his reading.

Moving apace. But a more usual application would be afoot. The navigator was designed for use with the special charts that relate the times it takes for pulses to arrive from the various stations in a loran chain. The navigator shows the time differences in a nine-digit in-line display. To find his location the operator compares the numbers in the readout with those on the charts.

Allen estimates that a minimum of 30 seconds is needed to lock the PSN-2 to the three loran chain stations; at worst, the process should take but a few minutes. After lock-on, the displayed data is updated automatically every 1.5 sec-

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The device is fairly simple to operate. First, the receiver is set to respond to the pulse repetition rate of the loran chain in its area; this is a semipermanent adjustment to the receiver pack and would probably be made on entering a given theater of operations.

In the field, the soldier tunes to the approximately 100-kilohertz signal of the master station in the loran chain—using automatic, electronically slewed tuning—then repeats the process for the two so-called slave stations. To take care of interference, the company has built in radio-frequency filtering, also tunable and controlled from the belt pack. All tuning functions use a dime-size meter.

Press to read. After locking on to the signals, the soldier presses a "read" button to light the digital readout panel, which is normally darkened to save the battery.

Allen describes the system as digital, because it accepts r-f information and digitizes it. This digital mode of operation also allows the navigator to operate without automatic gain control while retaining a 120-decibel dynamic range through "hard limiting."

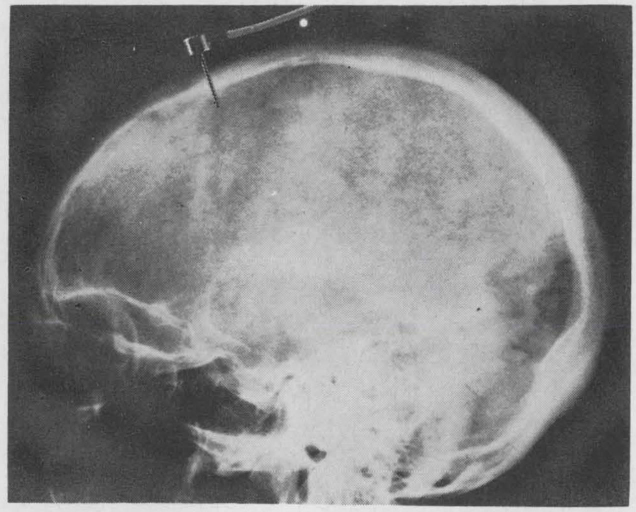
A spokesman for the Sperry Gyroscope Co., which had promised delivery of a similar unit by April 1967, says that two were tested. However, Sperry did not get the contract; the reason, says one source, is that Sperry's manpack couldn't consistently achieve its claimed positional accuracy of ±60 feet. Also, it required more manual tuning and was not as reliable as desired.

Sperry points out that, while it's no longer in the manpack business, it's still deeply involved with airborne loran for navigation and target acquisition.

Medical electronics

Swell gage

Now that the heart, for all practical purposes, may no longer be the measure of a man's mortality, more and more attention will be given to keeping the brain alive.



Brain probe. This thin-film strain gage (top), developed by Statham Instruments, is easily inserted into a patient's skull to monitor intracranial pressure, eliminating the need for a bulky catheter.

One major cause of death due to a brain injury is intracranial pressure. When pressure due to a blood clot, stroke, or tumor grows too great, the flow of blood to the brain stops and the patient dies.

For the past six years or so, neurological researchers at Philadelphia's Pennsylvania Hospital have been monitoring the amount of intracranial pressure with a fluid-filled catheter inserted at an angle into the skull through a hole about the size of a nickel. Because the danger of infection was so great, the sensor had to be removed in about two days.

Strain gage. Now, however, the researchers at Pennsylvania Hospital and four other Philadelphia institutions are starting to use a thin-film strain gage, developed by Statham Instruments Inc., to measure intracranial pressure. The new device can be inserted by a technician in a matter of minutes, even in the patient's room, and can remain in the skull for three to four weeks; the danger of infection is less because the hole is smaller and the catheter is eliminated.

All the technician has to do is shave and sterilize an area of the scalp, make a small stab wound, and drill a 2-millimeter hole into the dura matter—the outermost, tough membrane covering the brain.

The pressure-sensing extension of the transducer, which is protected from body fluids by a silicone-rubber diaphragm, is then inserted through the skull hole into the dura matter. The conventional catheter, which wasn't protected, would often become clogged, introducing error in the pressure measurements.

How it's made. Statham's gage is a further application of the company's other pressure transducers [Electronics, Feb. 5, p. 168]. These thin-film transducers are manufactured by a vacuum-deposition process in which a ceramic on a metal substrate is used as insulation.

Four strain gages, deposited onto the insulator, are electrically connected to a bridge circuit through vacuum-deposited leads. These multiple evaporations are performed during a single pumpdown. The lead wire is attached to the film by microwelding.

Heart of the matter

Electrocardiogram analysis by high-speed digital computers has always been expensive. Finding a way to cut the time required to put EKG data into the computer, reducing user cost, has occupied engineers at Beckman Instruments Inc. for almost two years. Now they think they've developed a solution

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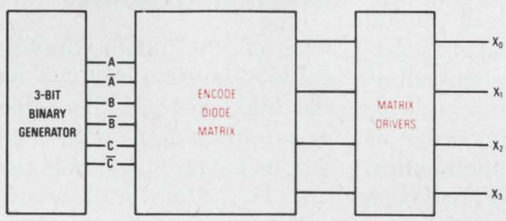
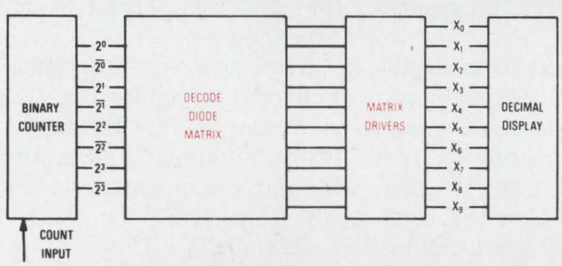
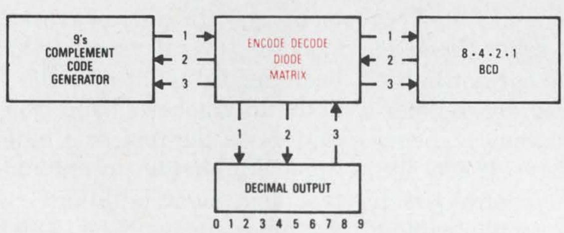


Suppose you need a three-bit binary output encoded into a four-bit binary shift code. Why use *five* AND gates and *four* OR gates? Simply combine these nine gate functions into *one* RM-30 six by eight diode matrix and save both time and money.



Why use ten logic gate packages to decode from binary to decimal for display read-out? Use only *two* RM-84 eight by five diode matrices. It makes no difference what weighted binary code you are working with, Radiation diode matrices can be easily customized to match.



When one logic code must be converted to several other codes for processing, think diode matrices! Specify only *four* RM-84 diode matrices and form a 16 by 10 matrix array. Six conversions can be performed by this single bi-directional array... replacing approximately 80 logic elements.

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Sales Offices: 600 Old Country Road, Garden City, N.Y. 11530, (516) 747-3730 — 2600 Virginia Avenue, N.W., Washington, D.C. 20037, (202) 337-4914 — 6151 W. Century Boulevard, Los Angeles, Calif. 90245, (213) 670-5432 — P.O. Box 37, Melbourne, Florida 32901, (305) 727-5430 — International Sales: Marketing Department, P.O. Box 37, Melbourne, Florida 32901, (305) 727-5430 with their new Digicorder.

The machine is a mobile digital data acquisition and recording system designed to record standard 6- or 12-lead EKG's in digital form on half-inch IBM-compatible magnetic tape for direct entry into most general-purpose computers, says Paul Hansen, project engineer and Digicorder designer. The system records data from patients at 1.8 inches per second and converts the signals from analog into digital form without an external conversion network.

"Since it became practical to analyze EKG data on a computer," says Dave Froelich, product line manager for the clinical instruments operation, "there have been two ways of getting information into a form suitable for computer processing. You could record on frequency-modulation tape, demodulate the analog signal, and run it through a digitizer for conversion, or you could run the EKG signal over phone lines directly into a computer."

In real time. In either case, a separate conversion network to put the data in digital form is required, and entry into the computer is done in real time. But with the Digicorder, the EKG data is fed into the computer at 100 to 150 inches per second—nearly a hundred times the speed at which it was recorded.

"This means we can put a complete EKG into a computer almost every second, where it takes about 90 seconds to do it in real time," Froelich explains. "Since processing time takes about 30 seconds on a medium-speed computer with either mode, we can save the user about a minute-and-a-half's computer time with Digicorder. At $2 a minute, this saving could mount rapidly.

The recorder part of the system is an instrumentation-grade tape unit rated for continuous duty and made to Beckman specifications. It can record seven or nine tracks with packing densities of 556 characters per inch for seven tracks and 800 characters for nine tracks. The nine-track model is for use on computers comparable to IBM's 360 series, Froelich says.

In operation, the EKG signal from a patient is picked up by a differential ac-coupled amplifier, fed through a filter and into the a-d conversion network, where the analog data's accuracy is "frozen." It is then placed on the magnetic tape for processing. The Digicorder has an accuracy of better than ±0.5% and a sample time of 8 microseconds, which Froelich says is very good. The EKG waveform is sampled 500 times a second by the a-d converter, with a resolution of 1 part in 1,024 bits.

The unit's electronics are on 16 printed-circuit boards. Motorola resistor-transistor-logic integrated circuits are used for all digital functions. The analog parts are hybrid—some IC amplifiers as well as discrete transistors.

Simple controls. Digicorder is designed for use by paramedical personnel, so its controls have been kept to a minimum. They include a selector switch so data from two patients can be recorded sequentially.

Beckman engineers wanted the unit to contain a self-checking system. Therefore, the a-d converter's output—10-bit information—is sent back through a d-a conversion network and displayed on the oscilloscope. If a normal wave pattern appears, the EKG data is being correctly recorded, Froelich points out.

Additionally, an echo check is made by sensing the current in the write head of the recorder to determine if the information is being picked up by the tape. If it's not, a light flashes on the control panel.

Although only a single patient at a time can be monitored, a dual set of input wires is included for rapid screening operations. Froelich estimates that 30 persons an hour could be recorded in an efficient operation.

Speed and cost. With 7,000 hospitals and clinics in the country, the manager sees a big market for the Digicorder. "Any medical facility that runs at least 10 EKG's a day is a potential user. The main advantages we have over competitive systems are speed and cost. We can get the user into the computer faster than any other recording mode."

Digicorder is designed for use with the computer program developed by Dr. Cesar A. Caceres of the U.S. Public Health Service. The price is $15,000, and the machine may also be rented. Froelich estimates costs at $1 per EKG, against at least double that with other methods.

Consumer electronics

Untangling cable tv

One of the major drawbacks of cable television (CATV) has been the high costs of the cable. Rural or suburban areas with small populations haven't been able to support a CATV system. As a result, politically powerful farmers' organizations have always opposed CATV that might jeopardize expansion of over-the-air tv.

Now, however, a decision by the Federal Communications Commission may lead to the first step toward providing CATV to rural areas through use of a microwave system. The step would be taken by the TelePrompTer Corp., New York, the largest U.S. CATV company.

TelePrompTer has been experimenting with microwave transmission for several years. It has been beaming tv and f-m radio signals in the 18-gigahertz band from transmitters on the roof of a building in upper Manhattan to antennas atop two apartment buildings two and six miles away. Now, TelePrompTer has asked the FCC to make a nationwide allocation of the frequencies between 18.349 and 18.797 Ghz for tv and f-m distribution. The FCC, however, turned down that request because it was opposed to "piecemeal allocation" of part of the spectrum before a decision was reached on the frequency needs of communication satellites.

More experiments. However, the FCC did acknowledge that TelePrompTer's proposal for "local distribution service holds sufficient promise for the future to warrant continued experimentation."

The FCC agreed to allow Tele-

Silicon Power PNP... of Age in '68

RCA PNP Type	NPN Complement	V_{CEO} (sus) V	I_C A	P_T W	H_{FE} @ −50 mA	H_{FE} @ −500 mA	Pkg
2N5415	2N3440	−200	−1	10	30-150	—	TO-5
2N5416	2N3439	−300	−1	10	30-120	—	TO-5
2N5322	2N5321	−75	−2	10	—	30-130	TO-5
2N5323	2N5320	−50	−2	10	—	40-250	TO-5

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Technical data from Commercial Engineering, Section IN6-1, RCA Electronic Components, Harrison, N. J. 07029.

RCA

PrompTer to continue its experiments in upper Manhattan and to run two rural experiments in areas of different geographical and climatic problems. The TelePrompTer system, which was developed by the Hughes Aircraft Co., is known as an amplitude-modulated link. It uses a single transmitter to send 12 color tv programs simultaneously for distances up to 20 miles.

Irving B. Kahn, president of TelePrompTer, calls the FCC decision "a great step forward." He says that when his company demonstrates that the hardware works as well in rural areas as it has in upper Manhattan, "there's going to be a tremendous clamor for this."

TelePrompTer and Hughes formed a joint subsidiary, Theta Communications, to make and market equipment for this transmission system. Now they're trying to figure out where to run the rural tests. TelePrompTer has CATV systems in a dozen cities across the country, but the tests might be operated by another cable company if the geography and climate in some other area are better for demonstrations. A decision on the test sites is expected later this month.

One test would beam signals to small clusters of receivers—most likely a group of 10 to 20 houses connected to the dish antenna by cable. The other test would beam to suburban areas where it isn't economical to run cable. Kahn points out that the cost of the dish antennas now runs into the low thousands. But if they were built on large production runs, the cost would drop to the low hundreds, which would make it feasible for a home in a remote area to have its own antenna.

Over water. TelePrompTer also sees as potential customers for its system residential areas that are separated from cable systems by barriers such as rivers. A microwave link over the water would be much simpler and cheaper than an underwater cable.

Kahn points out that the system will benefit not only the "real remote guy" but also "the big city guy," because it eliminates the necessity of installing underground cable ducts in urban areas.

In granting permission for the tests, the FCC said it would give TelePrompTer two years' notice of termination. This will give the company plenty of time to gather figures comparing costs of cable and microwave.

If the FCC eventually allocates spectrum for CATV use, the market for equipment will be "tremendous," says Kahn. But he notes that the big problem will be to convince the FCC of the need for permanent allocation of spectrum space.

Manufacturing

Spreading it thin

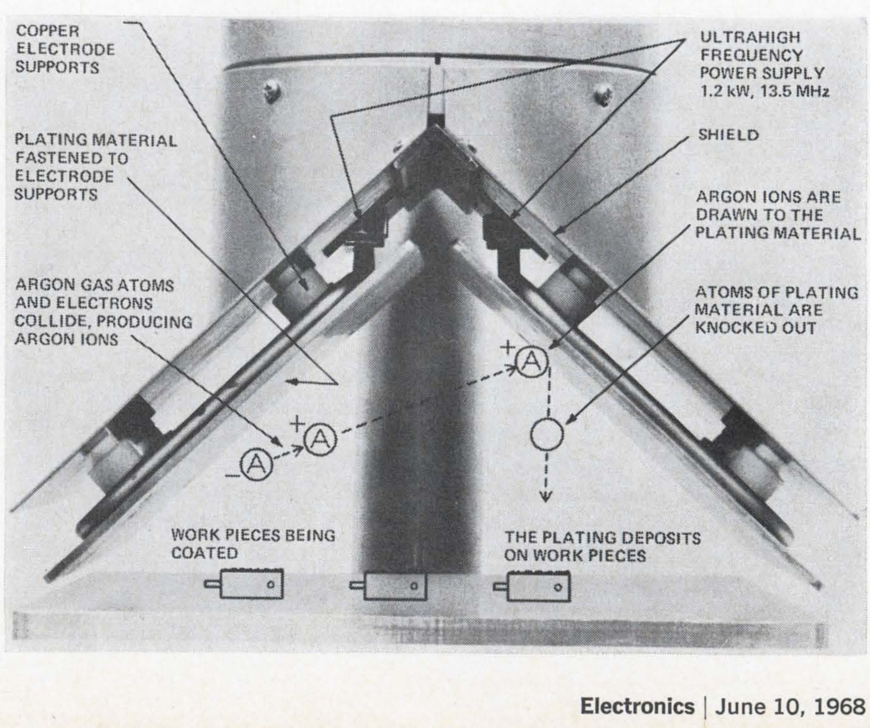
Evaporation deposition, although reliable for thin films, has had disadvantages that have restricted its use to certain deposition materials and to applications requiring only relatively weak coating bonds. The technique is usually limited to an impact energy of 0.3 electron volts, which results in a rather tenuous coating bond. So, alloys and compounds, which may have several evaporation points, can't be deposited without chemical separation of the compound or alloy elements.

In Palo Alto, Calif., Varian Associates' Vacuum division has developed a method of directly plating any solid surface with any metal, alloy, or dielectric substance (such as glass, ceramic, or quartz) with million-per-day production rates and low unit costs. Alloys and most compounds can now be deposited without chemical separation.

Thin coating. In an argon atmosphere at 1×10^{-3} torr, radio-frequency-induced plasma sputtering will deposit a uniform thickness on highly irregular surfaces with a precision of one millionth of an inch.

Vance Hoffman, product marketing manager for the division, says, "Unlike the sometimes chancy evaporation-deposition method, plasma-sputtering coating is completely controllable." At a standard vacuum pressure, with a fixed r-f power input (13.5 megahertz), the time of exposure is the only intervening variable affecting the coating depth.

One of the important applications areas for Varian's Plasma-Peak coating equipment, says Hoffman, will be in electronics and computer manufacturing for deposition of thin-film resistive coatings, dielectric encapsulation, tantalum deposition, and the surface application of magnetic films on



memory cores, tapes, drums, and disks.

Most of the big semiconductor houses have shown an interest in Varian's sputtering equipment, says Hoffman, and many have begun extensive R&D work at the wafer stage. Additionally, Northrop, Westinghouse Electric, Western Electric, and Bell Telephone Laboratories have purchased Varian systems for research. One of the areas now under investigation is the simultaneous deposition of ceramic and metal (Cermets) for thin-film applications.

Coat of gold. In other areas, PlasmaPeak has been used to plate millions of stainless steel Schick Krona Chrome razor blades with chromium. And, says Hoffman, fabric of any width can be gold-coated, at 20 feet per minute, to produce an opaque, reflective appearance.

Through a series of vacuum locks, a conveyor belt can continuously introduce material to be coated; to maintain the purity of the atmosphere in the vacuum, the system is continuously swept with argon.

In the plating process, the plating material is fastened to an inverted V of two target plates charged to 2,000 volts. The r-f energy excites the entrapped electrons, causing them to collide with the argon atoms; the collision changes these atoms to positively charged argon ions. The ions, which are attracted to the target plates, dislodge plating-material atoms, which then strike the work piece with an energy approaching 300 electron volts. The effect of completely random collisions between ions and plating atoms ensures a uniform coating over the entire area to be plated.

Other ways. Previous sputtering technology relied on d-c-induced plasma, with the deposition material on a cathode and the work piece on an anode. Other systems have used a second anode and an electron beam to increase sputtering rates. Hoffman says, "These two methods, although sound in principle, haven't been widely used, because they were too slow."

A good example of how the new deposition process will benefit industry comes from the Varian Tube division. Hoffman says that division needed a high-conductance copper plating on molybdenum that would withstand extremely high temperatures. Using conventional technology, they got only a 50% yield; using PlasmaPeak techniques, they got almost 100%.

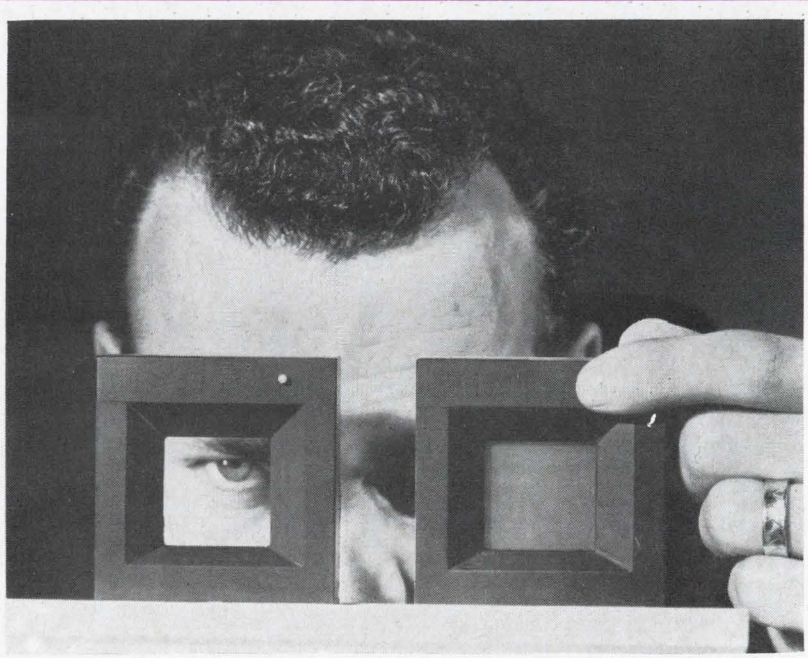
Space electronics

Fast talk

To keep intermodulation distortion between channels at a minimum, the Initial Defense Communications Satellite System is limited to four frequency-modulation voice channels in its 20-megahertz bandwidth. But the Space and Re-Entry Systems division of the Philco-Ford Corp., which built the IDCSS satellites, has tested a digital transmission technique that puts the equivalent of 128 voice channels through the system during operation.

The technique is to code digital signals before transmission, so that more than one bit can be sent at a time, and multiplex the transmitted signals by time division. The "M-ary" coding (M standing for 2, 4, 8, or 16, depending on how many signals are needed to transmit the code) is central to Philco's approach to PSK or FSK (phase-shift keying or frequency-shift keying) digital transmission. So far, the company has found the military somewhat contrary in the matter of digital communications; most recently, the JIFDATS (Joint In-flight Data Transmission System) went analog. But Edwin A. Fink, manager of advanced electronics in the division's new space electronics systems operation, says firmly that "we think that the optimum transmission of data is by shifting either phase or frequencies in this way."

Fast formula. The IDCSS experi-



Afterglow. RCA's liquid crystal display becomes frosted, right, when voltage is applied. Company says the thin-screen display, which uses low power and ambient light and is compatible with IC's, will be competitive with vacuum-tube displays. Thus far, RCA has an alpha-numeric display and a light shutter. Other firms are also doing work in this area, including Sylvania and the Marks Polarized Corp. [Electronics, July 25, 1966, p. 41].

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ment, which took place over a year ago, used 16-ary FSK. A binary PSK system designed by the company can transmit data at the rate of 350 megabits per second; by comparison, the OGO satellite transmits data at only tens of kilobits per second.

The "M" in M-ary stands for the number of possible waveforms transmitted; it is equal to 2^N, where N is the number of bits of information per transmitted bit. A binary system thus transmits one bit of information per transmitted bit, since 2^1 equals 2. In a quarternary system, N would equal 2, since 2^2, of course, equals 4. Each transmitted bit would stand for 00, 01, 10, or 11. A 16-ary system could handle all the combinations of four groups of 0's and 1's.

PSK is a little hard to detect above quarternary, because the phase angle becomes smaller, but FSK is practical through 16-ary, Philco found. Above that the amount of extra equipment required becomes prohibitive.

Changed plans. The question of who needs such high-speed transmission tends to get lost in security matters and in the argument over digital vs. analog voice transmission. Philco designed and built an engineering model of a 4-phase PSK system to provide 20-megabit capability for the Advanced Space-Ground Link System—only to lose the contract when it was decided to eliminate the high data-rate carrier from the ASGLS satellite.

The Earth Resources Technology Satellite will need high-speed data transmission to make finer differentiation in gray levels from digitized photographs. The Goddard Space Flight Center, which handles ERTS, reportedly wants a 100-megabit system. Philco has built and tested such a system. The company won't discuss the classified systems, but it is known that the manned and advanced unmanned surveillance system will also need a high data rate to dump information quickly when they pass over a ground station.

Voice communication is another matter, and Philco is finding little indication that the military is ready to accept a digital technique for it. Still, the Army has at least one request for proposals out for a digital communications modem—indicating that the three-service system (JIFDATS) begun under former Defense Secretary McNamara may be augmented by the individual services.

Argument closed. Inside Philco, where work on high-speed data transmission has been going on since 1960, the analog vs. digital argument is considered closed, and most work has centered on which kind of digital coding is best for a given system.

"High-speed transmission means wideband," says Fink, "and wideband means a higher noise level. So you look for the most efficient transmission system—the one that uses the least energy per transmitted bit."

For example, he says, Philco found that the best binary FSK system for an error rate of 10^{-5} used 12.5 decibels in energy per bit of one-sided noise density. The figure for the best practical binary PSK method was 10.5 db. But a 16-ary FSK method used only 7.5 db—half as much power as the PSK method and only a quarter that of the binary FSK method.

Both techniques require more complex equipment, and FSK gobbles up bandwidth, Fink concedes. Since a PSK system wipes out the carrier by transmitting all the energy to sidebands, the carrier must be synthesized at the receiving end. FSK requires serial-to-parallel and parallel-to-serial converters, plus oscillators for each of the frequencies used; the bandwidth it takes is from two to eight times that of an analog f-m channel.

Instrumentation

Finding a Friend

Integrated circuits, unlike vacuum tubes or discrete devices, can't be tested easily after they've been packaged with conventional voltmeters and ammeters. Most IC's, because of their complexity, require at least 40 test points, and these

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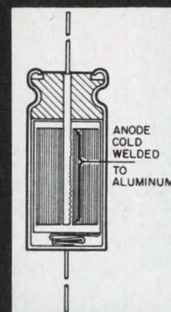

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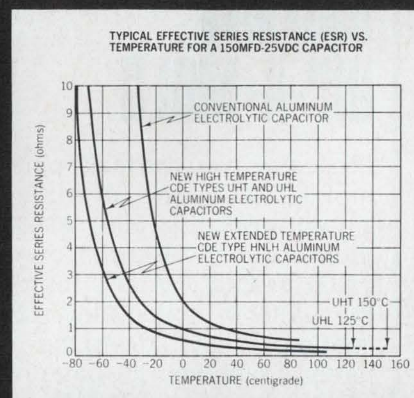

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UHR	Large Axial Lead Case Sizes: ⅝ x 1⅛ to 1" x 3⅝". Ratings: 10 mfd to 12,000 mfd, from 5 VDC to 200 VDC, designed to meet and exceed MIL C-39018/3.) (Also available in −55 to +85° C specifications.)	**−55 to + 105° C OPERATION**
HNLH	Miniature Axial Lead Case Sizes: ¼ x ⅝ to ⅜ x 1½". Ratings: 1 mfd to 600 mfd, from 3 VDC to 150 VDC. (Already stock standards on our Distributor's shelves.)	**−80 to + 110° C OPERATION**
UFH	Computor Grade Case Sizes: 1⅜ x 2⅛ to 3" x 8⅝". Ratings: 5500 mfd to 300,000 mfd at 5 VDC 240 mfd to 9000 mfd at 150 VDC.	**−55 to + 105° C OPERATION**

For your design considerations, ask for details from your local CDE Sales Engineering Office. Or write:

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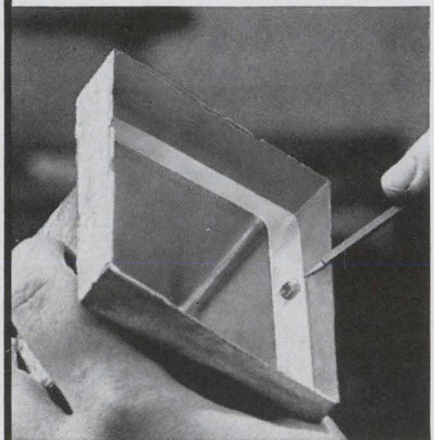


are hard to reach with a probe.

Now, engineers testing IC's not only for go/no-go answers but also for detailed data on what's wrong will have a Friend. That's the acronym for a tester developed by Scully International. The Downers Grove, Ill., division of the Bendix Corp. designed the Frequency Response Instrument for Electronic Network Diagnosis and a fault-diagnosis program, called FDP, under an Air Force contract.

Maybe a product. Although the tester was built as a prototype, Scully executives are now thinking about offering an advanced model as a product, with a price between $30,000 and $50,000.

With the aid of a computer, the engineer uses the fault-diagnosis program to generate a list of symptoms—potential component failures. Then, by relating these symptoms to their causes, he can quickly prescribe a cure.

For discrete circuits, the cure could mean surgery—replacing the faulty component. But for faulty IC's there is no cure, only rejection. However, since the cause is known, this information can be used in redesigning the IC's.

To use the program, the engineer first partitions an undamaged circuit's schematic into several sections. Although the ideal section contains a maximum of 10 nodes and 20 branches, as many as 30 nodes and 40 branches are possible —but at a price. Larger sections lower the efficiency.

The components' nominal values and the connections are described to a computer, which then determines the forward-voltage transfer function for the circuit as a function of frequency. Usually, several frequencies are chosen for voltage measurements. The number of frequencies varies from circuit to circuit, but the range is from 1 hertz to 7 megahertz.

One at a time. Once the behavior of an undamaged circuit is known, the computer uses the program to vary one component at a time and repeats the measurements at the same chosen frequencies. The components' values are reduced and increased. This provides data on the variation of circuit response as related to such things as short circuits, open circuits, and partial shorts.

The computed data is then checked against the known data under ideal working conditions and a scale, fault dictionary, and test procedure are punched onto tape. This tape becomes the input for the automatic tester. The data is stored for many conventional circuits—filters, amplifiers, and other linear devices.

Equipped with this scale and fault dictionary, the technician is then ready to trouble-shoot. When a faulty circuit comes in for checking, the technician takes the tape corresponding to that circuit and feeds the stored data into Friend. The tester repeats all the checks at all the prescribed frequencies, and the machine compares the results and the known data.

Based on what the tester tells the technician, he can decide whether to replace a faulty component or reject the IC.

The output from the tester appears as a set of digits, one for each test frequency.

A signature of all zeros indicates a circuit functioning within specifications. A faulty circuit will result in a signature containing some nonzero digits. It is this signature that the technician looks up in his fault dictionary. All responses are measured within a 3% accuracy.

Industrial electronics

Bright future

When the Army took the wraps off its Starlight night-vision scopes and promptly tagged them the greatest untold story of the Vietnam war [Electronics, June 28, 1965, p. 78], the oohs and aahs were reserved for the tactical advantage gained by American troops using the image-intensifying devices. But to the manufacturers of the gear, the best could be yet to come.

One sales executive says, "Now that the military has declassified the scopes, I'm going to be on the

On the line. Technicians assemble Starlight night-vision scopes for the Army at Electro-Optical Systems in California.

phone tomorrow with a whole list of prospective customers who can use the image-intensifying tubes for research. But more important, the police departments around the country are waiting in line for a chance to get their hands on the things." It's known that the police in Chicago and Detroit are ready to start buying if the price can be made attractive. The scopes sell to the Army at $2,000 for the smallest model, $3,500 for the medium size, and $5,000 for the giant tripod-mounted device.

Economy model. "If we can get the price of the small one down to the magic figure—$1,000—we've got it made," says one maker's spokesman. "There are about 175,000 police cars in the country, and when you figure one per car—well, it's quite a market." And getting the price down will be relatively simple. In the military model there are three image-intensifying tubes, each with its fiber optics and phosphor-coated lens. By eliminating one or two tubes—the police don't need 40,000-times intensification—the market is opened.

But the whole question of whether to sell a scope to anyone who wants one raises an ethical problem. Says Maj. W. B. Latta, head of the Army Electronics Command, the agency that sponsored development of the Starlight: "This is really a national policy question that must be answered on a level higher than mine."

Still, there are a number of possible scientific applications for the image intensifier—in astronomy, for example, or in nuclear research, where tracks of atomic particles could be photographed in a cloud chamber.

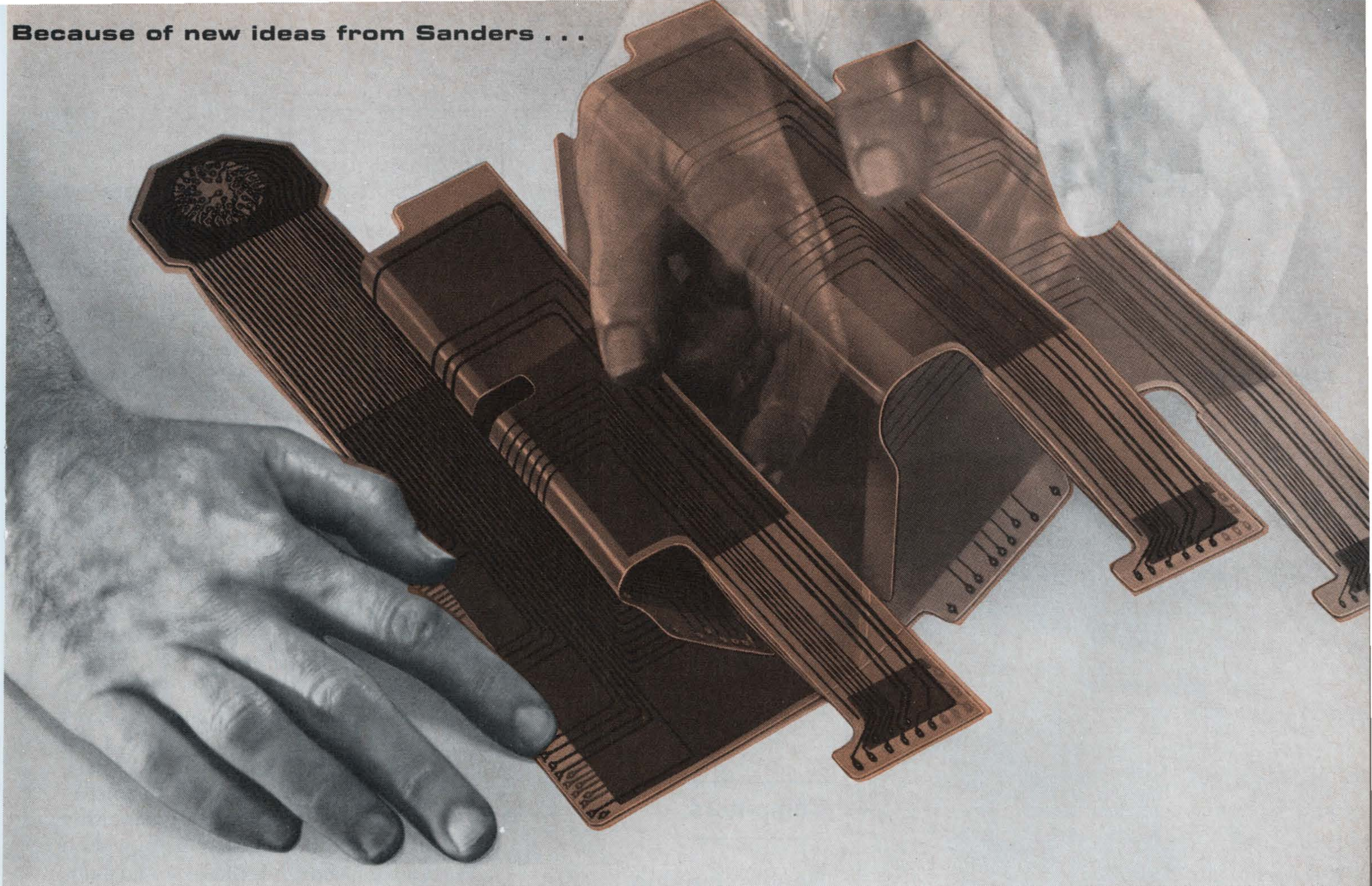
So in the absence of a clear policy directive from above, each manufacturer—Varo Inc., Garland, Texas; Machlett Laboratories, Stamford, Conn., a subsidiary of the Raytheon Co., and Electro-Optical Systems Inc., Pasadena, Calif.—is presumably free to go its own way.

Weld watcher

If a chain is only as strong at its weakest link, then a pipeline is only as good as its poorest weld.

Unlike most pipeline crawlers—used to detect faulty welds—that are trailed by huge umbilical-like cable linking them to an external power source, the Picker Corp., White Plains, N.Y., has developed a crawler that carries its own power supply. The machine X-rays welded joints.

Rechargeable. Priced at $30,000, Picker's machine can crawl along on its nylon wheels at a top speed of 39 feet per minute, and can ex-



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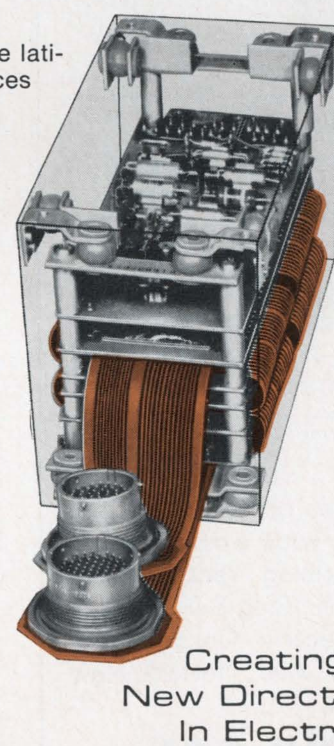

A unique 3-layer combination of flexible and rigid sections, the finished FLEXPRINT assembly in this airborne control system reduced volume 50%, with comparable savings in size and weight, installed faster and at lower cost. Wave soldering was made possible by careful material selection.

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Circle 63 on reader service card

amine up to a mile of pipeline without having its nickel-cadmium batteries recharged. Its camera is positioned at a weld by a radioactive isotope locator that's held by an operator, who walks alongside the pipeline.

At each weld, the operator wraps a strip of film around the outer circumference and then triggers the crawler's locomotive section, which emits a 360° x-ray beam. Cobalt-60 is used as the X-ray source. Weld defects show up when the film is developed.

Capable of climbing 30° inclines, the crawler can be used in pipelines ranging from 18 to 60 inches in diameter; the wheels are mounted on adjustable base plates.

Computers

Double thinking

Computer designers have always been bothered by the need to go through save-and-restore routines every time there's an interrupt in their general-purpose digital systems.

Engineers at Varian Associates' subsidiary, Varian Data Machines, Irvine, Calif., think they've found a way to overcome this hurdle. The result is a new, mini computer—the 520/I—selling for $7,500 without a teletypewriter.

The unique feature of the system, says Robert Thomason, vice-president for engineering, is its dual set of program-counter, index-register, and accumulator registers in the central processor. These create two "environments" within which the computer can operate interchangeably, Varian's Thomason explains.

When an interrupt occurs, he says, the program can switch to the registers of the second environment without any delay for saving the contents of the registers of that environment. When the interrupt ends, the program returns to the undisturbed data held in the first environment. Each environment has its own particular word-length control.

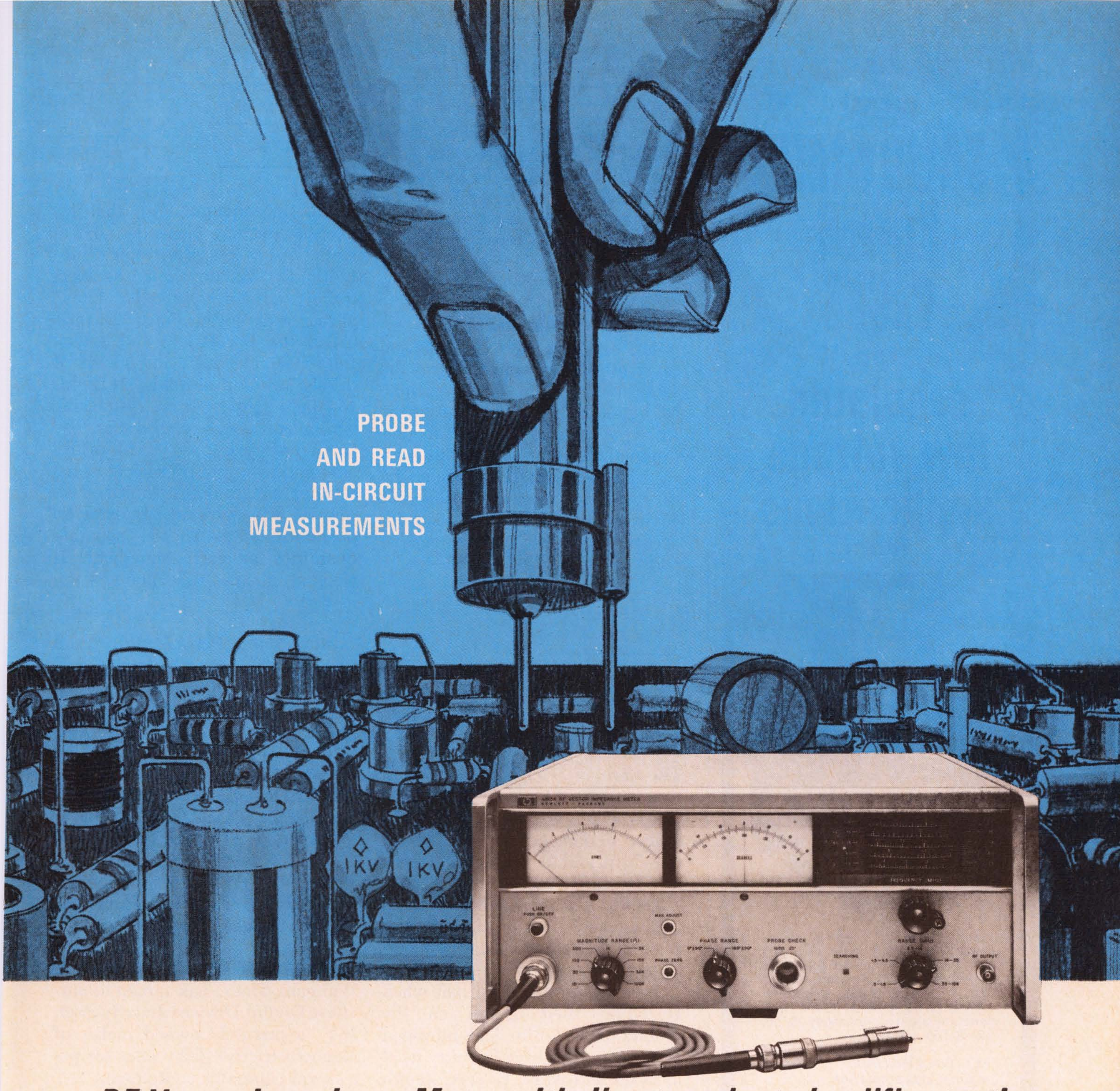
Different lengths. By operating in a dual environment, the computer can interlace background and foreground tasks without losing time in save-and-restore registers, or can find return addresses. What's more, each environment contains a 16-bit hardware index register and can operate at different word lengths. The user could be processing at one word length in one register, then switch to another word length for operation in the input-output cycle in the other register, Thomason says. Word lengths may be 8, 16, 24, or 32 bits. Program data is stored and processed in 1-, 2-, 3-, or 4-byte units.

Thomason says the "dual environment" of the computer gives it a capability unmatched by comparable machines, especially those processors costing less than $10,000. He says that using monolithic integrated-circuit technology and and an eight-bit-wide memory enabled the firm to reduce costs and power without sacrificing performance or capability. The computer has direct addressing to 4,096 bytes, as well as indirect and indexed addressing, features that Thomason maintains are uncommon in systems available at this price level.

For programing ease, users are provided with 11 interrupts combined into four hardware priority levels. Eight of the sense lines are attached to a single priority level; the other three remain separate. Because each program has its own set of registers, response to interrupts is rapid and multiprograming is efficient, vice president Thomason says.

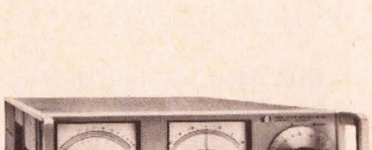
The computer's circuitry is on hard-wired printed-circuit boards, one for control and process functions and one for the memory. Transistor-transistor logic is used in the arthmetic parts and is furnished by Fairchild, Motorola, and Texas Instruments. In addition, the hardware registers use medium-scale integrated devices supplied by Motorola. There are 16 flip-flops. Diode-transistor logic is used in the control circuitry.

Two-dimensional. The memory



RF Vector Impedance Meter with direct readout simplifies testing

The Hewlett-Packard 4815A RF Vector Impedance Meter provides fast, direct reading measurements of impedance and phase angle over the frequency range from 500 kHz to 108 MHz. The convenience of probe measurement and direct readout make the instrument equally useful for laboratory, receiving inspection or production line measurements. The 4815A reads complex impedance over its full frequency range without charts, data interpretation or a slide rule. As a result, it offers fast, accurate evaluation of the complex impedance of both active circuits and components. Low-level signal strength minimizes circuit disturbance and prevents overloading the test component. Price: $2,650.00.



A COMPANION INSTRUMENT COVERS THE 5 Hz to 500 kHz RANGE

The Hewlett-Packard 4800A Vector Impedance Meter measures impedance in seconds. It does for AC measurement what the ohmmeter does for DC testing. Just plug it in and read it. Price: $1,650.00. Complete specifications are yours on request.

Application Note 86 discusses many applications of the Vector Impedance Meters. For your copy of this note and complete specifications, please contact your local Hewlett-Packard field engineer or write: Hewlett-Packard, Green Pond Road, Rockaway, N. J. 07866.

HEWLETT hp PACKARD

IMPEDANCE INSTRUMENTS

Circle 65 on reader service card

1072C

is a high-speed random-access unit. It can be expanded from 4,096 eight-bit bytes to 32,768 bytes, and the memory cycle time is 1.5 microseconds, with an access time of 500 nanoseconds. To save space, the memory is made of 30-mil ferrite cores spread out on a two-dimensional plane.

The 520-I differs from "two computers in one box," Thomason says, in that all registers use the same memory. When the machine is operating in one routine it isn't possible to operate another program simultaneously. But with the 1.5-μsec switching time, he says, one can transfer to a different environment quickly. This is both access and instruction time, he adds.

Companies

Suit up

The Supreme Court has agreed to hear an appeal by the Zenith Radio Corp., which is seeking nearly $35 million in damages from the Hazeltine Corp. and its subsidiary, Hazeltine Research Inc.

Zenith was originally awarded this amount back in 1965, but a Federal court in Chicago then reversed the decision.

The case originated in 1959 when Hazeltine sued Zenith on the ground that Zenith had infringed on a patent covering circuitry used in black-and-white tv sets. Zenith countersued in 1963, charging Hazeltine Research with violation of the antitrust laws in the use of its patents.

Zenith claimed that Hazeltine issued some 500 patents to pools maintained by U.S. and other companies manufacturing in Britain, Australia, and Canada, and that this pooling system was used to prevent the export of Zenith radio and tv sets to those three countries. According to briefs filed with the Supreme Court, the pools generally wouldn't grant patent licenses for products made in the U.S. and exported to those countries.

For the record

Sobering thought. Not that it's likely to put any bartenders out of work, but K&M Electronics Inc., Baltimore, has developed an electronic bartender for the home, yacht, or executive suite. The unit, called the Bar-Tronic and selling for $5,000, can pour any one of 24 drinks in four seconds. It holds 15 ingredients, mixer dispensing equipment, and is refrigerated. The Bar-Tronic can mix its 24 drinks automatically by preselected dial settings, or an almost limitless variety of drink proportions using 25 pushbuttons to choose separate quantities of each ingredient. It weighs about 125 pounds—unloaded.

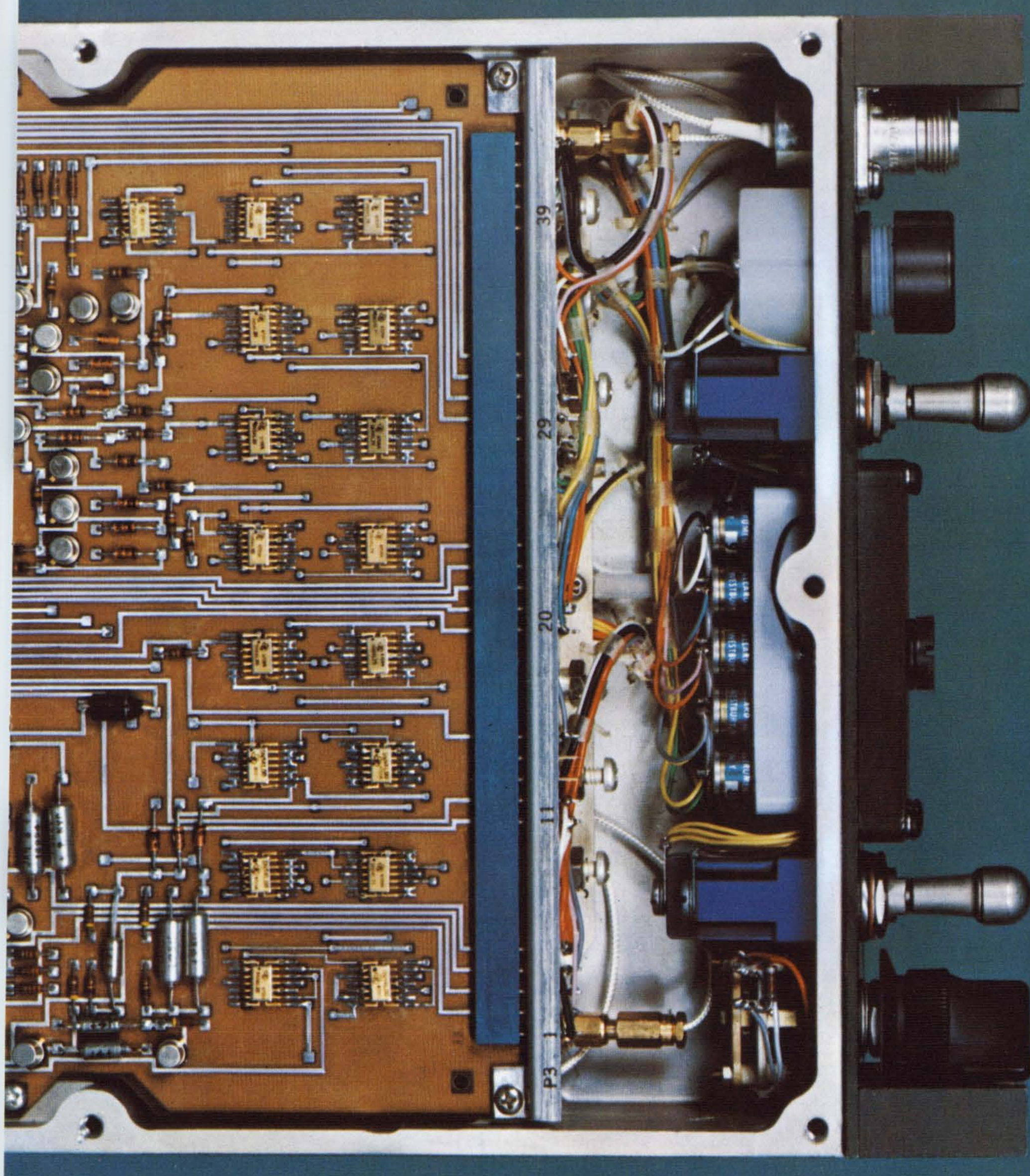
Move along. Between July 1 and March 1969, Honeywell Inc. will move the operations of its Test Instruments division from San Diego to the division's headquarters in Denver. The San Diego plant will become the new home of the Special Products division of Honeywell's Electronic Data Processing division, which will be moved from two plants at Newton and Lawrence, Mass. A Honeywell spokesman says the San Diego plant staff will nearly double within a year.

Acquired. Tyco Laboratories Inc., Waltham, Mass., has agreed to purchase Digital Devices Inc., Syosset, N.Y., a privately owned maker of magnetostrictive delay lines for peripheral computer equipment.

Sold. Laser Systems Corp., Ann Arbor, Mich., has purchased Lear Siegler Inc.'s Laser Systems Center, also in Ann Arbor.

Run deep. Testing is now under way on the first of two sonar subsystems being developed by Honeywell's Marine Systems Center for the Navy's submarine-personnel rescue program. The three-dimensional sonar system has four hydrophones, mounted fore and aft on the hull of a rescue ship on the surface. The system will be used to pick up and locate sounds.

TTL Trends
from Texas Instruments



Linking soldier to satellite . . . that's the job for these seventeen low-power TTL integrated circuits from Texas Instruments. They help form the "intelligence center" for an *Alert Receiver Terminal* — part of an advanced new communications system being developed by Collins Radio Company for the Tri-Service TacSatCom (Tactical Satellite Communications) program. Prototype receiver terminals are being built for the U. S. Army under a Tri-Service contract administered by the U. S. Air Force's Electronic Systems Division. Collins engineers use 54L circuits in achieving a portable and lightweight receiver capable of unscrambling messages from a satellite 22,000 miles away. Weighing only 12.8 pounds (with battery) and just 8″ by 11″ by 2″ in size, the Alert Terminal is designed for battlefield use. It is made to go where the soldier goes — detecting, decoding and verifying satellite-relayed digital messages — to get the "word" out . . . fast!

Low-power TTL unscrambles satellite messages

Objective: Demonstrate that a man-carried satellite receiver can effectively get the "word" out—to widely dispersed soldiers—fast!

Approach: Book-size digital receivers are being developed to detect and display coded messages dispatched from distant ground stations and relayed by satellite. Prototype models are now being built by Collins for the Tri-Service system. Each receiver uses 17 Series 54L low-power TTL integrated circuits from Texas Instruments. Included are: Six SN54L71 R-S master-slave flip-flops, four SN54L00 quadruple 2-input NAND gates, six SN54L20 dual 4-input NAND gates, and one SN54L30 8-input NAND gate.

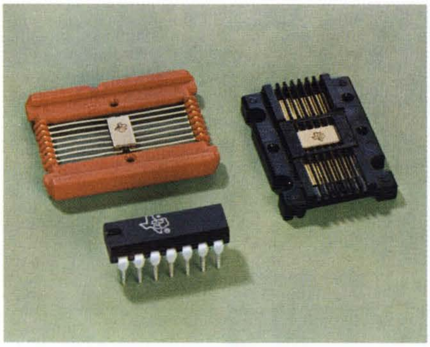
Keeping the equipment small and portable, while still meeting the rigid performance and reliability levels specified, presented extremely tough design problems. A high performance level is essential in decoding and displaying messages weakened by 44,000 miles of space travel. Series 54L circuits provide positive triggering with low-signal currents under severe conditions of humidity, dust, shock and vibration—at temperatures as low as minus 40°C.

Another requirement is to make the receiver—plus batteries—small enough to be carried by one man. The low power drain of Series 54L, only one-tenth that of standard TTL, helps keep down battery requirements while small size and low package count helps hold overall receiver size to only 8″ x 11″ x 2″. With battery, the equipment weighs only 12.8 pounds.

While the Alert Terminal can be carried and set up by one man, it can also be incorporated into any of three larger and more versatile systems Collins is building for TacSatCom. These units can transmit and receive voice and teletype as well as coded messages. All systems operate in the UHF band of 225 to 400 MHz and are engineered to meet the same critical performance and reliability standards.

Based on acceptance by the Department of Defense, TacSatCom—including the Alert Receiver Terminal and other sophisticated system components—can be operational by the early '70's. The complete system will make possible voice and teletype communication to hundreds of mobile receivers without the formal procedures, interference and waiting periods confronting present satellite communication users.

The task of helping link soldier to satellite is a tough, new job for integrated circuits. It's the sort of job that requires outstanding reliability...along with an optimum balance of signal power and low temperature operating capability. In short, it's the kind of job made to order for Series 54L/74L TTL integrated circuits from Texas Instruments.



New plastic package, two new complex-function circuits, expand low-power TTL line

TI now offers its Series 54L/74L low-power TTL integrated circuits in dual-in-line plastic packages... with bonus results. The line's low drive requirements and low power dissipation are now coupled with the low first cost and reduced handling costs of the plastic package. This is in addition to the popular long-lead hermetic flat pack (available in either the Mech-Pak™ or Barnes carrier) as shown above.

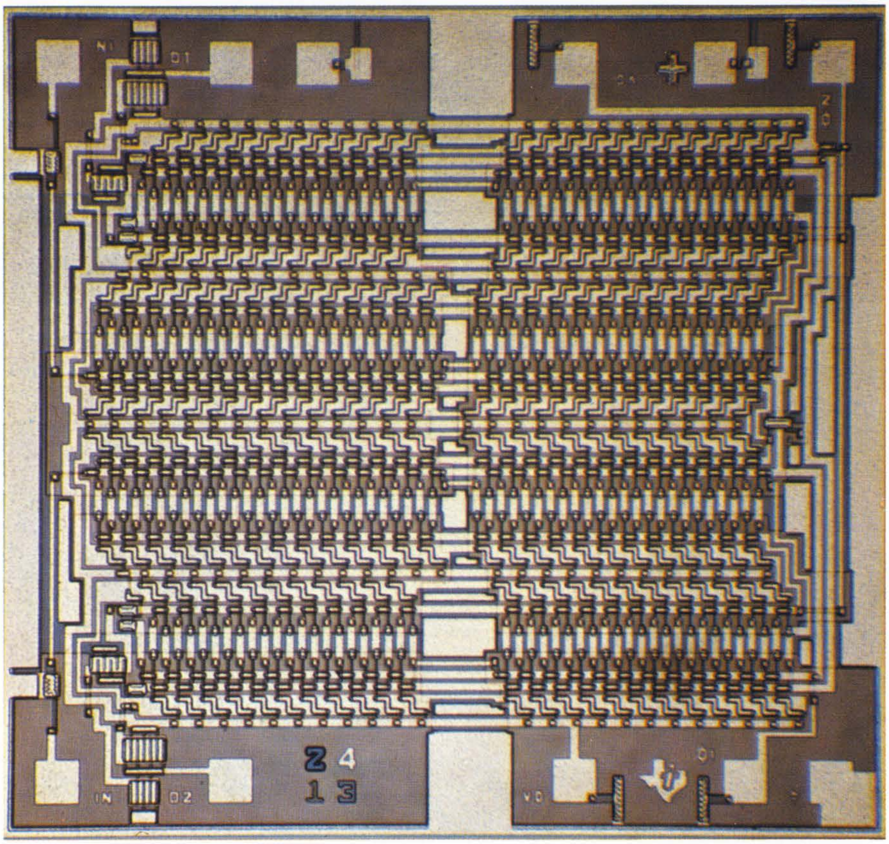
TI's low-power series is also more versatile than ever, thanks to two new complex-function circuits. These include a dual J-K master-slave flip-flop (SN54L78/74L78) and an eight-bit shift register (SN54L-91/74L91). Together they now bring the extra reliability *and* lower cost-per-function of complex-function ICs to military and industrial low-power applications.

For data sheets on the entire family of low-power TTL, write on your company letterhead to Texas Instruments Incorporated, P. O. Box 5621, MS 980, Dallas, Texas 75222.

TEXAS INSTRUMENTS

INCORPORATED

Dual 50-bit static shift register highlights eight new MOS ICs



This is a photomicrograph of the longest static shift register available in a production device today. It's TI's new dual 50-bit MOS IC...one of eight new computer-designed circuits. Companions include three other dual SRs (32, 25 and 16 bit), a six-channel analog switch, an audio amplifier, a dual full adder, and a dual 3-input NOR gate.

For your moderate speed digital applications, TI's new MOS integrated circuits can offer significant savings. For example, cost-per-bit for these MOS static shift registers is only about one-fourth that of bipolar registers.

All four new MOS static registers operate over the full d-c to 1 MHz spectrum (3 MHz under moderate loading). Unlike dynamic registers with a minimum clock rate, these static MOS circuits can store information for relatively long periods. They also possess high noise immunity, because of high input impedance, typically 10 megohms.

The dual 50-bit static register features very low power drain of only 1.6 mW per bit. Furthermore, longer static MOS registers and specially tailored units can be readily provided...thanks to TI's computer-aided design which makes custom derivitives possible in economical and timely quantities.

Six-channel analog switch

To permit switching of lower-level signals without excessive attenuation, the TMS 1A 6009 AA features low "on" resistance (150 ohms).

It is recommended for analog and time-division multiplexing, and chopping circuits.

Audio amplifier

Small size and modest cost make the TMS 7A 7000 LA ideal for many industrial and consumer applications. It is an R-C coupled audio amplifier with a gain of 45 dB over the frequency range of 10 Hz to 50 kHz. Output voltage swing (8 volts peak-to-peak) is obtainable with a single −20 to −30 volt power supply.

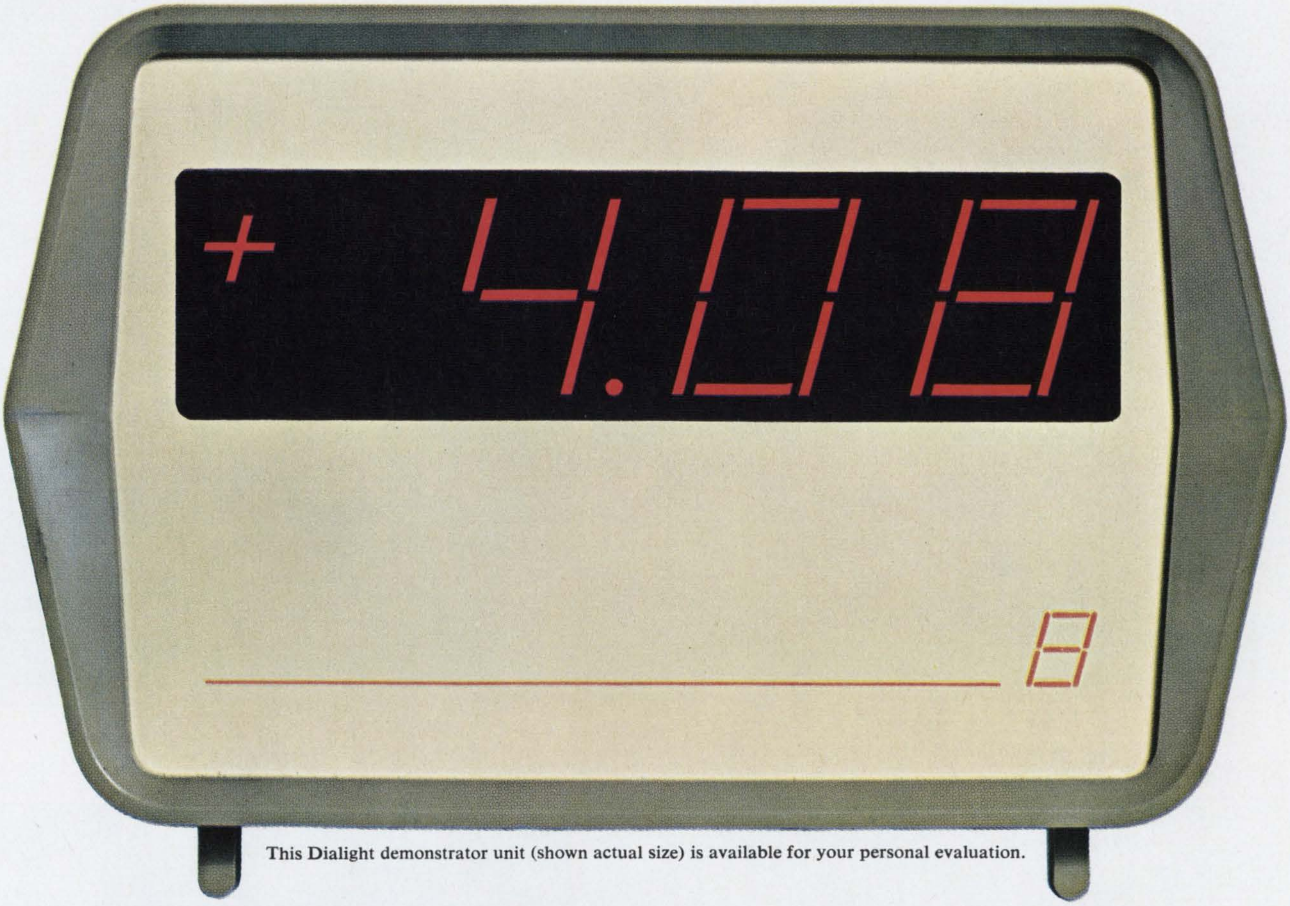
Dual full adder and dual NOR gate

High input impedance, buffered outputs and high noise immunity are characteristics of the TMS 1A 1700 AA dual full adder and TMS LA 1702 dual 3-input NOR gate.

For data sheets on any or all these new MOS ICs, write on your letterhead to Texas Instruments Incorporated, P. O. Box 5621, MS 980, Dallas, Texas 75222.

TEXAS INSTRUMENTS
INCORPORATED

Tear out this page.



This Dialight demonstrator unit (shown actual size) is available for your personal evaluation.

Place it next to any readout you're now considering. Then walk back 30 feet and prove to yourself that low-cost Dialight readouts are easier to read.

The only way to be sure is to compare Dialight readouts with others. This little test will give you a rough idea of the difference. But it's not quite as convincing as the actual demonstration we'll be happy to provide you with on request.

Dialight readout modules cost as little as $3.99 each (less lamps in 1000 lot quantities). They operate on 6, 10, 14-16, 24-28 volts AC-DC, 150-160 volts DC and 110-125 volts AC. Caption modules are available; each is capable of displaying up to six messages at one time. Windows are of non-glare type in a choice of colors.

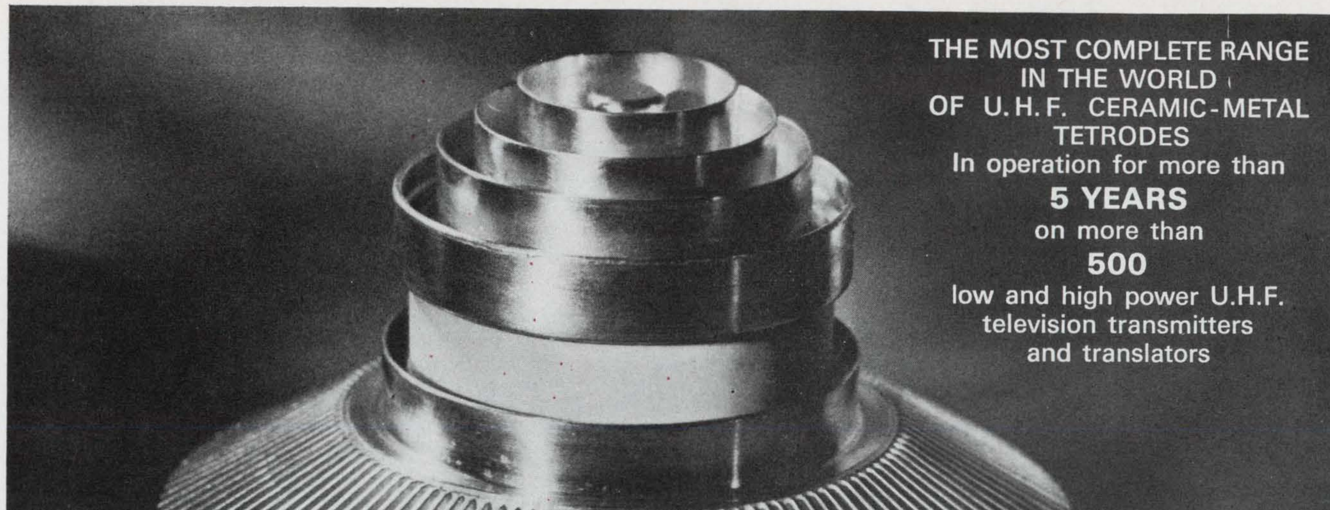
Options: universal BCD to 7-line translator driver, 10-line to 7-line converter for decimal input, RFI-EMI suppression screen. Custom translators available.

To arrange to borrow a Dialight demonstrator unit, write us on your company letterhead.

For copy of our current catalog, circle reader service number below. Dialight Corporation, 60 Stewart Ave., Brooklyn, N.Y. 11237. (212) 497-7600.

DIALIGHT

Circle 71 on reader service card



OUTSTANDING PERFORMANCES
IN SSB COMMUNICATIONS — TROPOSPHERIC SCATTER LINKS — RADARS

1.5 kW TH 297 — COMPACTNESS — 3 kW TH 293 — RUGGEDNESS — 6 kW TH 313

THE MOST ADVANCED TECHNOLOGY * — THE LOWEST OPERATION COST

HIGH LINEARITY — 12 kW TH 290 — LONG LIFE — 25 kW TH 491 (VAPOR COOLED) — HIGH RELIABILITY

** Special grids patented*

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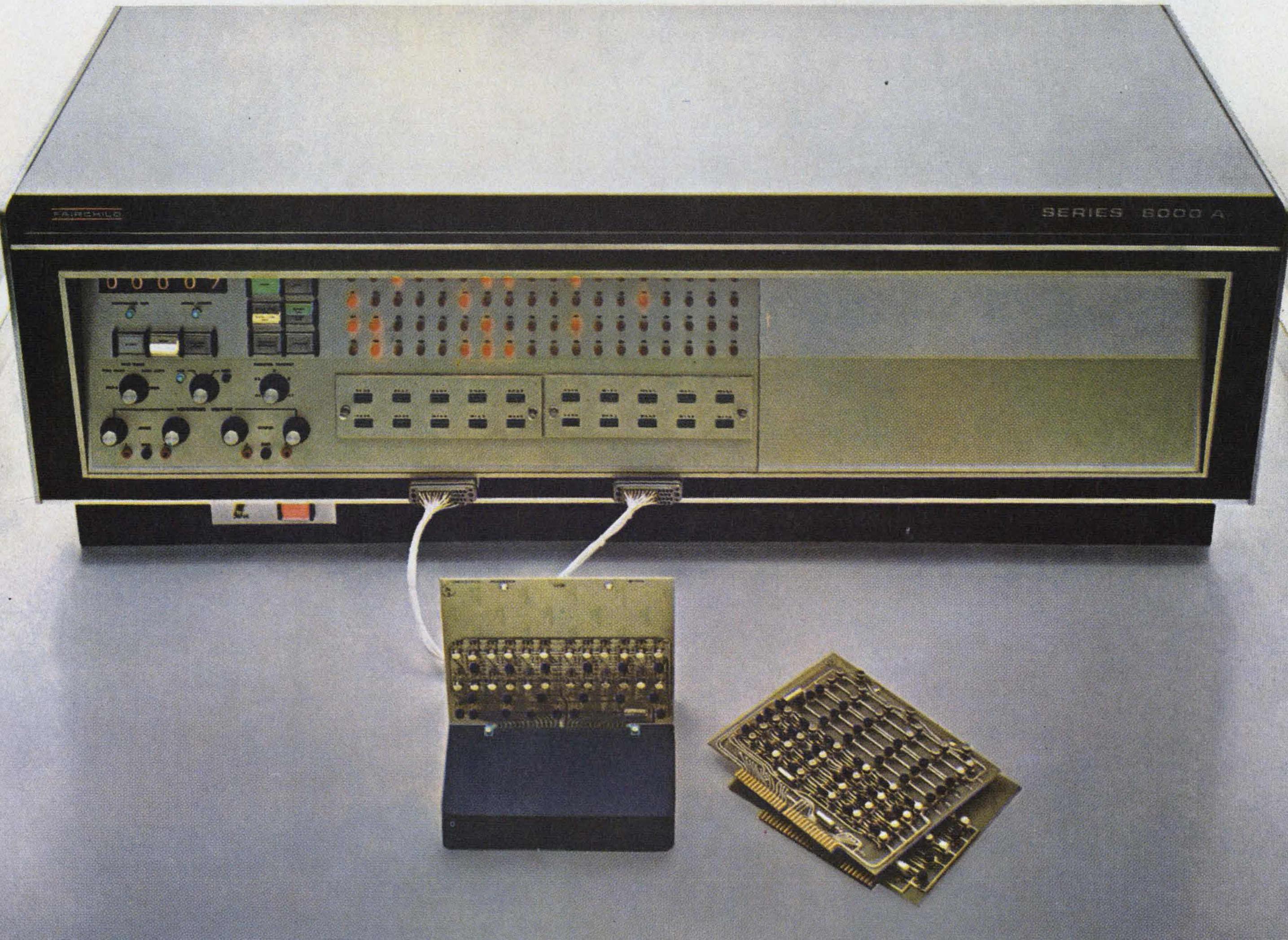
THOMSON ELECTRIC Co INC. 50 ROCKEFELLER PLAZA · ROOM 916 NEW-YORK, 10020 N.Y. U.S.A. · Phone : (212)245.3900

Circle 73 on reader service card →

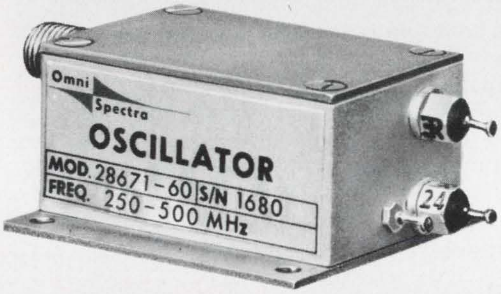
Logic card test system. Half-a-million tests a second: $96,000.

The Fairchild 8000A Logic Card Test System will test almost any complex circuit you've got. LSI. MSI. Thin-film circuits. Anything. It's computer-controlled and can make 10,000 tests a second per pin. Its basic 48-pin capability can be expanded to 144 pins. And, every pin has its own comparator. There's no faster, more economical way to functionally test complex devices or printed circuit cards. Why not call Fairchild collect and get all the facts. Our number is (408) 735-5461. Ask for Ulrich Kaempf.



FAIRCHILD INSTRUMENTATION A Division of Fairchild Camera and Instrument Corporation 974 East Arques Avenue, Sunnyvale, California 94086 (408) 735-5461 TWX: 910-339-9217

SOLID STATE VTOs OCTAVE RANGES 10 MHz - 5.2 GHz



SERIES 28670
10 MHz to 1000 MHz

In octave frequency ranges from 10 MHz to 1000 MHz, the OSM® Series 28670 Voltage Tuned Oscillators are high performance, compact, and light weight signal sources. Their many applications include remotely tuned oscillators, medium power sweep oscillators and digitally tuned frequency sources in automated test equipment. Features include medium power output, good frequency stability, low noise, minimal power requirements and operation from −54°C to 71°C.

SERIES 28770
1.0 GHz to 5.2 GHz

These new high power solid state OSM® Series 28770 Oscillators were designed to replace VTMs and BWOs in commercial and military system applications.

From 1.0 GHz through 5.2 GHz these small (1" x 1" x 2") electrically tuned units feature high power output with greatly improved harmonic suppression (30 dB typical) without filters. Oscillator systems are available that can be pulse modulated, power leveled, injection locked, and tuning curve linearized.

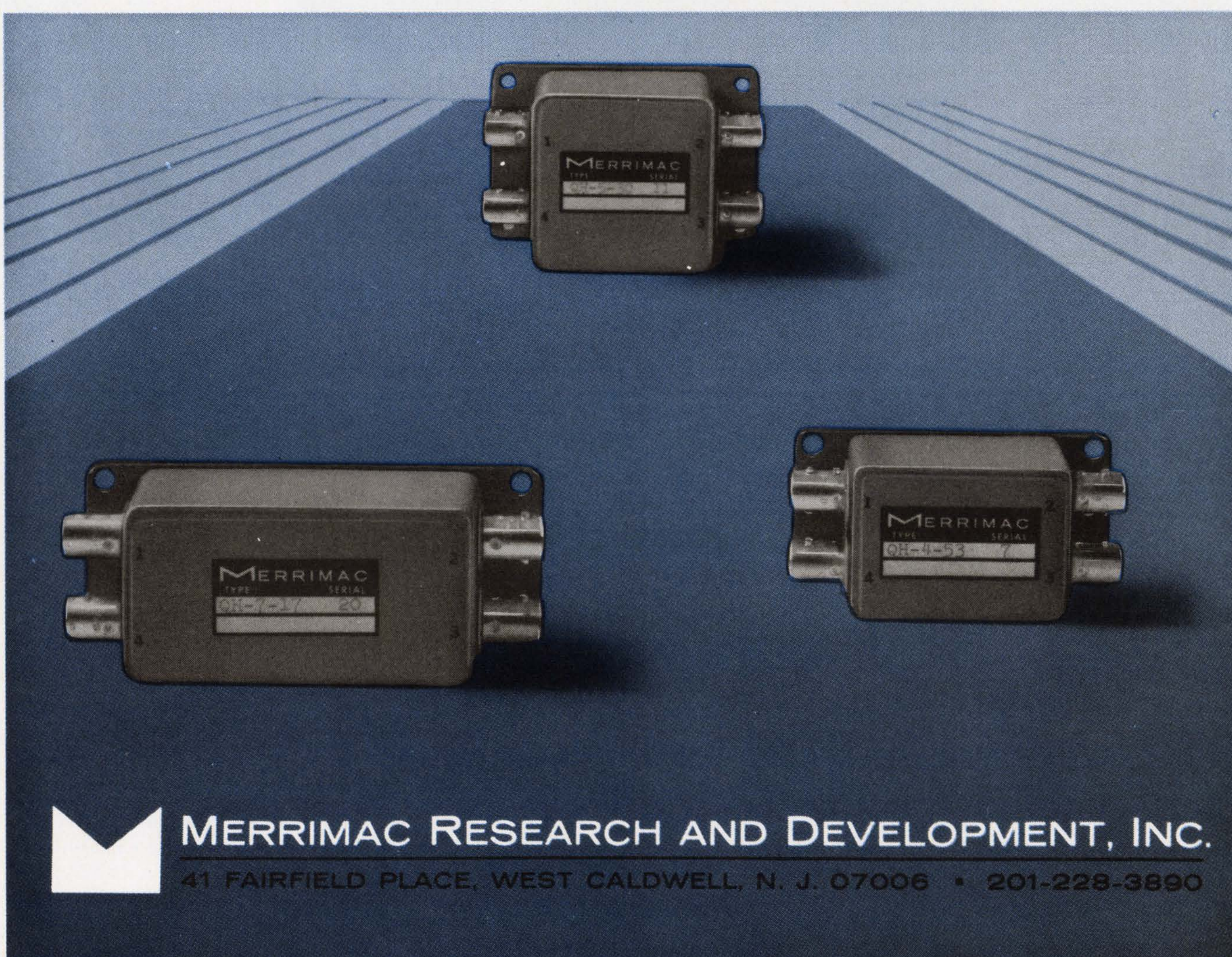
For further information call, TWX or write your nearest Omni Spectra representative or Omni Spectra, Arizona Division, 253 So. Hinton St., Scottsdale, Arizona 85251. Tel. (602) 947-4346 TWX (910) 950-1296

Send for our new 68 page catalog of OSM® Solid State Devices, Components and Connectors.

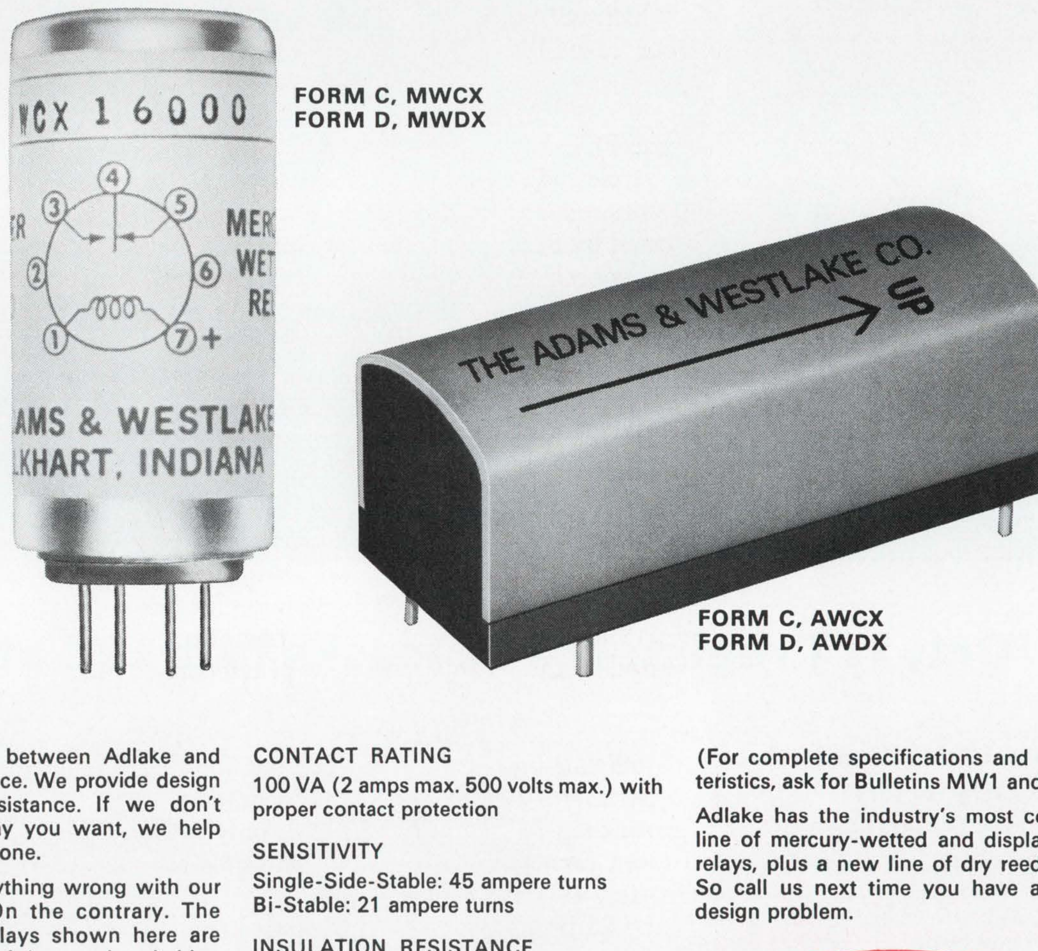
Omni Spectra, Inc. Arizona Division

THREE NEW BROADBAND QUADRATURE HYBRIDS

Merrimac's new lineup of broadband quadrature hybrids are unsurpassed in performance, quality and price. The QH-7-17 covers the full bandwidth over 2-to-32 MHz with 23 db minimum isolation. This four-port hybrid network exhibits less than 0.75 db insertion loss and output equality of 0.3 db. Phase quadrature is 90° ±2°. Other new broadband quadrature hybrids include the QH-4-53 covering 30-to-76 MHz and the QH-5-30 covering 10-to-50 MHz. Their low prices will surprise you! These broadband networks are extremely useful for imageless mixing, single sideband modulation, radio direction finding, phasing of antenna systems, and homing systems. Also available are a variety of reduced bandwidth and miniature quadrature hybrids from audio to microwave. For more details, write or phone Merrimac.



The most important thing about these relays is the company that makes them



FORM C, MWCX
FORM D, MWDX

FORM C, AWCX
FORM D, AWDX

The big difference between Adlake and other people is service. We provide design and application assistance. If we don't have the exact relay you want, we help you develop a new one.

Not that there's anything wrong with our standard relays. On the contrary. The mercury-wetted relays shown here are ideal devices for high-speed switching and for circuit isolation, especially when high package density is essential.

Some specifications:

CONTACT ARRANGEMENT

(Plug-In)
MWCX-16000: SPDT, Form C
MWDX-15000: SPDT, Form D

(Printed Circuits)
AWCX-16000: SPDT, Form C
AWDX-15000: SPDT, Form D

LIFE

In excess of one billion operations with proper contact protection

CONTACT RATING

100 VA (2 amps max. 500 volts max.) with proper contact protection

SENSITIVITY

Single-Side-Stable: 45 ampere turns
Bi-Stable: 21 ampere turns

INSULATION RESISTANCE

1000 megohms min. at 500 VDC, 45% RH and STAND OFF VOLTAGE at 1000 VAC 60 Hz (between all mutually insulated terminals except between windings of bifilar construction coils)

BRIDGING TIME, FORM D

10 to 500 microseconds

TRANSFER (null) TIME, FORM C

10 to 600 microseconds

OPERATE MAKE TIME

As low as 1.0 milliseconds for Single-Side-Stable, and 0.9 milliseconds for Bi-Stable operation

(For complete specifications and characteristics, ask for Bulletins MW1 and MW2)

Adlake has the industry's most complete line of mercury-wetted and displacement relays, plus a new line of dry reed relays. So call us next time you have a circuit design problem.

Adlake
SINCE 1857

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Washington Newsletter

June 10, 1968

Blame terrain radar for F-111 crashes

Although the Air Force insists that the seven F-111 crashes haven't been caused by the craft's terrain-following radar, authoritative sources in Washington claim the unit was at fault in some of the mishaps. **The tip-off: F-111's have been ordered to fly at higher altitudes for the time being, and it's at the lower altitudes that the terrain-following radar is crucial.**

One source brands the explanation that a "tube of glue" caused one crash as hogwash. He claims the radar was at fault. **The Air Force has listed a number of official reasons for the crackups but none mention the radar.**

The radar is made by Texas Instruments and is designated AN/APQ-110, which will be replaced in the F-111D integrated avionics system by another TI-built terrain-following radar, the AN/APQ-128.

Breakup of FCC may be in the air

Will the FCC be disbanded? That's the question being raised in Government circles. **There's a likelihood that the President's Task Force on Telecommunications will propose a multiagency setup along the lines suggested by FCC Commissioner Robert T. Bartley.**

In a speech before the Illinois State Broadcasting Association last month, Bartley called for the creation of three agencies to replace the FCC—one to regulate broadcasting, another to regulate common-carrier rates and services, and the third to administer spectrum allocation. **His reason: the FCC is so bogged down by legal procedures that it can't keep up with what he calls the state of the communications art.**

Bartley isn't alone in clamoring for a change. Last week, the Electronic Industries Association's committee that serves as a liaison with the Office of Telecommunications Management appealed for strong federal leadership in telecommunications plans and policies. The committee told the task force in no uncertain terms that such leadership requires **"far more extensive analytical, planning, and engineering resources than are now supported by the FCC and director of telecommunications management."**

L-band, tv tests likely for ATS-F

NASA officials have their work cut out for them this summer—selecting the experiments for Applications Technology Satellites F and G. **From the more than 50 already suggested, only a handful of experiments will be chosen for each mission.** The satellites are scheduled for launching in the early 1970's.

Of the 28 proposed communications experiments, two appear to have the best chances of hitching rides—**a test of L-band equipment and an attempt at a direct tv broadcast from space.** Others likely to make it are wave-propagation experiments (there will be nine of these on ATS-E to be sent aloft in 1969) and frequency-utilization experiments above 10 gigahertz.

The remaining proposed experiments involve meteorology, astronomy, and navigation.

Because all three teams bidding to build the ATS-F and G satellites were selected for competitive contract negotiations, the original NASA target of August for selecting the contractor has gone out the window. NASA officials now hope to pick a winner from among Fairchild-Hiller, GE, and Lockheed Missiles and Space Co. by early fall.

Washington Newsletter

Navy will pick DX semifinalists

The Navy will pick two or three semifinalists late this month from the six competitors for design and production of the DX, a new generation antisubmarine and shore-support destroyer. The winner will be selected in August 1969. **Preliminary estimates are that half of each vessel's cost will be for electronics, so shipbuilders have teamed with electronics firms in their bidding.**

For example, Newport News Shipbuilding has joined Control Data, General Electric, and Philco-Ford's Communications and Electronics division, while Avondale Shipyards has lined up North American's Autonetics, Collins Radio, ITT, and the Edo Corp. **The Defense Department is asking for $246 million in fiscal 1969 for the first five ships.** The Navy will want 50 to 100 vessels, each costing $40 to $50 million.

Meanwhile, Litton Systems, Inc. has been selected over General Dynamics Corp. and Newport News as designer-builder of a new type of helicopter-carrying assault ship, the LHA. The Navy wants to build five and possibly 10 LHA's at a cost of about $100 million each. However, Congress hasn't set aside the money, and current budget-tightening makes it doubtful that a go-ahead will be received in 1969.

FCC approval seen on phone rulings

There are growing indications that the FCC will uphold the examiners' decision in the controversial Carterphone and Microwave Communications Inc. cases, **thus opening the way for "foreign attachments" on telephone system lines and providing competition in microwave service.** The FCC is expected to make its decision this month [Electronics, May 13, p. 59].

However, it will probably provide that technical standards be established by common carriers—subject to FCC approval—to enable such attachments as the Carterphone to be connected to phone systems.

The decision on the microwave case will probably win approval on the basis of Microwave Communications' offer to reduce tariffs between Chicago and St. Louis.

Task Force findings: job for the man who follows LBJ

It appears now that the recommendations of the President's Task Force on Telecommunications, due in August but almost sure to be late [Electronics, Dec. 11, 1967, p. 67], won't be made public until the new Administration takes over. A source at the Office of Telecommunications Management, which is doing much of the task force's legwork, says **the recommendations are going to be controversial and difficult to implement and that President Johnson would just as soon dump them in the lap of the next President.**

Addenda

The Senate is expected to adopt without change the House bill extending the life of the Renegotiation Board by three years. **The measure approved by the House last month kept at $1 million the minimum amount of annual business a contractor must do with the Government before the board can review its profits** [Electronics, May 27, p. 74]. As the board's authorization expires June 30, the Senate will move quickly on the extension . . . When Wernher von Braun warned Congress that draining off NASA money for poverty programs would result in a U.S. technological lag similar to Britain's, he failed to impress the British. Said one embassy official: **"Oh, him. Peter Sellers took care of von Braun years ago in 'Strangelove.'"**

Sorensen's QRE Series, available from stock, will limit overvoltage excursions to 250mV under any condition — then reduce the output voltage to 0 within 10μ sec.

Model QRE 7.5-10

Model QRE 10-3.7

Sorensen QRE Series for IC's:

- ☐ **10μ sec adjustable "Crowbar" overvoltage protection**
- ☐ **Voltage Regulation: ±0.01% for maximum line and load changes combined**
- ☐ **Voltage Ripple: 300μV r.m.s. (3mV peak-peak) max!**
- ☐ **No turn-on/turn-off overshoots**
- ☐ **Remote Programming**
- ☐ **Remote Sensing**
- ☐ **Ambient Temperature: —20 to +71°C**

Model Number	Output Voltage Range	Output Current Range @ Ambient @ 40°C	@ 50°C	@ 71°C	Size (inches) h	w	d	Price
QRE 10-2.2	0-10Vdc	0-2.40	0-2.20	0-1.50	3⅜	5⅛	8¼	$135
QRE 10-3.7	0-10	0-4.10	0-3.70	0-2.50	3⅜	5⅛	11¼	$155
QRE 7.5-10	0-7.5	0-10.0	0-10.0	0-6.60	3½	19	13¼	$295
QRE 7.5-20	0-7.5	0-20.0	0-20.0	0-13.0	5¼	19	13	$465
QRE 7.5-50	0-7.5	0-50.0	0-50.0	0-33.0	5¼	19	15¼	$645

Contact your local Sorensen representative or: Raytheon Company, Sorensen Operation, Richards Ave., Norwalk, Connecticut 06856. TWX 710-468-2940.

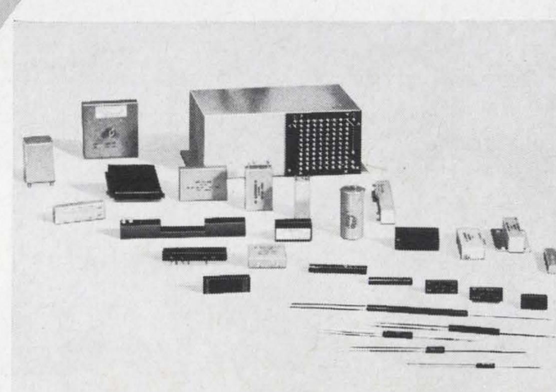
RAYTHEON

for more data on this versatile instrument . . . **Call Sorensen: 203-838-6571**

JFD announces . . . NEW delay Line SERIES...

*

JFD Delay Lines are top quality, ruggedly constructed, precision components of proven dependability. A variety of models, having a wide range of electrical and physical parameters, are production items. Characteristics and mounting methods available in standard JFD units meet the requirements of a wide variety of circuit applications. Delay Lines for highly specialized applications are designed in JFD laboratories. A staff of skilled engineers employ proven techniques to limit development time to a minimum.



Illustrations shown 1/15 actual size.

Distributed Constant

JFD distributed constant Delay Lines manifest minimum rise-time and distortion characteristics. Miniaturized and hermetically sealed models are available. Measured delay-time is within 5% of rating in most models.

Lumped Constant

JFD lumped constant Delay Lines are compact in size relative to delay-time. Attenuation, distortion and temperature coefficient of delay are minimized. Ratio of delay to rise time is excellent and delay tolerances may be held to within 0.2% when required.

Continuously Variable

JFD continuously variable Delay Lines are designed to withstand shock and vibration and meet military environmental requirements. Resolution is better than 1/1000th of maximum delay across the entire delay range, in most models.

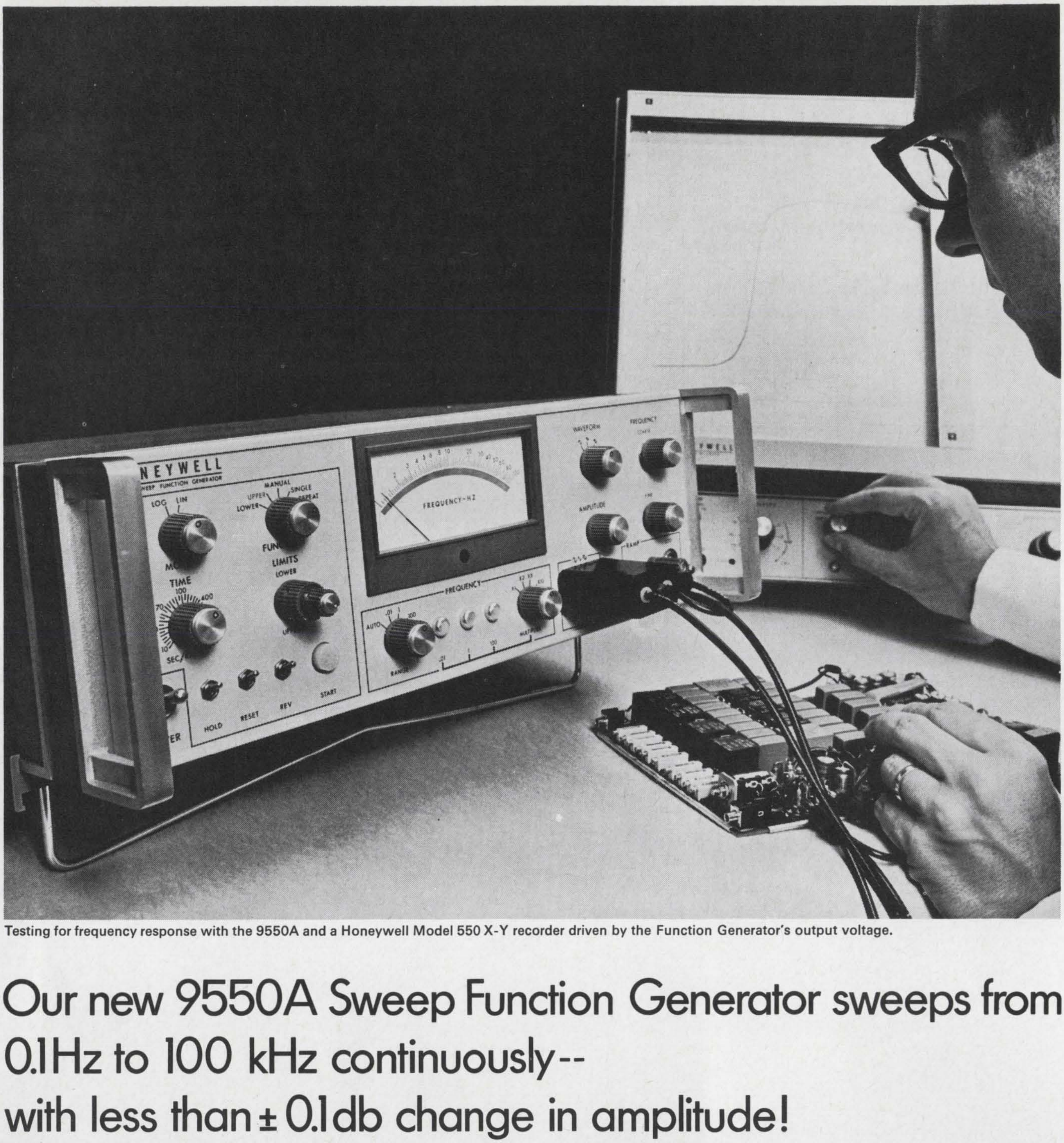
For additional information, write for catalog DL-68.

"TODAY'S COMPONENTS BUILT FOR TOMORROW'S CHALLENGES"

JFD

JFD ELECTRONICS CO. / COMPONENTS DIVISION / 15th Avenue at 62nd Street / Brooklyn, New York 11219 / Phone 212-331-1000
Offices and subsidiaries in principal cities, world-wide.

Circle 83 on reader service card →



Testing for frequency response with the 9550A and a Honeywell Model 550 X-Y recorder driven by the Function Generator's output voltage.

Our new 9550A Sweep Function Generator sweeps from 0.1Hz to 100 kHz continuously-- with less than ± 0.1db change in amplitude!

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Six decades of frequency are spanned by the 9550A's logarithmic sweep, with linear sweep over a two-decade frequency span. The instrument's auto-range permits a linear voltage-to-frequency relationship over the entire range, and a logarithmic analog voltage-to-voltage relationship accurate to within 0.3 db. Log or linear voltage proportional to the changing frequency is produced by the 9550A to drive associated recording instruments such as the X-Y recorder in our illustration. Sweep start and stop limits and single or repetitive sweep cycles are programmable.

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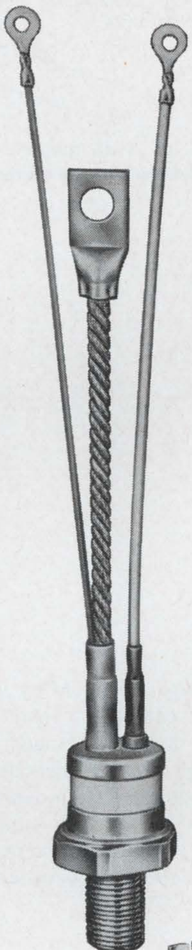

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I^2t	— I^2t FOR FUSING (FOR TIMES ≧ 1.5 MILLISECONDS)	3370 A^2SEC.
Idm	— MAXIMUM FORWARD LEAKAGE CURRENT AT 125°C. AND RECURRENT PEAK VOLTAGE	10 MA
t off	— TYPICAL OFF TIME AT 125°C.	40 μ SEC.
t on	— TYPICAL ON TIME	10.5 μ SEC.
t r	— TYPICAL RISE TIME	3.25 μ SEC.
t d	— TYPICAL DELAY TIME	7.25 μ SEC.
θJ-C	— MAXIMUM THERMAL RESISTANCE, JUNCTION TO CASE (DC)	0.32°C./W.
Tj	— OPERATING JUNCTION TEMPERATURE	125°C.
Tstg	— STORAGE TEMPERATURE	—40°C. to 150°C.

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Vgt	— TYPICAL GATE VOLTAGE TO TRIGGER AT 25°C.	1.3 V.
Vgd	— MAXIMUM NON-TRIGGERING GATE VOLTAGE AT 125°C.	0.25 V.
Igt	— MAXIMUM GATE CURRENT TO TRIGGER AT 25°C.	200 MA
Igt	— TYPICAL GATE CURRENT TO TRIGGER AT 25°C.	100 MA
Pgm	— MAXIMUM PEAK GATE POWER	15.0 W.
Pg avg	— AVERAGE GATE POWER	3.0 W.
Igm	— MAXIMUM PEAK GATE CURRENT	4.0 A.
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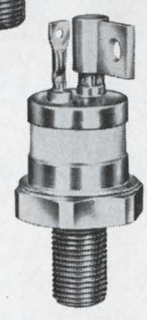
*1300 Volt Transient Rating



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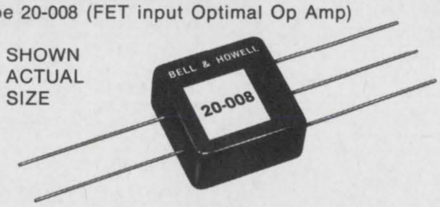

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input bias current	150 nA	10 pA
common mode rejection	100 db	100 db
gain band width (at 10 kHz)	20,000,000	20,000,000
output current	5 mA	5 mA
PRICE (in quantities of 10-99, any mix)	$25	$33

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parameter	TYPE 20-007-B	TYPE 20-007-C	TYPE 20-008-03
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input bias current (max.)	150 nA	150 nA	25 pA
PRICE, (quantities 10-99, any mix)	$20	$15	$28

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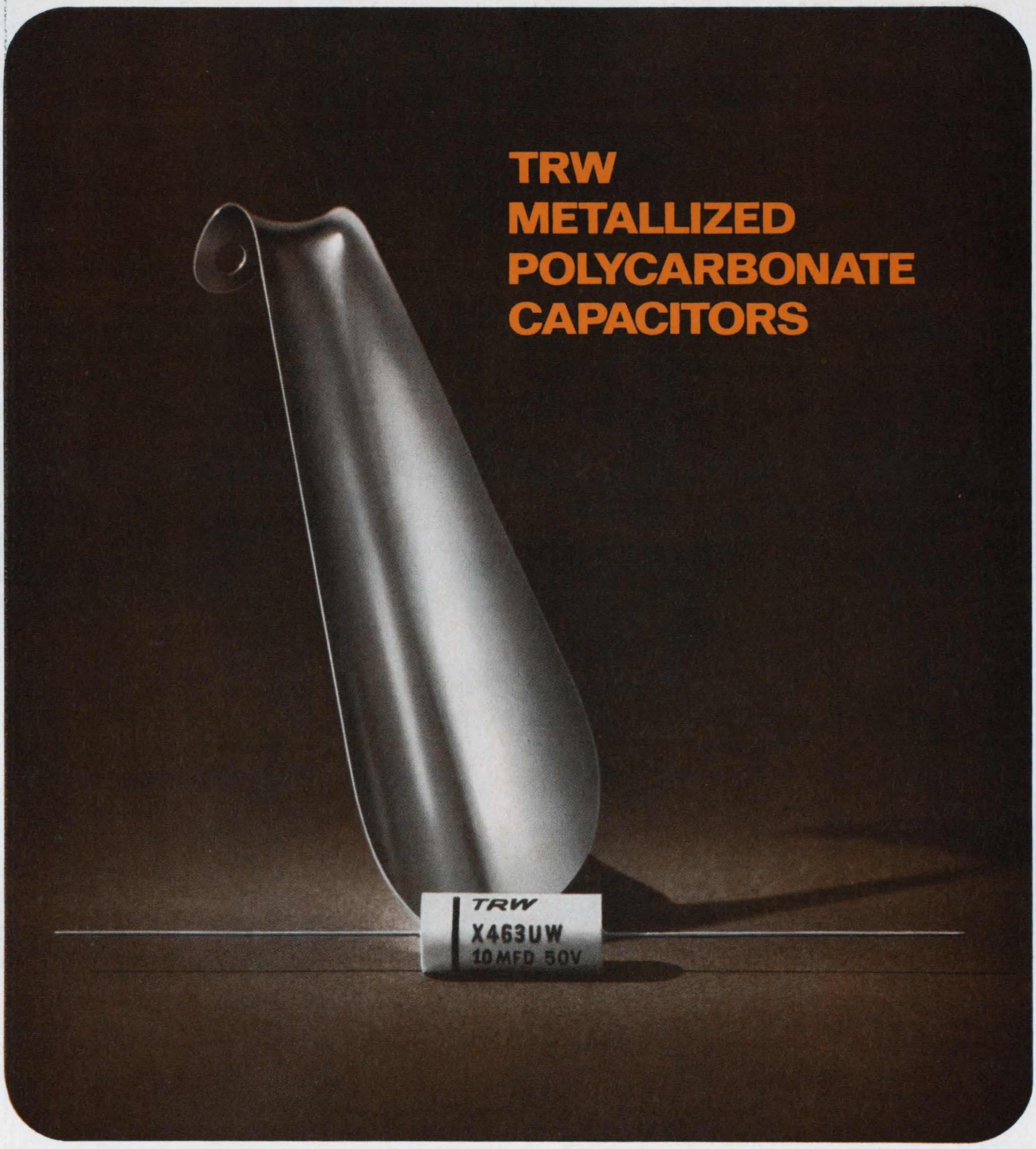

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Circle 87 on reader service card

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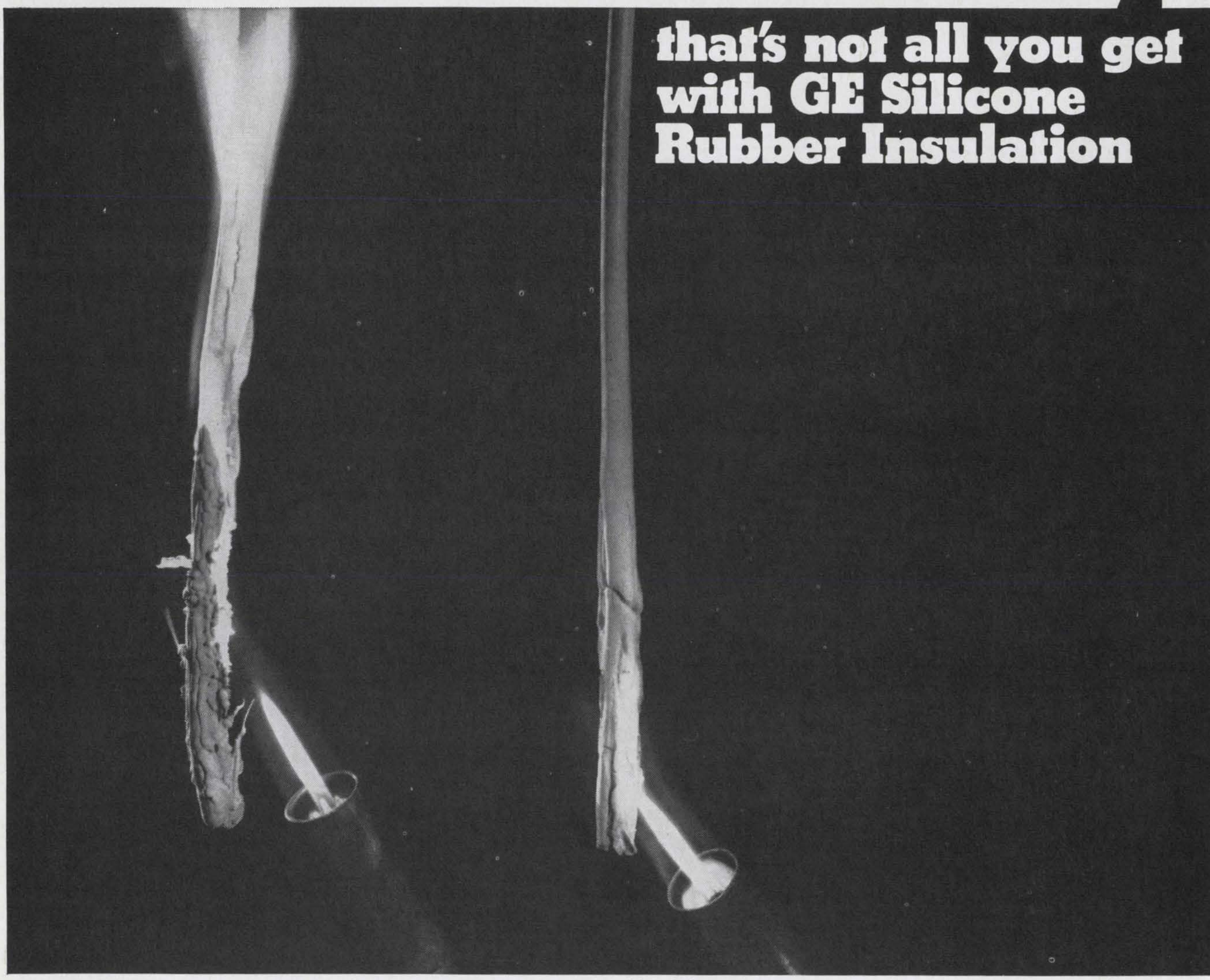

New ultra-tough SE-9090 braidless wire and cable insulation (right) doesn't support combustion like conventional insulation. It's shown here passing the UL vertical flame test. SE-9090 has both outstanding insulation resistance and dielectric strength.

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GENERAL ELECTRIC

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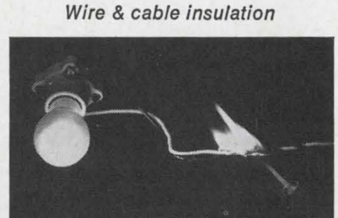
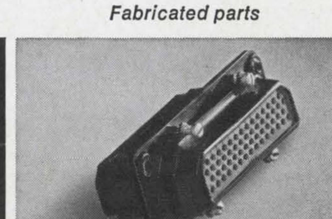
Conformal coatings

Wire & cable insulation



Fabricated parts



 Circle 88 on reader service card

Circle 89 on reader service card→

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Introducing the potentiometer that's four-times as noise free, twice as linear, has up to 20 times the cycle-life of the Allan-Bradley Series J . . . and costs about 10% less.
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It's quietly revolutionary.
CLAROSTAT

CLAROSTAT 2 Watt Potentiometer

MODEL 380 MIL STYLE RV 4

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SIZE: 1$\frac{1}{16}$″ DIAMETER
RESISTANCE RANGE: 100 OHMS TO 5 MEGOHMS
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POWER RATING: 2 WATTS (SINGLE CONTROL)
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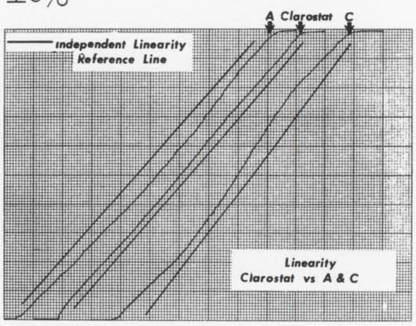

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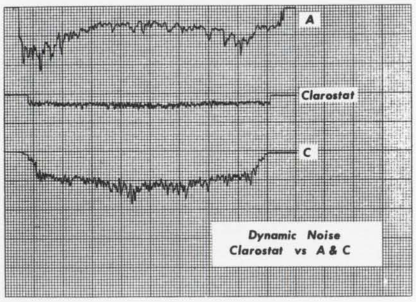

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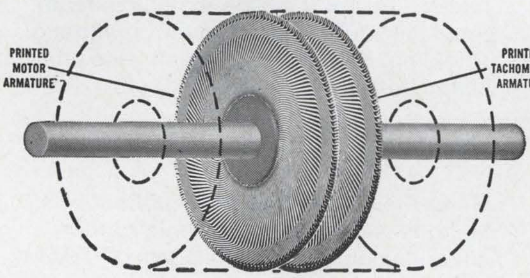

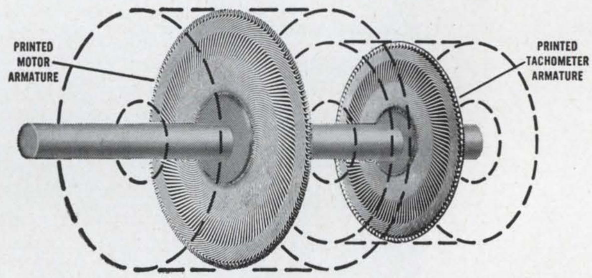

INTEGRAL TACHOMETER – Adds a superior tachometer to standard printed motors **with no increase in motor size.** Tach features include low ripple (5% peak-to-peak at 100 rpm; below 2% over 1000 rpm), excellent linearity and elimination of mechanical coupling and torsional resonance problems. The printed tachometer armature typically has the equivalent of over 100 commutator bars raising the frequency of output ripple far beyond that attainable with conventional tachometers. Ideal for wide speed range velocity servos.

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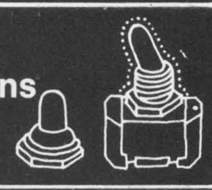

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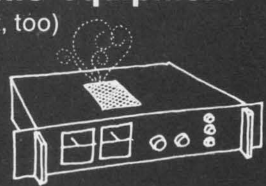

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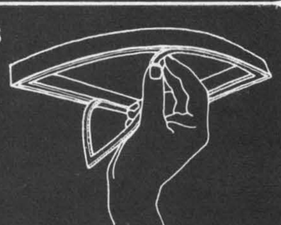

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103

Who's who in this issue

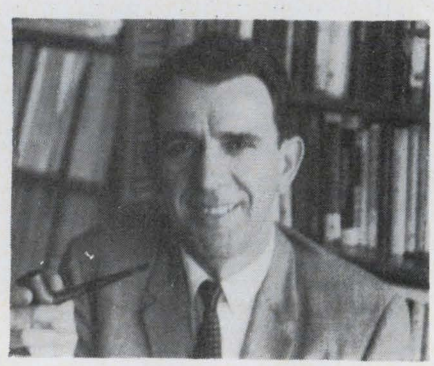
From cathode-ray tubes to microwave integrated circuits—with stops on the way at color-television tubes, germanium transistors, and diodes—describes the path taken by **William J. Moroney** [p. 100]. Director of semiconductor development at Microwave Associates Inc.'s engineering division, he holds a bachelor's degree in chemistry from Niagara University, another in chemical engineering from Syracuse University, and a master's in physics from Northeastern University.

Moroney's experience in sealing color-tv tubes with glass frits paved the way for his work in sealing semiconductors with glass.

Looking ahead. Currently, his staff is engaged in such projects as basic raw materials for diodes, bulk oscillators—including Gunn and avalanche diodes—varactor diodes, and, of course, microwave IC's. Most of the work on the latter is still in the research and development stages. As for the future of microwave IC's, Moroney says a great deal will depend on whether heavily funded programs are in the offing.

But, says Moroney, even at the present development rate, all indications point to tomorrow's microwave circuits being semiconductor oriented.

The education of **Louis de Pian** [p. 114] in both electrical engineering and the English language was begun in Greece and completed in the U.S. He was born in Athens in 1925 and came to the U.S. in 1949 to obtain his doctorate at the Carnegie Institute of Technology. He taught at Carnegie until 1957, when he became a professor of applied science at George Washington University.



Pioneer. De Pian, now chairman of the electrical engineering department at George Washington, wrote "Linear Active Network Theory," published in 1962, five years before any practical active filters came on the market. Soon afterward he organized a formal course on active filters at George Washington University.

One of the biggest hurdles that must be overcome in achieving radiation-hardened circuits is the lack of adequate data. That's the opinion of **Fred W. Karpowich** [p. 122]. A senior staff engineer at Avco's nuclear-effects section, he says: "For now, the only way to get information is to talk directly to companies doing such work and to attend the classified meetings.

This lack of communications, Karpowich points out, leads to duplication of testing efforts.

Outlook brightens. But he sees some hope. "Since the Government's requirements for future systems will include radiation specifications," says Karpowich, "the need for radiation testing will rapidly increase." He feels that the Government—particularly the military—is beginning to look at radiation effects as just another environment, like temperature and humidity. And this, he believes, will force manufacturers to provide radiation test data on their device specifications.

"Engineers concerned with radiation hardening must broaden their horizons in many disciplines," says **Joseph T. Finnell Jr.** [right]. Head of the nuclear-effects section at the Avco Corp.'s Missile Systems division, he feels not enough use is made of computer-aided techniques for design and analysis.

Finnell, who has written several

articles and presented a number of papers on the effects of radiation, feels computer techniques are cheaper in the long run. Unless a one-shot approach in circuit testing proves fruitful, repetition of both measurement and analysis becomes time consuming and costly.

What's ahead. But Finnell believes most engineers recognize that computer techniques are the wave of the future. He anticipates greater use of computers in both designing and testing of radiation-hardened circuitry.

General Electric's vibrating rate sensor has been engineer **Bill Gates'** baby for the past 2½ years [p. 130]. He's carried it through from the initial concept to its current test flights. Before this project, Bill worked on the development of electrostatic gyros, a d-c brushless torque motor, and optical inertial tracking systems for space vehicles.

He's been with GE since 1960, even before he got his bachelor's degree in electrical engineering from Rensselaer Polytechnic Institute in 1961. He earned a master's degree in engineering from Union College two years later.

Boost IC op amp power with Helipot's miniature hybrid amplifier.

Actual Size

Here's how it performs:

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- 30 MHz bandwidth
- ±16V voltage swing
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- −55 to +125°C operation
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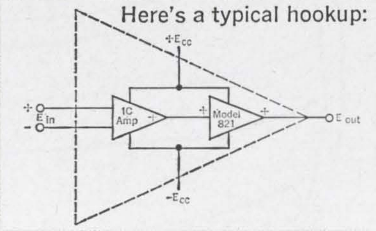

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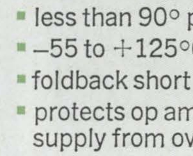
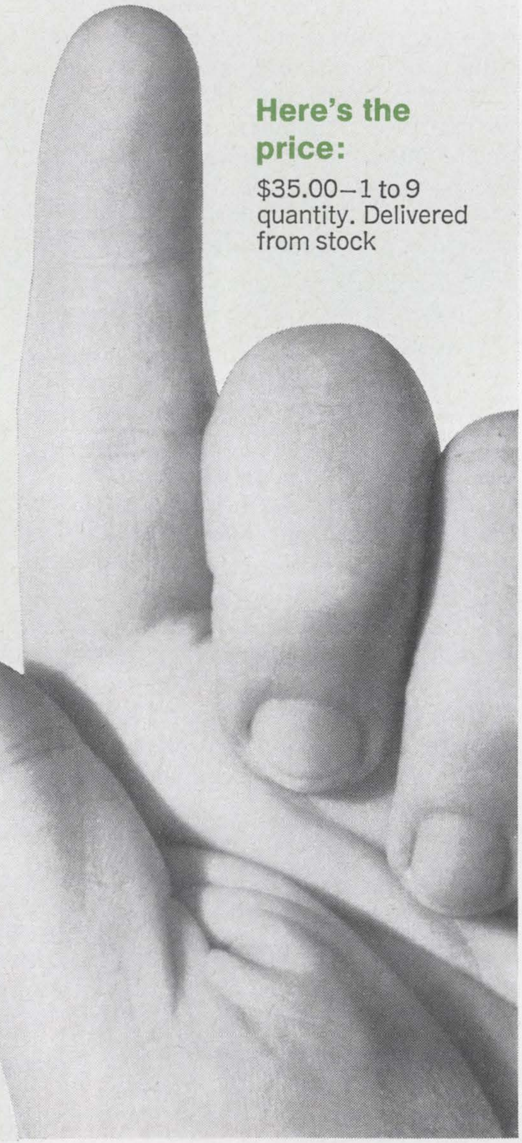


The new Model 821 is a hybrid, cermet thick film power amplifier which drives load resistances as small as 100 ohms to within 4 volts of the supply voltage from d-c to 30 MHz. Its combination of unity voltage gain and wide bandwidth permits boosting the power of an IC amplifier without affecting its other performance capabilities. In addition, the Model 821's ability to block all overload reflections results in the prevention of heat generated errors in the op amp and allows immediate recovery upon overload removal.

Completely self-contained, this fully sealed power amplifier is only 0.170″ high, occupies just 0.5 sq. inches of board space, and is compatible with both flat pack and dual in-line IC packages.

Ask your local Helipot sales representative for complete information on the Model 821.



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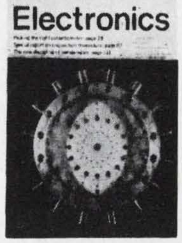
June 10, 1968 | **Highlights of this issue**

Technical Articles

A wide-angle look at microwave IC's page 100



Integrated-circuit technology holds out the same promise for microwave circuits as it does for lower-frequency circuits: smaller size, lower cost, and higher reliability. But microwave IC's which are hybrids, differ from other members of the IC family. An example of this is the circuit shown on the cover—a single-pole, multithrow S-band switch now in the development stage. The cover was photographed by Vincent Pollizzotto.

Using the gyrator in active filters page 114

No longer a theoretical device, the gyrator is now being used in many applications to eliminate inductors in low-frequency filters. Two basic procedures for designing gyrator filters indicate how the engineer can use this unusual circuit.

A guide to radiation testing page 122

Basic techniques for testing components in simulated radiation environments are outlined. Among the areas covered: the sources that best simulate different radiation environments, their location, and their use. Among the factors considered: the problems posed by the different types of radiation.

Coriolis force drives aircraft rate sensor page 130

A vibrating metal beam rotated around its longitudinal axis at a varying speed will experience a Coriolis force perpendicular to the vibration plane. This force, when sensed by piezoelectric sensors, can provide a measure of an aircraft's angular acceleration. This new rate sensor thus has no moving parts, and it costs less, lasts longer, and is more reliable than conventional rate gyros and accelerometers.

Trends in consumer electronics page 136

Color-television receivers will outsell black-and-white sets this year for the first time, but not principally because of any major technical improvements in present or upcoming equipment. However, set makers are working to improve color tuning and picture quality, though black-and-white set designs remain pretty much frozen. Portables will account for a high percentage of this year's color sales. Large-screen color tubes are brighter than ever, and a single-gun color tube that requires no convergence circuitry will make its debut this summer.

Coming

In the next issue, a way of producing real-time pictures of microwave field patterns in full color will be described.

Microwave IC's: part 1
New problems, but newer solutions

With the application of both thin- and thick-film methods in hybrid fabrication, integrated circuits provide answers to the problems of size, cost, and reliability raised by new microwave systems

By William J. Moroney

Microwave Associates Inc., Burlington, Mass.

Bearing little resemblance to its older, lower-frequency cousins, the microwave integrated circuit nevertheless still retains the IC family traits. Like all IC's, it holds out the promise of higher reliability, greater functional versatility, smaller size, and lower cost than conventional circuitry. The differences, however, stem from the job cut out for microwave IC's—handling frequencies ranging from 300 megahertz to the millimeter spectrum at 94 gigahertz.

Instead of the familiar chips of silicon encased in TO metal cans, flatpacks, and dual-in-line plastic cases, microwave IC's are hybrid circuits on ceramic substrates with lumped and distributed elements.

And because it's distributed, a microwave IC is larger than its monolithic cousins—typically, 2 by 2 inches compared with 50 by 50 mils. Size, though important, is a secondary consideration in microwave systems; greater importance is attached to reliability, versatility, and over-all system costs.

Military and space systems, particularly radar and communications, are currently the biggest outlets for microwave IC's. But air and sea navigation—including traffic control, guidance, and collision-avoidance systems—plus closed-circuit television hold out great potential for microwave-IC applications. And potential consumer applications range from garage-door devices to cooking ovens.

The changing scene

The appearance of IC's on the microwave scene is part of the solid-state evolution. Microwave engineers have been employing solid state devices since 1958, when they replaced the tube devices used for power generation and switching with varactor-diode multipliers and p-i-n diodes. These devices were fabricated and encased in packages that were capable of handling parasitic capacitances and inductances but weren't optimized for microwave frequencies. To overcome the unwanted parasitics stemming from the diode package's ceramic sleeve and metal prongs, engineers had to build in neutralizing elements. The C's of 0.2 to 0.75 picofarad and L's of 0.1 to 1 nanohenry associated with the 0.03-to-0.75-inch components were merely designed around.

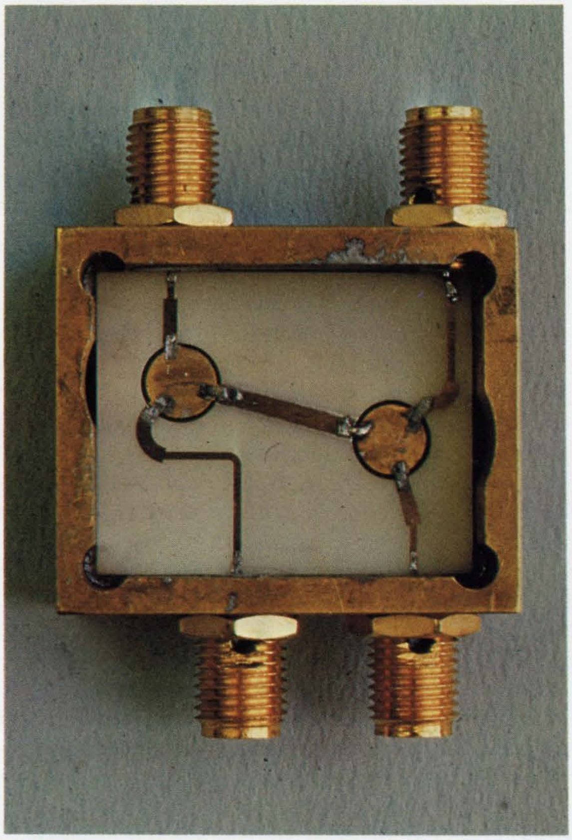
In the 1960's, microwave transistors emerged to challenge amplifying tubes. Also in use were solid state sources, switches, limiters, parametric amplifiers, and phase shifters. And semiconductor makers, to ease microwave design problems, began to put these devices in coaxial structures and in strip-line form.

Microwave IC's have come along within the last two years. Most of the circuits developed thus far employ distributed elements in which the total electrical property is a function of the running length. For circuits operating at 1 Ghz and higher, distributed networks are preferred because the lumped network becomes impractical. Lumped-element lengths must be less than 1/16th of a wavelength. As the wavelengths get shorter, lumped elements become too small to fabricate and the desired electrical characteristics become extremely difficult to obtain.

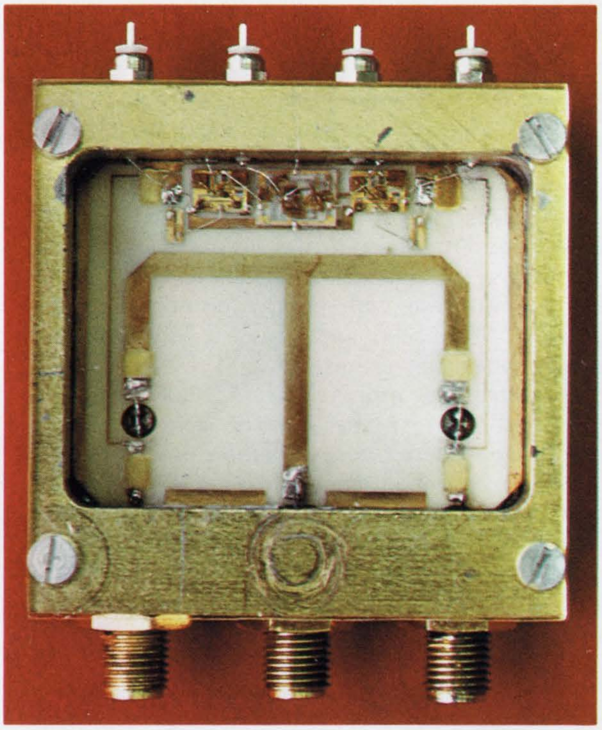
Lumped networks are generally smaller than the distributed type. Lumped load resistors and bypass capacitors—on stubs rather than in the transmission line or in networks—are in X-band applications and active chips have operated at 16 Ghz and even at higher frequencies.

Flat transmission-line fabrication falls into two

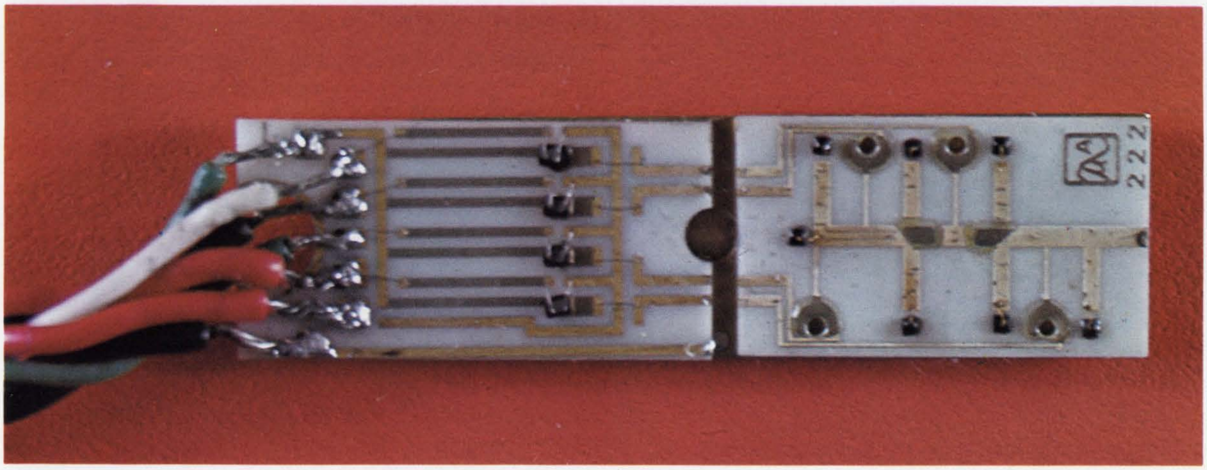
Variety of sizes and functions



Circulator. This X-band, four-port circulator uses 20-mil thick alumina and handles 500 watts peak with an 0.8 db transmission loss and 0.4 db reception loss. The circuit provides 40 db isolation over a 25% bandwidth. Magnets are located below the ferrite disks, which are mounted in holes in the ceramic. The ceramic is 1 inch square. Thick-film techniques are used.



Switch. An L-band single-pole, double-throw switch handles 2 kilowatts peak power at 0.001 duty cycle. The alumina board measures 2 by 2 inches and is 60 mils thick. Conductors are deposited on the board by thick-film process. Signal input is through the center conductor and shunt diodes direct the signal to one of the two output arms. Insertion loss is 0.5 db.



Phase shifter. A Ku-band, four-bit phase shifter, measuring only 0.220 by 1 inch, has two 20-mil alumina boards mounted on a supporting plate—one board for the thick-film phase shifter, and the other for the thin-film driver for the p-i-n diodes. The diodes are located at ends of various length impedance stubs, which act as transformers to translate the diode reactance to achieve the desired phase shift. The power level is 100 watts peak.

Microwave IC materials

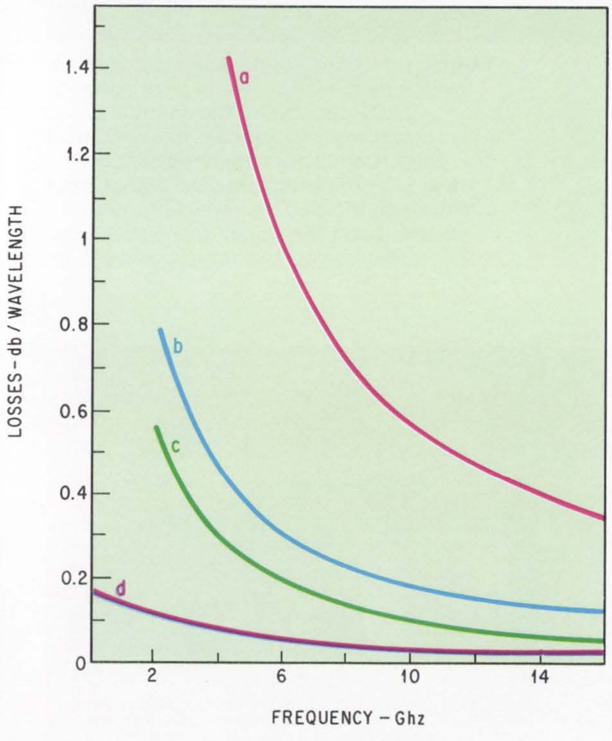
Dielectrics	Coefficient of expansion (10^{-6} cm/cm/°C)	Thermal conductivity (cal/cm²/sec/°C)	Resistivity (ohm-cm)	Dielectric constant (ε)
Alumina, 96%	6-9	0.04	10^{14}	9
Beryllia	~6	0.50	10^{17}	9
Silicon, high resistivity	~2.5	0.37	10^{3}	11.8
Gallium arsenide, semi-insulating	~6	0.10	10^{6}	12

Conductors	Coefficient of expansion (10^{-6} cm/cm/°C)	Thermal conductivity (cal/cm²/sec/°C)
Copper	16	1.0
Kovar	4.5	0.04
Aluminum	25	0.5
Steel	11	0.1
Gold	14	0.7
Silver	19	0.1

basic categories—microstrip and stripline. The microstrip approach calls for a dielectric material with a circuit pattern on one side and simple ground plane on the other. Because the unbalanced line's radiations can interfere with energy propagation, this approach had limited appeal when low dielectric constant materials were used.

In the stripline approach, the circuit pattern is sandwiched between two dielectric strips. Although this approach doesn't pose radiation problems, it is difficult to use in microwave IC's.

Although there are several monolithic microwave IC's under development, none have thus far reached the market. The diversity of devices required in a microwave circuit—special-purpose diodes, transistors, passive elements, and the like—is still beyond the capabilities of monolithic-IC technology.



Lower loss. Because of alumina's high resistivity, its losses are low—lower than those in silicon. Curve "a" indicates the dielectric loss in 1,000 ohm-cm silicon, 10-mils thick; curve "b" shows dielectric and conductor losses for 5,000 ohm-cm silicon, 10 mils thick; "c" is dielectric loss for 5,000 ohm-cm silicon, 10 mils thick. Curve "d" represents dielectric and conductor loss in alumina that is 20 mils thick.

Moreover, the cost of alumina ceramic material is much less than that of the silicon and gallium arsenide required in monolithics. Silicon is 10 times more expensive and GaAs 100 times costlier. Even when polishing costs are taken into account, the processing of alumina costs less.

And with silicon there is the problem of resistivity and losses. Since silicon's resistivity can drop to as low as 200 ohm-centimeters, its dielectric loss can be quite high; the lower the resistivity, the higher the loss. Because loss is a function of length —2.5 decibels per centimeter for 200 ohm-cm silicon —large-area circuits become impractical. GaAs monolithics with resistivities of 10^6 ohm-cm are feasible but thus far impractical. GaAs is still too costly and the devices are still imperfect. Transistor and p-i-n-diode structures, for example, have been plagued with short carrier lifetimes.

Monolithics can be used in preference to hybrids in applications in which the frequencies are below 500 Mhz or above 14 Ghz. Below 500 Ghz, lumped components are practical and thus the dielectric loss will be low. Above 14 Ghz, in the millimeter range, the line lengths will be so short that line losses will be low even though a distributed-parameter approach is taken.

Through thick and thin

Despite the development effort going into monolithics, it perhaps is no greater than the effort going into film hybrids. The big difference is that the results have been far more fruitful in both thin- and thick-film circuits than with monolithics.

In the thin-film process, composite metals—chrome and gold—are vacuum-evaporated in layers only 500 angstroms thick. In the thick-film process, silver or gold mixtures are fired at high temperatures onto a ceramic substrate. The thick-film approach is one of etching, rather than the printing associated with lower-frequency film circuits. The metal is deposited over the complete circuit and the desired pattern is defined by etching away the unwanted portions. Definition is better and losses lower than with the printed method, where the metal solution is squeezed through a pattern onto a fine mesh.

In both thin- and thick-film processes, the metal conductor's final form is typically 0.5-1 mil thick because of plating in a liquid bath.

Compared with the thin-film process, the thick-film method has a slightly faster turnaround time, requires less costly equipment, and yields capacitors with higher breakdown voltages (1,000 volts against 150 volts for thin films). But thin-film elements have the edge in uniformity, precision, and density. Moreover, they are far more adaptable to handle frequencies above Ku band then thick-film elements are.

Since circuit designs are made photographically with both methods, resolution is high. And conductor losses are about the same for both.

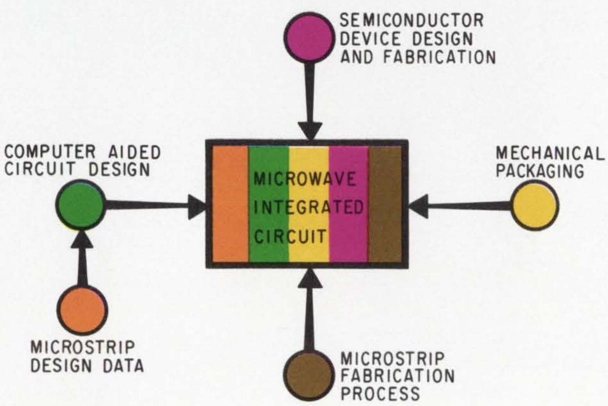
Variations in microstrip

In the typical microwave IC microstrip design, the ceramic has a dual role: substrate for the conductor lines and devices, and transmission line for the circuit. In a few cases, the ceramic serves merely as a substrate for the printed circuit and the components. Here, the ceramic is inserted into an air cavity that functions as a transverse-electromagnetic-wave (TEM) balanced stripline. Since air is the dielectric, this design exhibits lower losses than the ceramic dielectric circuit. The ceramic-air combination has been used in L- and S-band amplifiers.

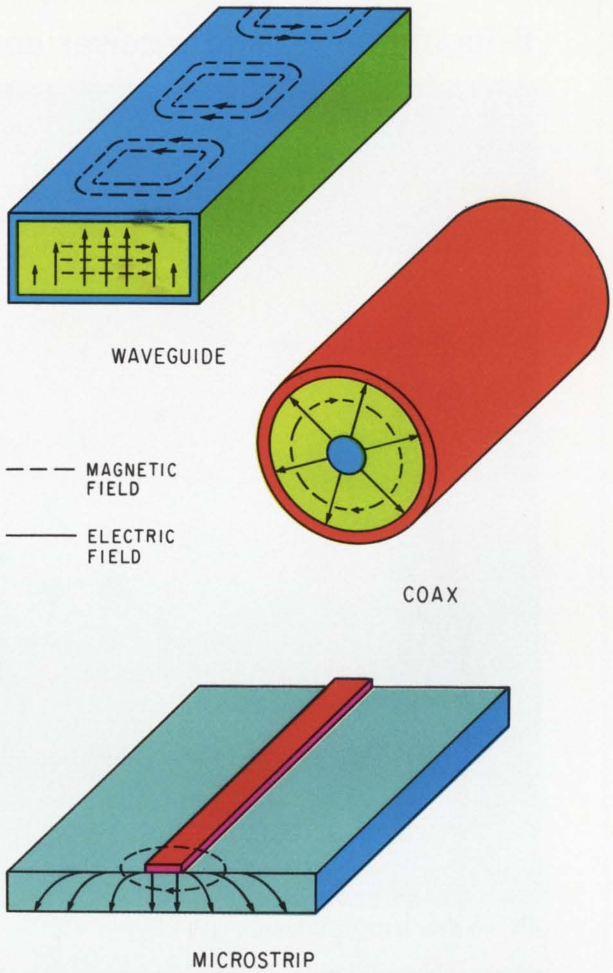
For the most part, however, alumina is the most widely used dielectric in microwave IC's. The alumina, Al_2O_3, has a dielectric constant of $\epsilon = 9$ and confines the field lines in the ceramic material with a minimum of radiation. Compared with glass, beryllia, and titanium dioxide—all used as dielectrics—alumina has the best over-all properties: low dielectric loss, high dielectric constant, little variation in electrical parameters with temperature change, and good stability with time.

When resolution is critical, sapphire (single crystal alumina) is used instead of 96% alumina. Sapphire has a much smoother finish (1-4 microns) than the alumina (5-10 microns).

Although beryllia's heat conductivity is about an order of magnitude higher than that of alumina, its dielectric constant is lower, and is more difficult to process. Glass costs less than alumina, but has a much lower dielectric constant and is more prone to chipping.



Inputs. What it takes to make an IC.



Transmission modes. Propagation of electromagnetic energy assumes distinct field patterns. Transverse electric mode is shown for waveguide structure, and transverse electromagnetic modes for coaxial configuration, and IC microstrip.

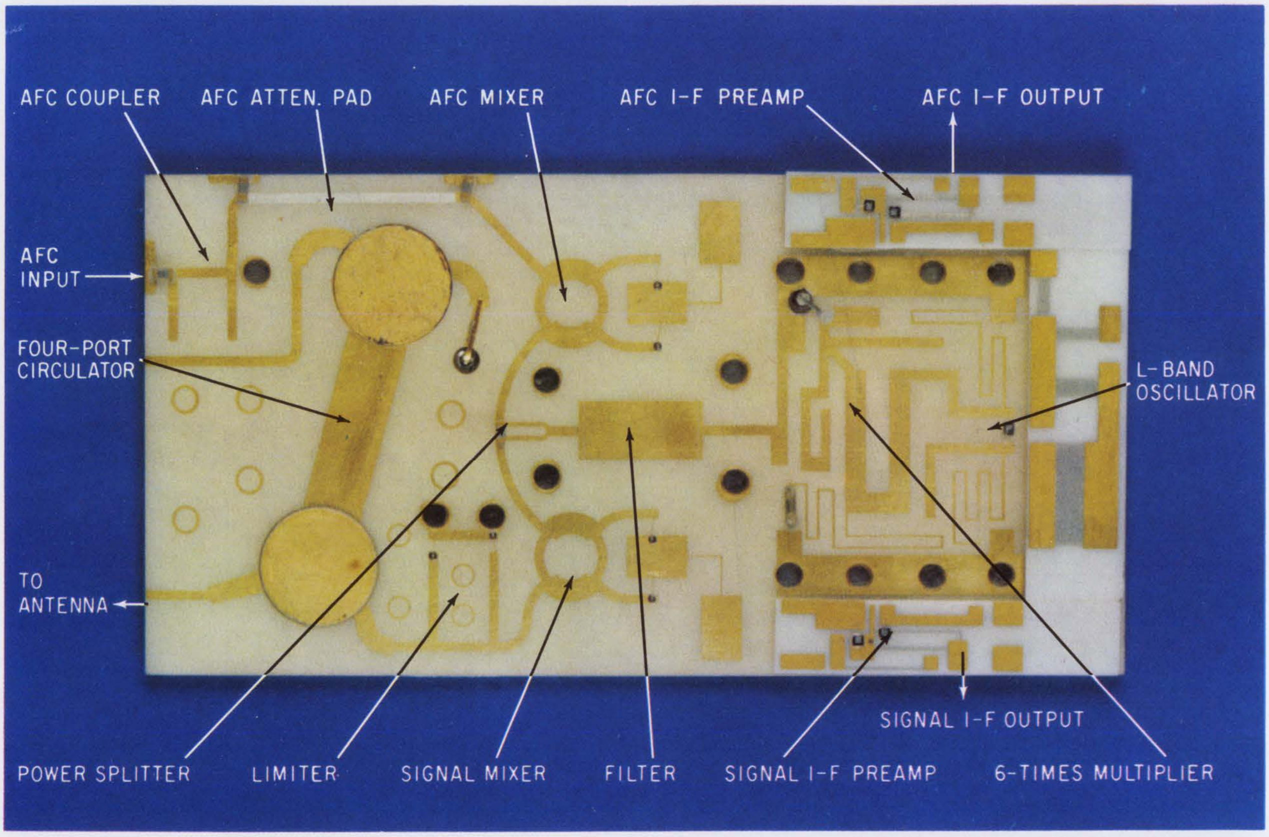
Titanium dioxide, on the other hand, has a higher dielectric constant than alumina. But titanium is more expensive, less uniform, and harder to process. A material 99% alumina has a smoother surface than the 96% type, therefore having lower conductor losses and permitting easier processing. But 99% alumina lacks the filler that gives thick-film bonding strength to 96% alumina.

Microwave engineers have found 10^{14} ohm-cm alumina best serves their needs and purposes. Dielectric losses are so low that conductor loss is greater in the microstrip—a situation far easier to live with because the loss is easily controlled.

With a typcial ceramic size of about 2 by 2 inches, the thickness is usually between 20 and 60 mils. The substrate's thickness affects both conductor loss and packing density—the thicker the ceramic, the lower the conductor loss and the lower the density. But a low packing density means that the over-all circuit size will be large.

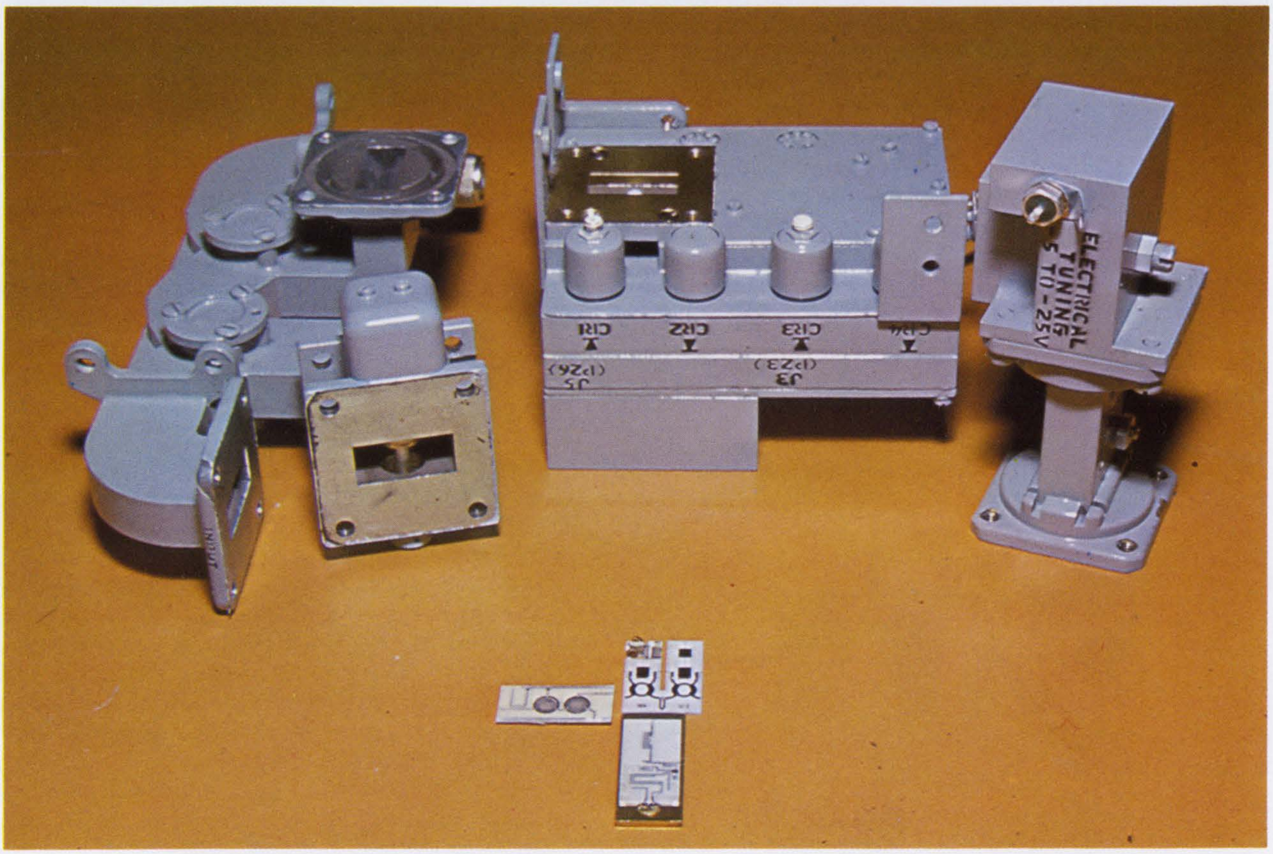
In laying out microstrip conductors, microwave designers often use meandering lines. To minimize interference between these lines—such as unwanted couplings—a distance of twice the ceramic's thick-

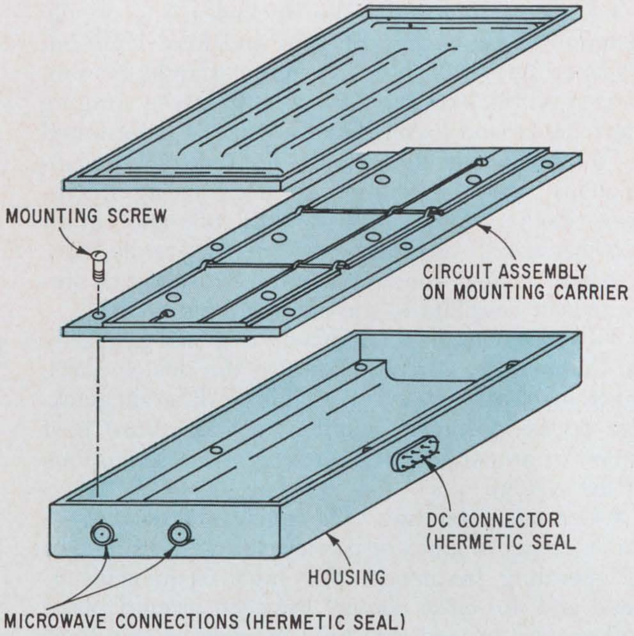
Bringing an X-band receiver down to size



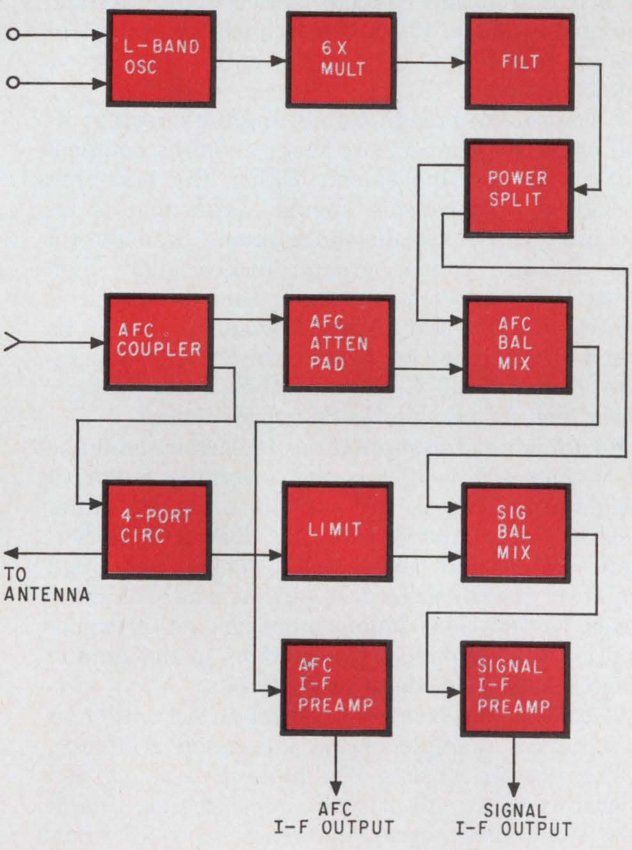
▲X-band receiver in IC form.

IC receiver compared with waveguide receiver.▼





Entire IC package.



Functional arrangement.

Space saver. Measuring only 2 by 3 inches on a 20-mil substrate, microwave IC receiver is only a fraction of the size of a conventional waveguide receiver but does the same job. Designed for X-band frequencies, the IC uses a six-times multiplier to convert the L-band oscillator's output to the required frequency range. The circuit includes a signal i-f preamplifier.

ness is maintained between conducting paths. Thus, the thicker the ceramic, the greater this isolation spacing, and the larger the total circuit area needs.

Thickness has little effect on guide wavelength, which is a function of both the dielectric constant and the impedance level; for the 96% alumina the wavelength is 40% that of air.

Building the circuit

Starting with the slab of ceramic as the dielectric transmission line operating in the TEM mode, the engineer employs photolithographic techniques and either thick- or thin-film processing to deposit conductors on the substrate. Active chip devices—transistors, diodes, and monolithic circuits—are then attached by either parallel gap welding, ultrasonic bonding, or thermocompression bonding. Most of the interconnections between the elements are provided by the passive network, which includes connector paths. What few that remain are made by parallel gap or ultrasonic welding. The subassembly is then bolted into either a brass, steel, aluminum, or Kovar box. Radio-frequency and d-c connectors are affixed, and a cover is welded on.

For IC packages with a diameter of more than 1 inch, heliarc welding—the joining of metals by the localized melting produced by a high-voltage arc—is often employed, particularly on steel and Kovar. When aluminum is the metal, heliarc welding can be used, but soldering is more common.

For smaller packages, projection-type welding is used.

Today and tomorrow

Engineers have successfully achieved a number of microwave functions in IC form. And the list continues to grow. Thus far, it includes amplifiers, mixers, harmonic generators, filters, switches, phase shifters, ferrite circulators, couplers, limiters, local oscillator multipliers, combination transmit-receive switches, frequency triplers and quadruplers, impedance matching networks, antennas, p-i-n devices, and transistors.

Interdigitated transistors, for example, are being built that provide an output of up to 2 watts at 2 Ghz, and there are oscillators with an output of 500 milliwatts at 10 Ghz. Moreover, p-i-n IC devices are already capable of switching speeds of 10 nanoseconds at 5 Ghz.

In many instances, IC techniques have not been able to match the higher power levels of the coaxial and waveguide structures. This has been the case with uhf circuits handling 50-kilowatt peak power at 300 Mhz, and with S- and L-band circuits handling tens of kilowatts peak at 390 Mhz to 5.2 Ghz. Conventional means have proved necessary to handle high current density.

Augmenting both the standard microwave hardware and microwave IC's is a class of small circuits that can best be described as microminiature devices. These circuits are usually made up of lumped elements and do not have a large number of different components. Instead of ceramic or conventional transmission lines, these circuits have air lines.

For example, consider a switch requiring six diodes. Shunt-diode chips are mounted on a metal ground plane and interconnections are made. Because of the lumped-circuit design, there is no need for a loaded transmission line with its fabrication difficulties.

Another example is a simple single-pole, double-throw switch consisting of two series diodes and two shunt diodes. These may be mounted directly on a ceramic chip that serves as a support and not as a transmission line. Moreover, the multidiode chip itself may eventually be placed on a larger microstrip structure as part of a complex hybrid microwave assembly.

At the moment, engineers still haven't reached two major goals with microwave IC's: high-Q circuits and high-power networks.

Because of conductor losses in microstrip, a typical Q will be 200 in a 50-ohm system. Some engineers believe, however, that the path to high Q's is with resistance-capacitance networks and sophisticated transistor-element feedback arrangements—a combination that lends itself to IC fabrication.

Average powers of 500 watts and pulsed powers of 5 kw are yet to be achieved. Heat dissipation has proved too excessive for center conductors of the microstrip line, or power losses too high—or both. Engineers are now considering other materials for thermal conduction—including beryllia—and paralleled stages for power sharing.

Microstrip guide

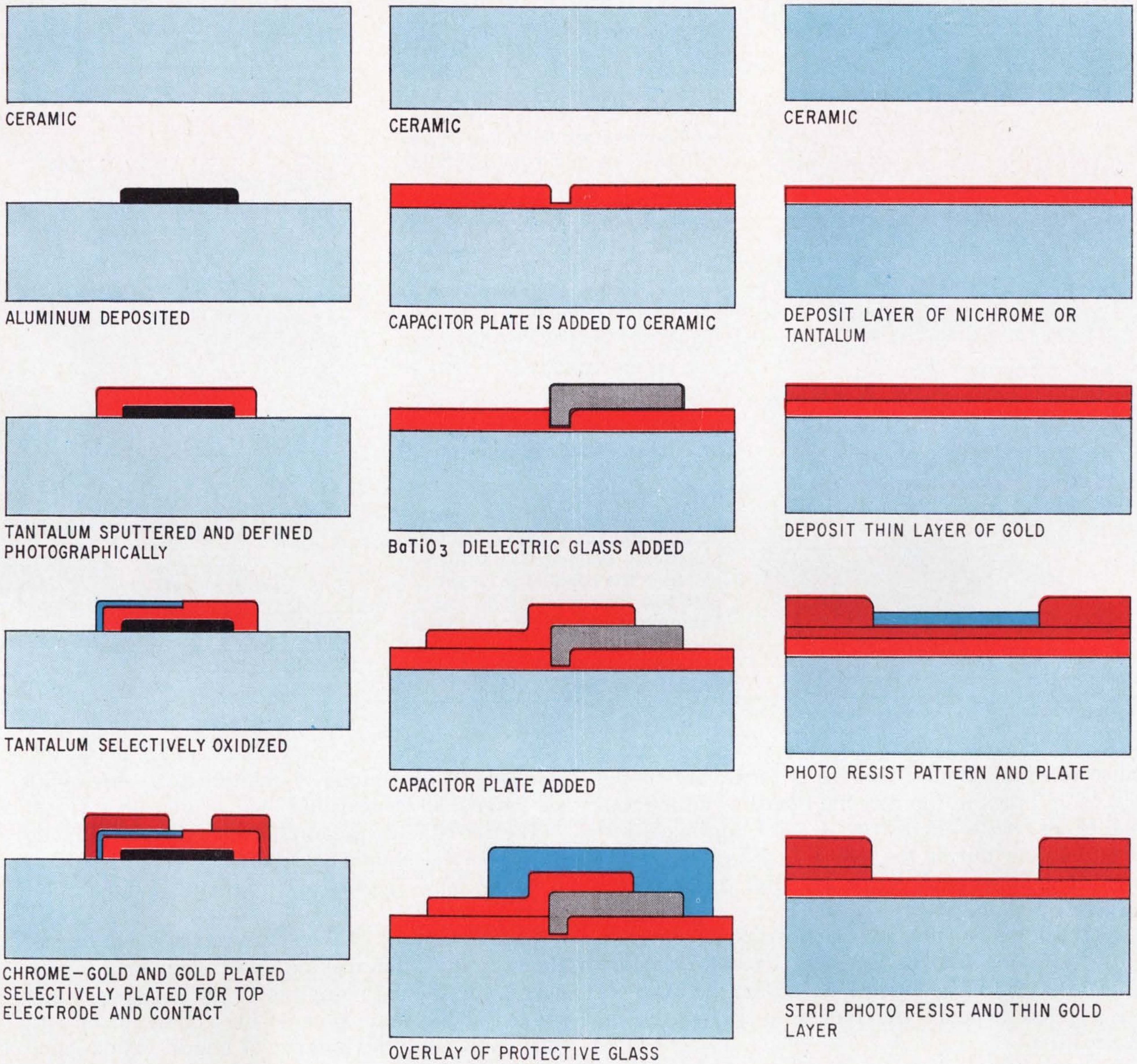
Before an engineer can design a hybrid microwave IC, he must determine the microstrip's characteristics and the dielectric's performance. The latter is based on the guide wavelength and its dependence on impedance, the impedance of various line widths for different ceramic thicknesses, and loss as a function of frequency and of thickness. Once the characteristics and performance are calculated, the engineer can then take the following into consideration:

- Operating frequency. Circuit length and width should be held to less than half the wavelength of operating frequency to minimize unwanted radiation. Generally, 25-to-30-db isolation between elements is maximum. For the same reason, open stubs and impedance mismatches result in radiation. And in circuits having long paths, holes in the ceramic serve as suppressors.
- Device type. The nature of the circuit—switch, amplifier, harmonic generator, or oscillator—dictates the isolation needed. For switches, the isolation must be 50 to 60 db; for amplifiers, 20-30 db; generators, 30 db; oscillators, 25-30 db. Shunt-mounted elements are preferred for dissipated continuous-wave powers in excess of 1 watt. A ground plane could also be formed along the edge of the ceramic to serve as a thermal conductor. An additional chip substrate, mounted in a hole in the alumina, such as beryllia or some other good thermal conductor, can be used for a good thermal heat sink in the circuit.
- Ceramic thickness. The thickness is generally determined by trading off size and loss. High-impedance lines—100 ohms or more—should be fabricated on thick ceramic (60 mils) to lessen fringing capacitance and losses. Over-all size is determined by the number of devices, the number of interconnections, and the relation to neighboring microwave sections. When individual circuits and circuit sections are all mounted on a single ceramic, only a single center conductor interconnection is required for coupling to the next ceramic board.
- Layout. Circuit arrangement depends primarily on the number, size, and form of the device parts. Since many devices are available in different package styles, designers should consider those best suited to proper bonding and the space limitations of the system.
- Ceramic mounting. The mounting of the ceramic circuit to a box or carrier is largely a function of operating frequency. For high frequencies—L band and up—close contact between ground plane and support is needed to hold the voltage standing-wave ratio to 1.2 or less. This can be achieved by either pinning the board to the carrier with eyelets or inserting spring contacts between the box and the ground plane. For lower frequencies, vswr's of 1.5 are obtained as long as the entire structure is rigidly mounted.
- Temperature range. Subjecting the circuit to its full operating temperature range requires compensation for part movement. Either the ceramic's coefficient of expansion should match that of its mounting carrier, or allowance should be made for this. Because copper ground planes allow high power and the copper-ceramic thermal match is relatively poor, movement allowances should be based on the following relationship: for a temperature change of 100°C, there will be a 1-mil shift per linear inch for an alumina-on-copper mount.
- Packaging. The support box or carrier should be of aluminum if weight is the governing factor; if weight isn't critical, the support could be either steel or Kovar. Aluminum poses difficulties in hermetic sealing and connector-lid joining, and often requires special surface treatment and soldering fluxes. Kovar's and alumina's coefficients of expansion are a good match. Connections to the ground plane should be made at many points.

Consider a receiver front end for an X-band radar as a typical example of the integrated approach.

The receiver consists of a duplexer, a mixer, and a local oscillator, all of which are integrated modules. The duplexer assembly includes a coupler network, a four-port ferrite circulator, and a diode limiter. In the mixer module is a signal mixer, an intermediate-frequency preamplifier, a power divider, and an automatic-frequency-control mixer. The oscillator portion contains an L-band transistor oscillator, a six-times multiplier, and a three-stage filter. The total system, each module, and a comparison of the IC approach with its waveguide equivalent are shown on page 102.

Film strips for resistors and capacitors



Forming passive elements in thin-film approach is done with tantalum layer. Thin layer of sputtered tantalum applied before chrome and then selectively contacted acts as a resistor. Oxidization of tantalum gives a dielectric, which can form a capacitor element.

Capacitors in thick-film process are formed by application of high dielectric constant barium-titanate glass, firing, and applying top electrode. Protection is rendered by cover glass coating, which is also fired. Gold plating is subsequently applied to accommodate chip devices.

Resistors in thin-film method may be of nichrome or tantalum. An 80% nickel—20% chrome layer is deposited; with tantalum, layer is formed by sputtering. In both cases, gold layer is deposited, plated, then stripped to form selective contacts.

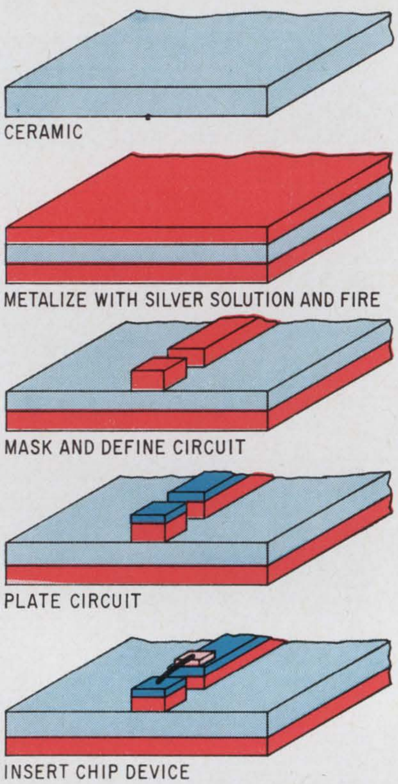
Specifications include a 10-db noise figure, a 5% bandwidth, a 500-watt peak power input, a 100-Mhz tuning range, a 2.5-watt d-c input, and a 2-by-3-inch over-all receiver size.

The substrate will be 20 mils thick, and each circuit will be made on a separate ceramic chip. The oscillator circuit's transistor must handle 1.5 watts dissipation and must be mounted to a copper heat sink either through the ceramic or to the box wall. Since the diode multiplier handles only 200 mw, it can be a series element mounted directly onto the ceramic. Because output power of the three-stage filter is only 25 mw, the device requires no special mounting consideration.

The mixer employs Schottky-barrier diodes and has a noise figure of 7.5 db.

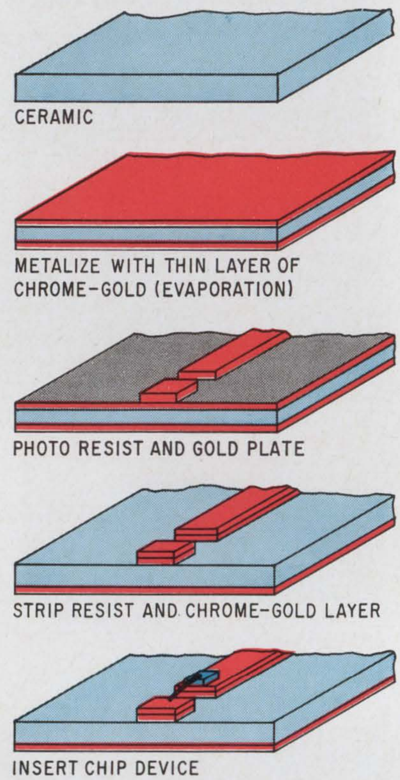
The ferrite circulator can be fabricated in microstrip form, with the ferrite used as the transmission medium. The reason: it has a high dielectric constant and need only be metalized in those areas that

Depositing thick and thin films



Film making: Starting marterial can be either a 96% alumina, with 4% glass binder or 100% single-crystal sapphire; thickness of the substrate is usually 20-60 mils. In the thick-film etched process (left), the substrate is polished to a 5-10-microinch finish and coated with silver or gold metal about 0.5 mil thick. Composite is fired at 850°C to bond the metal to the substrate. Photoresist is then applied and circuit is defined by mask and exposed. Unprotected metal is etched off. Gold plating via a liquid-plating bath completes the passive formation.

In thin-film process (right) a layer of chrome, about 500 angstroms thick, bonds conductive lines to dielectric substrate. A layer of chrome and gold can be evaporated or sputtered on. Circuit is photographically defined. Gold is then plated in the conductive circuit path to a thickness of 0.3-1 mil. Then resist and chrome-gold layer are stripped, and active devices are bonded to conductive lines.



must be active. Round sections of ferrite are simply placed in holes in the ceramic board as an alternative to all-ferrite microstrip. A third approach, ferrite disks on top of the ceramic, is favored when mounting holes can't be drilled. But this requires an extra bonding step.

Regardless of which approach is taken, provision must be made for the magnet elements that are used to energize the ferrites. As a rule, the magnets are located beneath the ferrite to allow ease in fabrication.

The circulator provides 30 db of isolation between transmitter and receiver, and has 0.8 db of loss. Included in the circulator module are the 50-ohm, 2-watt resistors used for load termination.

The limiter is employed to keep power input to the mixers below 100 mw, the safe level for the Schottky diodes. P-i-n diodes provide the limiting action; high-level signal bias serves to produce line shorts, thereby reflecting excess power.

A stub-limiter design in which the diodes are mounted at the end of a half-wavelength stub, with two of them a quarter-wavelength apart, is used because the receiver has a relatively narrow band. The limiter diode has a zero-bias punch-through characteristic, which maintains a low loss during small incident-signal conditions.

Isolation for the afc portion is provided by a 60-db coupler. Ordinarily, 30-db isolation is the maximum obtainable in microstrip because of radiation and cross-coupling limitations. But in this case, a standard 30-db coupler is combined in series with an external 30-db resistor.

The 150-Mhz i-f preamplifier is mounted directly on a separate ceramic board for convenience, and so is its d-c bias circuitry and the biasing circuits for other portions.

Capacitor needs of the entire receiver can be met either by thick-film techniques or chips or a combination. In the film approach, the capacitors are printed at the same time as the conductor circuit, thus minimizing the number of bonds. Chips—such as barium titanate capacitors, aluminum, or silicon-dioxide aluminum types—are used when film techniques cannot yield the desired values.

Enter CAD

One development that will ease the design burden and lower manufacturing costs is the use of computer-aided design techniques for generating microwave IC's. There already is a storehouse of information on microwave materials and devices, where characteristics, geometry, and their interactions are known, controllable, and predictable. Also, there are many common factors, such as impedance levels, switching and amplifying requirements, and circuit arrangements.

Eventually, much of the engineer's input in a design will boil down to simply a functional specification that will lead to a metalization pattern, just as it has been predicted for digital engineers working with large-scale integrated components.

Designer's casebook

FET voltmeter reads transients

By Graham R. Phillips

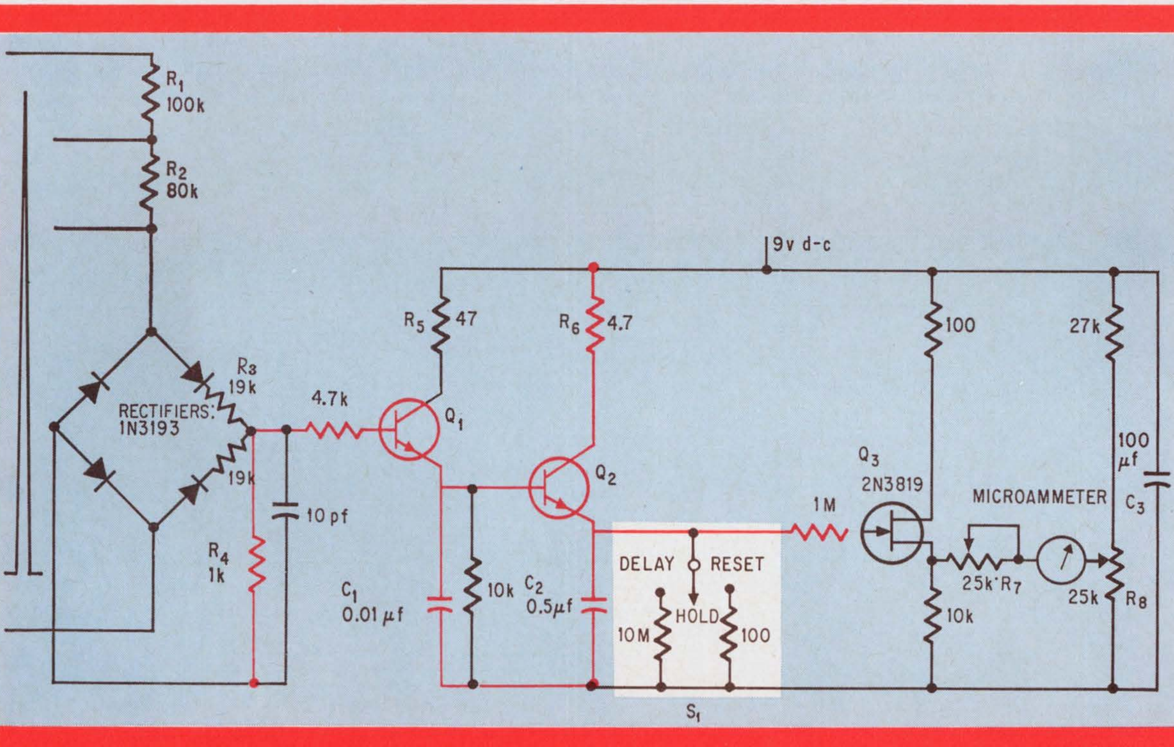
Century Electric Co., St. Louis

High-voltage transients generated by inductive switching are difficult to measure and detect because of their narrow pulse width. Since there isn't enough energy in the transient to deflect the moving coil in a voltmeter, engineers often spend long hours scanning an oscilloscope in hopes of seeing and perhaps measuring the transistor-destroying spikes. But a circuit that accurately divides the spike voltage and then increases the power content of the resulting low voltage can eliminate this tiresome watching.

Spikes appearing at the input, regardless of their polarity, are rectified by the bridge circuit and reduced by the R_1, R_2, R_3, and R_4 divider. A 600-volt spike coupled into the 1,000-volt input appears as 3 volts across the resistor R_4; at this input the string of resistors divides by 200.

The 3 volts on R_4 drives Q_1 into saturation and causes C_1 to charge through R_5 until its voltage is equal to Q_1's base voltage. Although C_1 is a small capacitor, it accumulates enough charge to hold Q_2 in saturation for the time it takes C_2 to charge through R_6. Because it is, like Q_1, an emitter-follower circuit, Q_2 tries to establish a voltage on C_2 equal to its base voltage. The resulting charge on C_2 is a hefty one capable of holding the field effect transistor, Q_3, in conduction for an indefinite amount of time.

Gating on the FET produces a source voltage of about 1 volt. Current is then drawn through potentiometer R_1 and the micrometer, causing a deflec-



Added strength. The divided portion of a transient voltage increases in power as it moves from R_4 in the divider to capacitors C_1 and C_2. The high input impedance of the FET allows C_2 to remain charged during the reading.

tion of the microammeter's needle. The needle remains deflected as long as switch S_1 is in the hold position. A fast or slow return of the needle to zero is achieved by switching to either the reset or decay positions.

Potentiometers R_7 and R_8 are used in calibrating the circuit. When there's no voltage across R_7, R_8 is adjusted so that its voltage at the wiper point is equal to Q_3's source voltage. No current flows through the microammeter and its needle is undeflected. If 5 volts is placed across R_4—corresponding to an input of 1,000 volts—an adjustment is made in R_7 so that the microammeter reads full scale.

Capacitor C_3 was added to the circuit because the current demand when Q_1 and Q_2 are switching cannot be supplied by the 9-volt battery acting alone.

Boosting op-amp output with two transistors

By Arthur Freilich

North Atlantic Industries Inc., Plainview, N.Y.

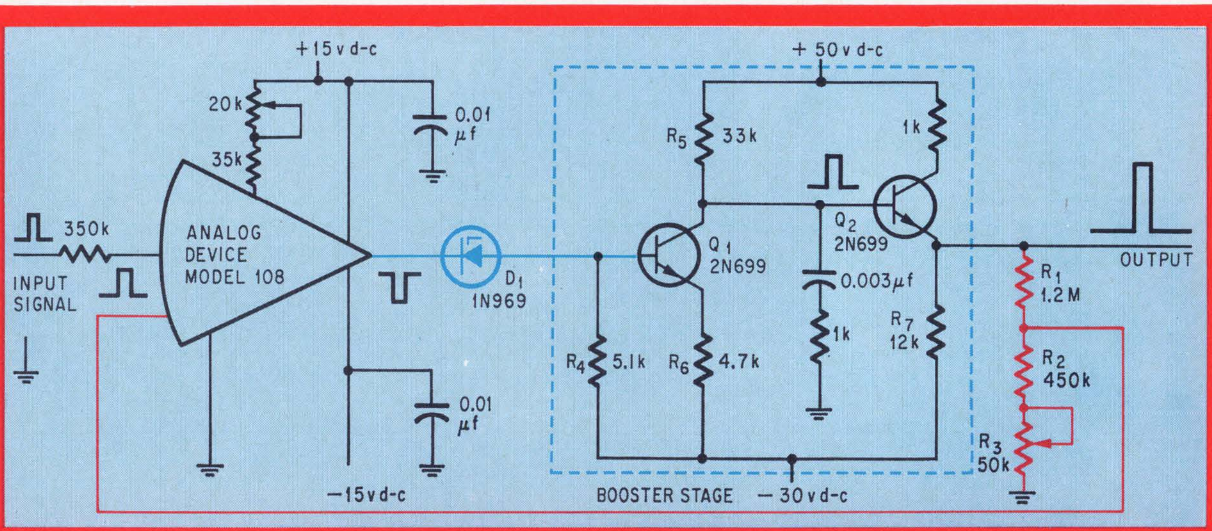
Low-voltage operational amplifiers with good gain, stability and input impedance characteristics can deliver high output voltages if they get an assist from an auxiliary circuit consisting of two transistors and a zener diode. The zener diode protects the fragile low voltage output circuit of the op amp from the high voltages in the auxiliary circuit. The two transistors comprise a cascade of emitter follower amplifiers that boost the output voltage.

When no signal is present at the input, there's no voltage at the point common to the output of the operational amplifier and consequently the cathode of zener diode D_1 is at zero volts. The zener is in avalanche breakdown and its anode is therefore at —22 volts. To maintain this level, the —30 volt supply draws enough current through R_4 to cause an 8-volt drop across that resistor.

This drop, appearing across the base-emitter junction of transistor Q_1, biases the transistor into conduction. At this bias point, current through the transistor and resistors R_5 and R_6 is 1.2 milliamperes, a current that causes a 49.5-volt drop across R_5, thus placing Q_1's collector at 0.5 volt. The 0.5 volt is also the voltage at the base of Q_2.

Since Q_2 is connected in an emitter-follower configuration, its emitter voltage tends to be the same as its base voltage. The base-emitter junction of Q_2 has a 0.5 volt drop when it is in conduction thus making the emitter voltage zero.

Since no current flows through R_1, R_2 and R_3 when there's no output voltage, the ground potential at the junction of R_1 and R_2 is coupled back into the operational amplifier as feedback. Since the two



Zener leverage. Small voltage changes in the output of the operational amplifier cause wide swings in the collector voltage of Q_1, and thus in the emitter of Q_2. Resistor R_7 gives the boosted voltage the capability of driving low-impedance inputs.

inputs are at ground potential, there's no voltage at the output of the operational amplifier and the circuit is locked into this mode of operation.

If, for example, a positive pulse with a peak value of 4.56 volts is injected at the input, a negative 2.8 volts appears at the op amp's output. This voltage and the zener's 22-volt breakdown cause the zener's anode to swing to —24.8 volts; the potential drop across R_4 is then —5.2 volts. At this bias point the current flow through Q_1 and resistors R_5 and R_6 is 1 milliampere, the resulting drop across R_5 is 33.5 volts, and the collector of Q_1 therefore sits at 16.5 volts. Since this is also the base voltage of the emitter follower, Q_2, it eventually ends up on Q_2's emitter minus the 0.5-volt drop of Q_2's base-emitter junction. The 16-volt output of the circuit, because of the 12-kilohm emitter resistor, readily matches low-impedance inputs.

With potentiometer R_3 set for a value of 25 kilohms, the output voltage is divided by 3.5 in the R_1, R_2, and R_3 divider. From the junction of R_1 and R_2 a feedback of 4.56 volts is coupled to one of the inputs of the operational amplifier. The near-equality of the two inputs stabilizes the circuit. The two inputs are, however, slightly different, and this difference is amplified by the operational amplifier. The gain in the amplifier is 120 db, so the 2.8-volt output of the operational amplifier is caused by a 28-microvolt difference between the inputs.

The equation relating feedback voltage to output voltage is:

$$V_f = V_o \frac{(R_2 + R_3)}{(R_1 + R_2 + R_3)}$$

where V_o = output voltage
V_f = feedback voltage
R_1, R_2, R_3 = resistors in feedback divider.

Thus, an increase in the value of R_3 increases the feedback voltage. Adjustment of R_3 should be made carefully so that the two inputs of the operational amplifier are as equal as possible.

The limitation on the output voltage's magnitude is the saturation point in Q_1 and Q_2. With a negative input pulse, the highest output is —20 volts. And the positive voltage can never be greater than +45 volts whatever the magnitude of the input pulse. As the output stage of a circuit that converts a change in phase angle to a d-c voltage, this op-amp circuit presented a 360° phase advance as +36 volts on the emitter of Q_2; a —20 volt level at that point indicated a phase lag of 200°.

Phase angle changes as small as 0.01% can be measured by the circuit if operational amplifiers with tight specifications are used. Amplifiers whose specifications do not change by more than 0.1% are now available for $28.

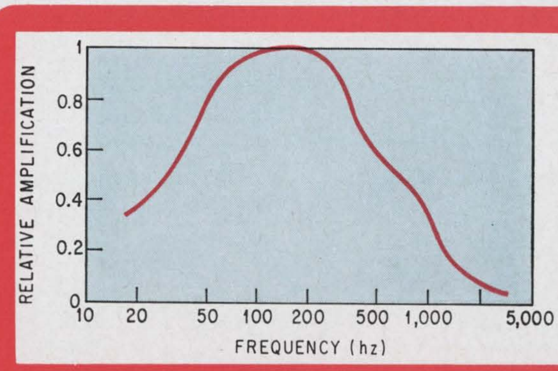
Zener simulates muscle signals

By William Paisner, Daniel Antonelli, and Worden Waring

Rancho Los Amigos Hospital, Downey, Calif.

Small electrical signals that are generated during the flexing of a human muscle smoothly and precisely control the servomechanisms in artificial limbs. During development of the amplifiers for these signals it was found convenient to have a permanent source of muscle signal. Fortunately, a zener diode biased into breakdown generates a broad spectrum of noise that will simulate a muscle signal. The zener's noise must be amplified and filtered, but the 1-kilohertz bandwidth of noise that results contains all the frequencies generated in a flexed muscle.

The 1N759 is a zener diode whose breakdown point is 10 volts. Consequently, the supply voltage on the other side of the current-limiting register R_1 biases the diode into breakdown. All the noise generated by the diode is amplified by Q_1—the supply's 12 volts are biased out—and fed into the filter consisting of C_1, C_2, and L_1. None of the frequencies above 1 khz get through this low-pass filter. The



Muscle building. Most of the high-amplitude frequencies in a muscle signal are in the 41 to 350 hz frequency range.

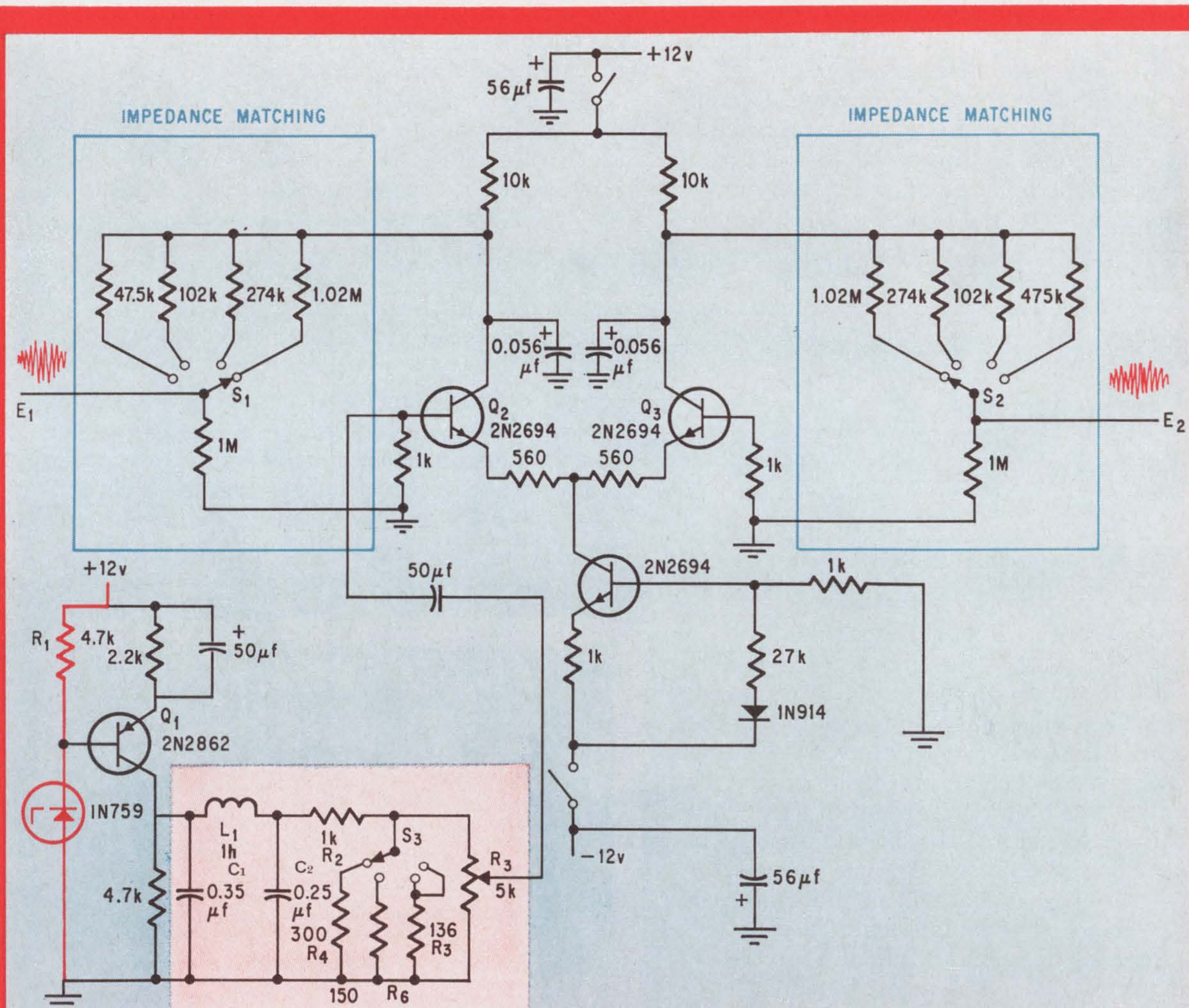
random selection of frequencies below 1 khz that do get through are the same, for all practical purposes, as those that appear in a signal generated by a muscle during normal flexing.

The amplitudes of the different signals in the filter are varied by adjusting potentiometer R_3 and switching R_4, R_5, and R_6 in and out of the circuit with S_3. To prevent these resistors from hurting the filter's frequency response, resistor R_2 is connected between them and the filter. The voltage divider, consisting of R_2 and the attenuating resistors, makes the impedance the filter sees almost constant, despite adjustments in R_3 and S_3.

After being coupled through C_3, the signal goes through a constant-current differential amplifier. This type of amplifier, which has a transistor in the emitter circuit, is used because its high impedance doesn't load down the low-power muscle signal. The frequency response of the differential amplifier is minus 3 db at 41 and 350 hertz. Most of the high-amplitude signals generated by a muscle are within this band.

Because phase reversal takes place in the differential amplifier, the two output signals E_1 and E_2 are out of phase with each other; these two signals simulate those usually picked up from muscles. Each signal is fed into an input of a differential amplifier in the front end of the electronic apparatus of the artificial limb.

The switches S_1 and S_2 in the collectors of Q_2 and Q_3, respectively, change the output impedances of the transistors and consequently the impedance that the signal presents. This simulates the differences in the impedance imposed upon the muscle signal by the skin surrounding the muscle. Resistors that vary from 47.5 kilohms to 1.02 megohms are used to accommodate all possible changes in the impedance imposed by the skin.



Perpetual tension. Myoelectricity—the white noise generated in a flexed muscle—is simulated by filtering and amplifying the noise from a zener during breakdown. The differential amplifier couples the signal into circuits that eventually manipulate artificial limbs.

1 OZ.

2 PDT

2 AMPS

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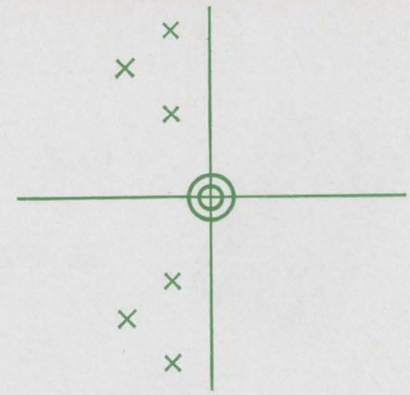


Active filters: part 2
Using the gyrator

Gyrators can overcome sensitivity problems in active filters. Here's an in-depth look at the theory of operation and principles of such inductorless circuits

By Louis de Pian

George Washington University, Washington

Thanks to the gyrator, engineers now have a new building device for making inductorless filters. Such filters don't suffer from the low-frequency bulkiness of an inductor and aren't limited to Q's of 100.

The gyrator is a nonreciprocal two-port network whose input impedance is proportional to its load admittance. Thus, the gyrator produces the electrical characteristics of an inductor when a capacitor is connected as its load. Moreover, the gyrator neither adds nor consumes signal energy in a circuit; thus, it behaves as a lossless passive network even though it may contain active elements. In this respect, the gyrator by itself can never be unstable.

Since capacitors have a higher quality factor and lower dissipation than inductors, the inductor effect that the gyrator produces with a capacitive load is usually a better inductor than the discrete types that are readily available.

Gyrator circuits can be used to make unnecessary the inductors found in many passive filter configurations. Several basic elements of inductor filters and their gyrator replacements are tabulated for handy design reference on page 116. Some examples of practical designs are as follows.

Design method 1

The most direct way to design active filters with a gyrator is to first design the passive filter with inductors and capacitors. Then replace all the inductors with gyrators and capacitors. As an example, suppose that the desired transfer function is for a second-order low-pass filter having a damping ratio ξ and a corner frequency ω_o. Let the d-c gain be unity and the open-circuit voltage transfer function be

$$F(s) = \frac{V_{out}}{V_{in}} = \frac{\omega_o^2}{s^2 + 2\xi\,\omega_o\,s + \omega_o^2}$$

The filter is first designed as an LC filter loaded with a resistance, R_L across the capacitor. The voltage-transfer function for this circuit, expressed in terms of the forward and output admittance parameters y_{12} and y_{22}, is given by

$$F = \frac{-R_L\,y_{12}}{1 + R_L\,y_{22}} = \frac{\dfrac{\omega_o}{2\xi s}}{1 + \dfrac{s^2 + \omega_o^2}{2\xi\,\omega_o\,s}}$$

Thus,

$$y_{12} = -\frac{\omega_o}{2\xi R_L\,s} = -\frac{1}{Ls}$$

$$y_{22} = \frac{s^2 + \omega_o^2}{2\xi R_L\,\omega_o\,s} = \frac{s}{2\xi R_L\,\omega_o} + \frac{\omega_o}{2\xi R_L\,s} = Cs + \frac{1}{Ls}$$

where

$$L = \frac{2\xi R_L}{\omega_o}, \quad C = \frac{1}{2\xi R_L\,\omega_o}$$

Finding this RLC filter in the table, the designer can then find its gyrator replacement. The results appear at the bottom of page 117. This equivalent circuit uses two gyrators, a load resistance whose value is R_L in parallel with a capacitor of value C, and another capacitor whose value is numerically equal to L/R_g^2.

The only impedance parameter needed to describe a gyrator is its gyration resistance, R_g. The input impedance to the gyrator is equal to the product of the load admittance, Y_L, and R_g^2. By definition, R_g is equal to the transfer impedances z_{12} and $-z_{21}$, since z_{11} and z_{22} are zero. Since R_g may drift in operations, the designer must have a measure of its effect on the over-all stability of the filter. To investigate the stability of this filter as the gyrator parameters vary, substitute R_x for R_g in the gyrator filter's voltage-transfer equation. This has the effect of changing the inductance of the LC filter into

$$L = \frac{2\xi R_L}{\omega_o} \frac{R_x^2}{R_g^2}$$

If $\frac{R_x^2}{R_g^2}$ is assumed equal to α^2, the transfer function becomes

$$F(s) = \frac{1}{LC\, s^2 + \frac{L}{R_L} s + 1} = \frac{\omega_o^2}{\alpha^2 s^2 + 2\xi\omega_o \alpha^2 s + \omega_o^2}$$

the d-c gain remains unity but the corner frequency and damping ratio change to

$$\omega_x = \omega_o \left(\frac{R_g}{R_x}\right)$$

and

$$\xi_x = \xi\alpha^2$$

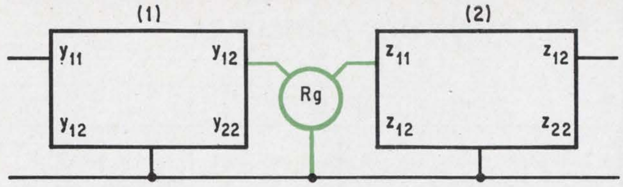
Thus, if the gyration resistance is increased by 10%, the corner frequency ω_x and the damping ratio ξ_x vary 9% and 20%, respectively. Although it is easy to design an active filter using this technique, the design has disadvantages—it requires two gyrators and has poor stability. Its main advantage is that the design is quite simple and can use existing LC filters as its basis.

Design method 2

A second approach to designing gyrator filters for the same active filter begins with a circuit in which a single gyrator is flanked by two RC networks. Both RC networks are represented as two-port networks—the left network by y-admittance parameters and the right one by z-impedance parameters. Such a configuration has the following open-circuit voltage transfer function:

$$F(s) = \frac{N(s)}{D(s)} = -\frac{R_g\, y_{12}(s)\, z_{12}(s)}{z_{11}(s) + R_g^2\, y_{22}(s)}$$

The object of the design is to find the proper RC networks, given F. This technique offers superior stability of corner frequency or damping ratio, since the method is based on good stability of the poles of the transfer functions. The design requires only one gyrator. However, the d-c gain does vary.



Cascaded networks. In this active-filter design, a single gyrator is cascaded with two RC networks, one defined by y parameters, the other by z parameters.

Here is the procedure:

Step 1. Divide both N and D by an arbitrary polynomial Q such that

$$F = \frac{N/Q}{D/Q} = \frac{R_g\, y_{12}\, z_{12}}{z_{11} + R_g^2\, y_{22}}$$

Step 2. Decompose D/Q into the form $z_{11} + R_g^2 y_{22}$. Thus, with $Q = Q_1 Q_2$,

$$\frac{D}{Q} = \frac{D_2}{Q_2} + R_g^2 \frac{D_1}{Q_1} = \frac{D_2 Q_1 + R_g^2 D_1 Q_2}{Q_1 Q_2}$$

Step 3. Equate the result of step 2 to $z_{11} + R_g y_{22}$ Thus

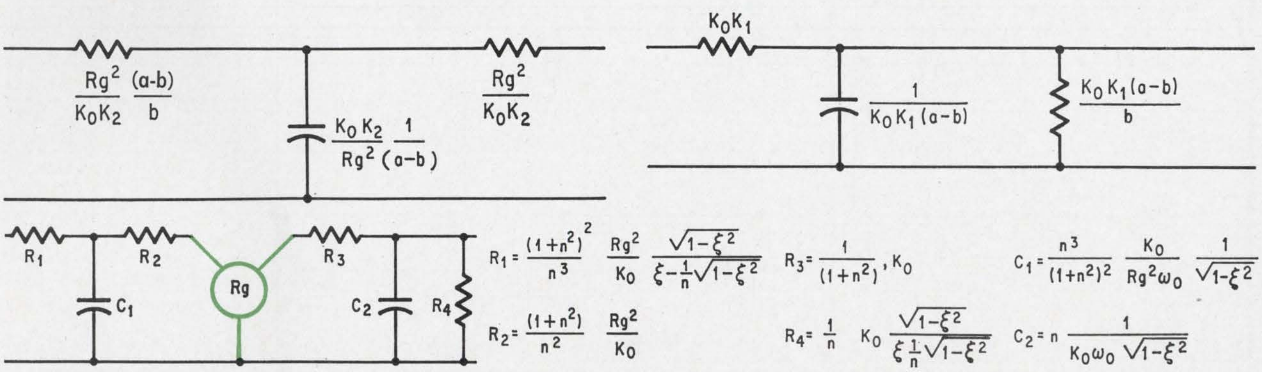
$$z_{11} = \frac{D_2}{Q_2}, \quad y_{22} = \frac{D_1}{Q_1}$$

Therefore, the denominator polynomial D can be expressed in terms of Q_1 and Q_2.

$$D = D_2 Q_1 + R_g^2 D_1 Q_2$$

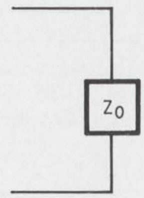
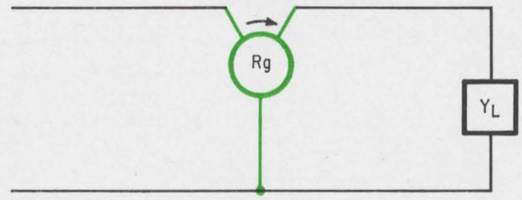
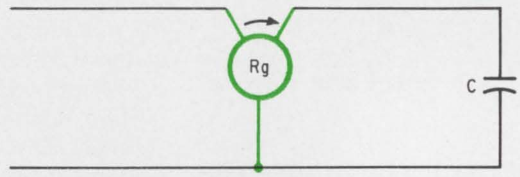
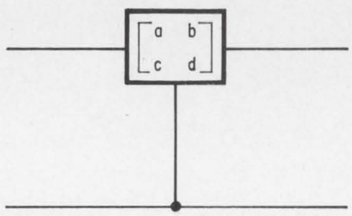
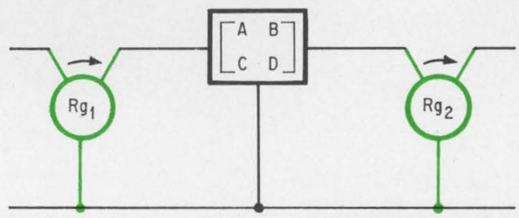
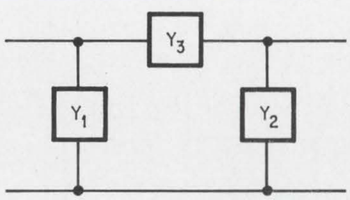
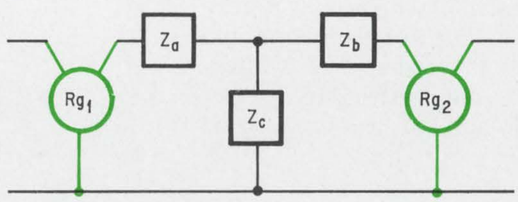
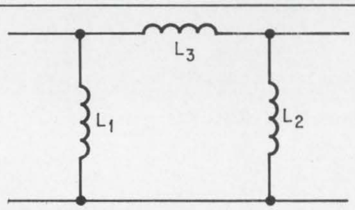
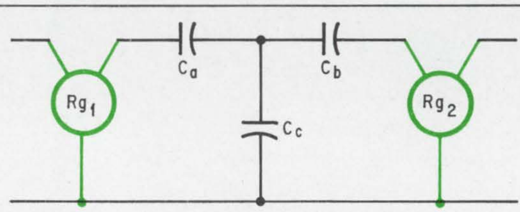
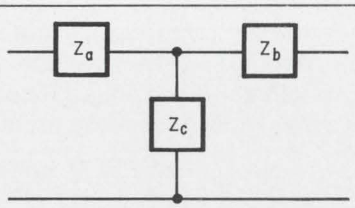
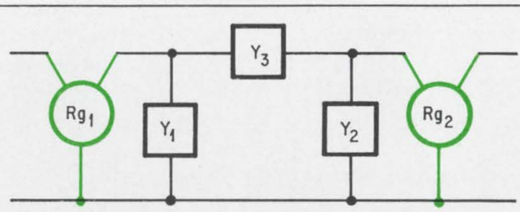
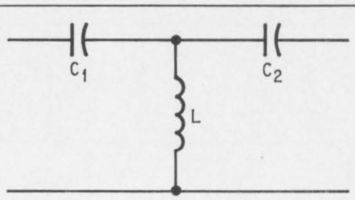
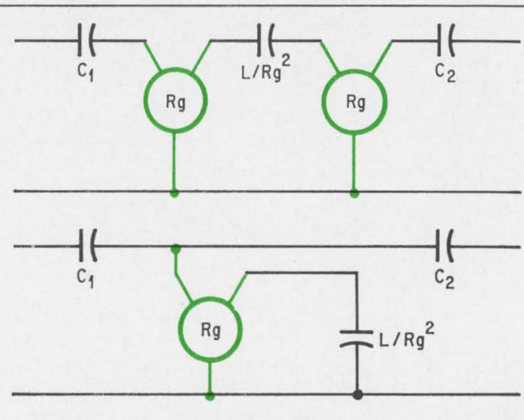
It is assumed that D_2/Q_2 is a possible RC impedance and D_1/Q_1 is a possible RC admittance. To achieve this decomposition, the designer can use the technique proposed by Calahan.[1] It provides a minimum sensitivity of the zeros of D to variations of the

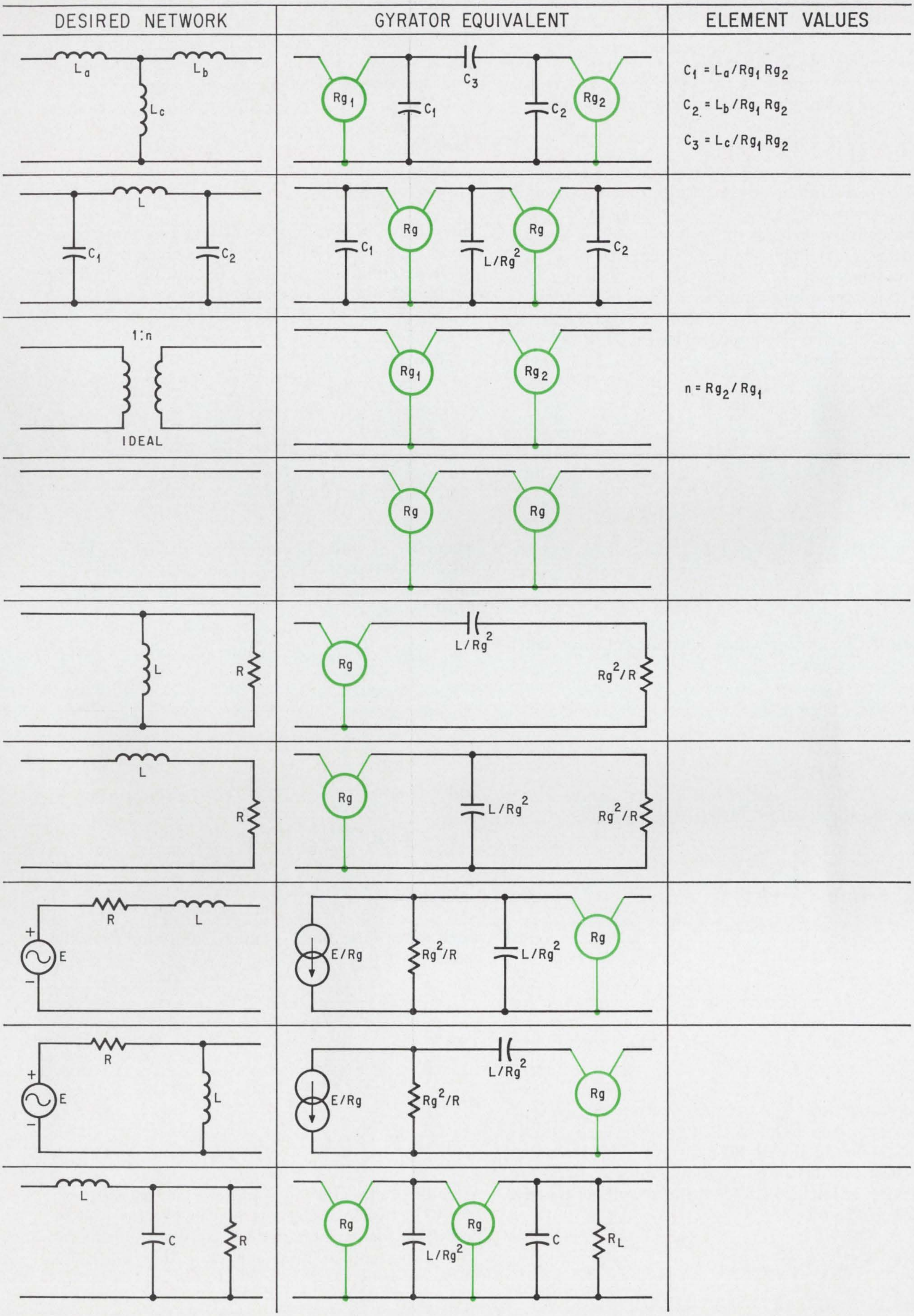
Continued on page 118



Active-filter design. Starting with a single gyrator flanked by two RC networks, the designer assumes the left one to be a T network. By synthesizing the over-all transfer function, he finds that the right network can be a series-parallel RC circuit. Values for all elements are shown on the drawing.

Basic gyrator principles

DESIRED NETWORK	GYRATOR EQUIVALENT	ELEMENT VALUES
		$Z_{IN} = Y_L Rg^2 = Z_0$
		$Z_{IN} = sL$
		$a = D\frac{Rg_1}{Rg_2}$ $A = d\frac{Rg_1}{Rg_2}$ $b = C\,Rg_1\,Rg_2$ $B = c\,Rg_1\,Rg_2$ $c = B\frac{1}{Rg_1\,Rg_2}$ $C = b\frac{1}{Rg_1\,Rg_2}$ $d = A\,Rg_2/Rg_1$ $D = a\frac{Rg_2}{Rg_1}$
		$Z_a = Y_1\,Rg_1\,Rg_2$ $Z_b = Y_2\,Rg_1\,Rg_2$ $Z_c = Y_3\,Rg_1\,Rg_2$
		$C_a = L_1/Rg_1\,Rg_2$ $C_b = L_2/Rg_1\,Rg_2$ $C_c = L_3/Rg_1\,Rg_2$
		$Y_1 = Z_a/Rg_1\,Rg_2$ $Y_2 = Z_b/Rg_1\,Rg_2$ $Y_3 = Z_c/Rg_1\,Rg_2$
		


DESIRED NETWORK
GYRATOR EQUIVALENT
ELEMENT VALUES
$C_1 = L_a / Rg_1 Rg_2$
$C_2 = L_b / Rg_1 Rg_2$
$C_3 = L_c / Rg_1 Rg_2$
1:n
IDEAL
$n = Rg_2 / Rg_1$
L/Rg^2
Rg^2/R
E/Rg
R_L

active network parameter R_g. The decomposition has the following form:

$$D = K_1 \prod_{i=1}^{m} (s + a_i)^2 + K_2 \prod_{i=1}^{m} (s + b_i)^2$$

where D is the given denominator of the form

$$D = \prod_{i=1}^{m} (s + s_i)(s + s_i^*)$$

K_1, K_2, a_i, and b_i are constants that the designer must determine, and s_i^* is the conjugate of s_i.

Since the degree of the polynomial D is assumed to be 2m, it requires 2m + 1 coefficients to describe it, and has 2m + 2 unknowns to evaluate. Thus, there are an infinite number of decompositions for D that each provide the same minimum sensitivity.

Equating the decomposed terms with the Q expressions yields

$$D_1 Q_2 = \frac{K_2}{R_g^2} \prod_{i=1}^{m} (s + b_i)^2$$

$$D_2 Q_1 = K_1 \prod_{i=1}^{m} (s + a_i)^2$$

Thus

$$D_1 = K_o \frac{K_2}{R_g^2} \prod_{i=1}^{m} (s + b_i)$$

$$Q_2 = \frac{1}{K_o} \prod_{i=1}^{m} (s + b_i)$$

where K_o is an impedance constant yet to be determined. Furthermore,

$$D_2 = K_1 \prod_{i=1}^{m} (s + a_i)$$

$$Q_1 = \prod_{i=1}^{m} (s + a_i)$$

Inserting these values for z_{11} and y_{22} yields

$$z_{11} = K_o K_1 \frac{\prod_{i=1}^{m} (s + a_i)}{\prod_{i=1}^{m} (s + b_i)}$$

$$y_{22} = \frac{K_o K_2}{R_g^2} \frac{\prod_{i=1}^{m} (s + b_i)}{\prod_{i=1}^{m} (s + a_i)}$$

The numerator N is decomposed so that $N/Q = -R_g y_{12} z_{12}$, and $Q = Q_1 Q_2$. Parameters y_{12} and z_{12} must be obtained with RC networks. This technique can best be illustrated with an example; therefore, consider a low-pass filter with a voltage-transfer function given by

$$F(s) = \frac{\omega_o^2}{s^2 + 2\xi\omega_o s + \omega_o^2}$$

where $N = \omega_o^2$ and $D = s^2 + 2\xi\omega_o s + \omega_o^2$.

Applying the decomposition technique yields

$$D = s^2 + 2\xi\omega_o s + \omega_o^2 = K_1(s + a)^2 + K_2(s + b)^2$$

The designer must evaluate the four unknowns K_1, K_2, a, and b. To do so he expands D algebraically and matches the coefficients of s. Thus,

$$D = (K_1 + K_2)s^2 + (K_1 a + K_2 b)2s + K_1 a^2 + K_2 b^2$$

Therefore,

$$K_1 + K_2 = 1$$
$$K_1 a + K_2 b = \xi\omega_o$$
$$K_1 a^2 + K_2 b^2 = \omega_o^2$$

Since there are four unknowns and only three equations available, the designer can choose to make some assumptions. Suppose, for example, that the expression for K_1 is manipulated to form $K_1 = 1/(1 + K_2/K_1)$ and K_2/K_1 is arbitrarily made equal to n^2.

Then, for $a > b$

$$K_1 = \frac{1}{1 + n^2}, \quad K_2 = \frac{n^2}{1 + n^2}$$

$$a = \omega_o (\xi \pm n\sqrt{1 - \xi^2}) \text{ and}$$

$$b = \omega_o (\xi \mp \frac{1}{n}\sqrt{1 - \xi^2})$$

To make z_{11} and y_{22} realizable, a must be larger than b; therefore, the plus sign is used with the radical to evaluate a and the minus sign for b. Furthermore,

$$D_1 = K_o \frac{K_2}{R_g^2} (s + b)$$
$$D_2 = K_1 (s + a)$$
$$Q_1 = (s + a)$$
$$Q_2 = \frac{1}{K_o} (s + b)$$

and

$$z_{11} = K_o K_1 \frac{s + a}{s + b}$$

$$y_{22} = K_o \frac{K_2}{R_g^2} \frac{s + b}{s + a}$$

the transfer functions y_{12} and z_{12} are found from the numerator $N = \omega_o^2$.

$$z_{12} = K_o \frac{M_1}{s + b}$$

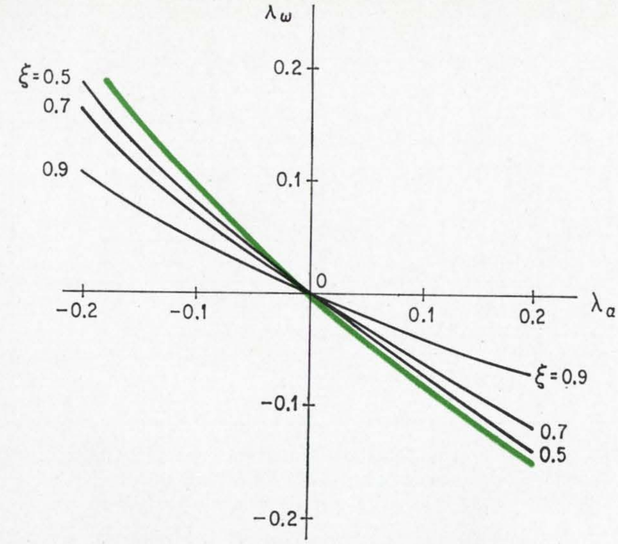
$$-y_{12} = K_o \frac{M_2}{s + a}$$

where

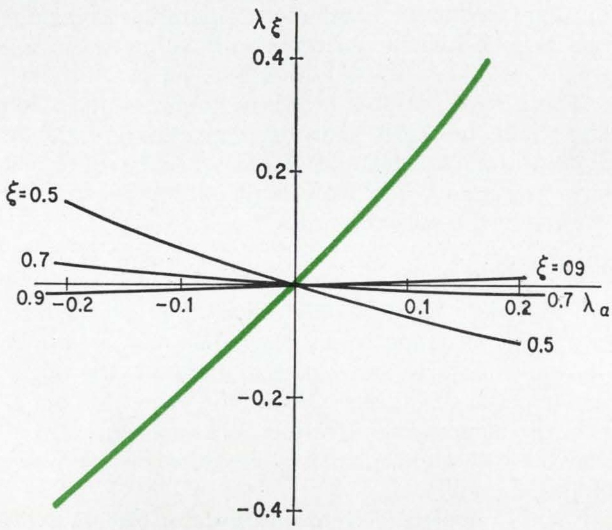
$$M_1 M_2 = \frac{\omega_o^2}{K_o R_g}$$

After the values for $-y_{12}$ and y_{22} are established, the RC network to the left of the gyrator can be produced, for example, as a T network of two resistor arms and a shunt capacitor. The value for M_2 is given by

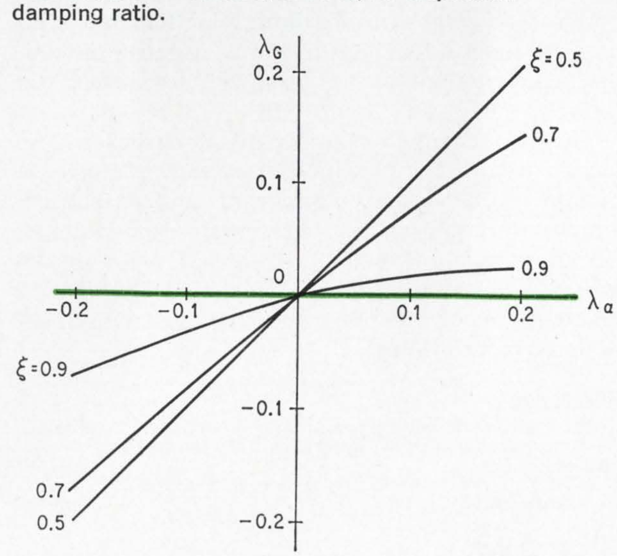
$$M_2 = K_2 b/R_g^2$$



Corner frequency vs. R_g. Colored line represents data obtained from design example 1. Second method's response in black, is superior for stability of corner frequency.



Damping ratio vs. R_g. Data obtained from design method 2, shown in black, is superior to that obtained from method 1, in color, for a specified damping ratio.



D-c gain vs. R_g. Colored line represents data from design method 1. Circuit offers uniform d-c gain.

The RC network to the right of the gyrator is synthesized with the help of z_{12} and z_{22}. It can be represented by a series resistor and a parallel RC combination. Here,

$$M_1 = K_1 (a - b)$$

Inserting the values for K_1, K_2, a, and b into the complete network yields the circuit on the bottom of page 115.

As was done in design example 1, R_x is substituted for R_g so that the stability of the filter can be examined with variations of the gyrator. Thus, let

$$\frac{R_x}{R_g} = \alpha$$

and

$$F(s) = \frac{\alpha \omega_o^2}{K_1 (s + a)^2 + \alpha^2 K_2 (s + b)^2}$$

or after inserting the values for K_1, K_2, a, and b,

$$F(s) = \frac{\omega_o^2}{h_2 s^2 + 2\xi\omega_o h_1 s + h_o \omega_o^2}$$

where

$$h_o = 1 - \frac{(1 - \alpha^2)}{5} (3\xi^2 + 1 - 4\xi \sqrt{1 - \xi^2})$$

$$h_1 = 1 - \frac{2(1 - \alpha^2)}{5\xi} (2\xi - \sqrt{1 - \xi^2})$$

$$h_2 = 1 - \frac{4(1 - \alpha^2)}{5}$$

where $K_2/K_1 = n^2$ was arbitrarily chosen to be 4.

The d-c gain, the corner frequency, and the damping ratio have changed to

$$G_x = \frac{\alpha}{h_o}$$

$$\omega_x = \omega_o \sqrt{\frac{h_o}{h_2}}$$

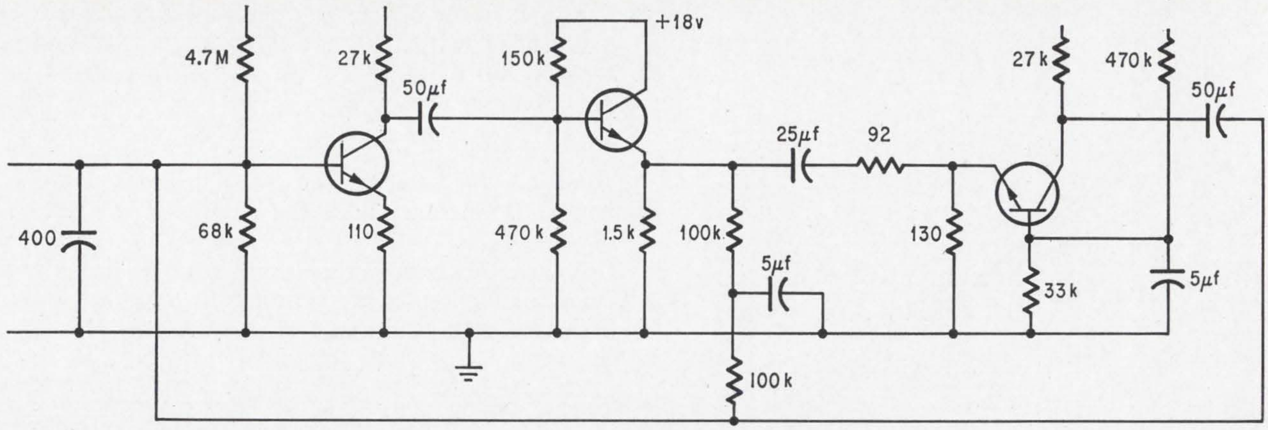
$$\xi_x = \xi \frac{h_1}{\sqrt{h_o h_2}}$$

If the damping is high, say 0.9, the transient response decays exponentially toward the steady state. For a 10% increase in R_g, ω_x and ξ_x vary respectively by 44% and 1%. Conversely, if the damping is low, the decay is oscillatory. For $\xi = 1$ the damping is called critical, making $\xi > 1$ exponential and $\xi < 1$ oscillatory.

To illustrate the design technique, consider a numerical example whose given values are: $K_2/K_1 = 4$, $R_g = 100$ ohms, $\xi = 0.6$ and $\omega_o = 5 \times 10^5$ radians per second. From the general equations given, the component values are calculated as:

$R_1 = 125\ 1/K_o$ kilohms, $R_2 = 12.5\ 1/K_o$ kilohms, $R_3 = 0.2K_o$ ohms, $R_4 = 2K_o$ ohms, $C_1 = 0.8K_o\ \mu f$, and $C_2 = 5/K_o\ \mu f$. If a value of K_o is arbitrarily selected as 2.5, then:

$R_1 = 50$ kilohms, $R_2 = 5$ kilohms, $R_3 = 0.5$ ohms, $R_4 = 5$ ohms, $C_1 = 2\ \mu f$, and $C_2 = 2\ \mu f$. The d-c gain for this filter is unity, the maximum gain is



Practical gyrator. Three transistors are used to form this this gyrator circuit. Gyration resistance is 118 ohms, and remains constant within a frequency range of nearly 3 decades. Entire network behaves as a passive device and neither consumes or adds signal energy. In the transmitting direction the circuit has a maximum insertion loss of 1.5 db; isolating direction 60 db.

1.04, occurring at $\omega = 2.65 \times 10^5$, and the gain is 0.3 at $\omega = 5 \times 10^5$.

Practical gyrator circuits

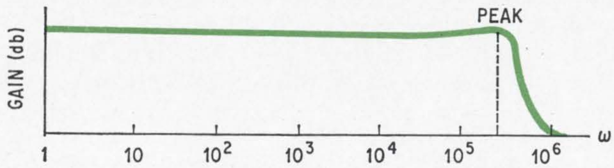
One practical gyrator was built by B. A. Shenoi of the University of Minnesota. The circuit has three transistors—one connected in a common-emitter configuration that acts as a forward amplifier, and the other two in a common-collector and common-base form, respectively, to provide active feedback.

This circuit is designed to have the following z impedances: $z_{11} = 0.685$ ohms, $z_{12} = -z_{21} = 118$ ohms, and $z_{22} = 2.2$ ohms. Because z_{11} and z_{22} are kept small, no additional negative-resistance circuits are required in series at the terminals for neutralizing the residual impedances. Ideally, z_{11} and z_{22} should be zero.

Impedances, z_{12}, z_{21}, z_{11}, and z_{22} remain constant for the frequency range of 100 to 10,000 hertz, and the frequency response is flat until 480 khz, where it has a corner frequency.

When a conductance equal in magnitude to y_{12} of the gyrator is connected in parallel with the circuit, the reverse transfer admittance of the resulting circuit is neutralized and the new arrangement can be used as an isolator. Measurements indicate that the circuit has a maximum insertion loss of 60 db in the isolating direction, compared with 1.15 db in the transmitting direction.

The insertion loss in the isolating direction is constant within 10% over a wide bandwidth of 2 khz to 250 khz. With better transistors and a biasing arrangement, the gyrator can be improved.



Frequency response. Circuit obtained from design examples has a flat gain until $\omega = 2.65 \times 10^5$ where it reaches a maximum gain of 1.04.

Both the input and output impedances can be reduced by increasing the load resistances and the biasing resistances, connected in parallel. To establish proper biasing currents and voltages, it becomes necessary to use higher bias supply voltages.

This circuit is stable for all frequencies up to 500 khz when the input shunting capacitor is 0.05 μf. With a capacitor value of 400 μf, stability up to 500 khz is assured when the circuit is either loaded or shorted at the output.

What's ahead

The gyrator isn't the only device that can be used to provide an inductorless filter. The next article in this series will describe another method—the negative impedance converter. Over the years, the negative impedance converter has received more attention than gyrators, primarily because of the work of J. G. Linvill.[2]

Shenoi's design method and gyrator circuit were responsible for arousing an interest in the possibilities of gyrators. As a result researchers and manufacturers are now giving serious attention to the gyrator as a means for obtaining practical active filters. Its main advantage over the negative impedance converter is that it is less likely to cause instability.

The two design examples given earlier by no means exhaust the possibilities of the gyrator as a building block in active filters, of course. The examples were chosen as representative of methods currently used by many circuit designers. In the future as better gyrators are developed, the gyrator will find greater acceptance among those who must design practical filters.

Reference

1. D.A. Calahan, "Sensitivity Minimization in Active RC Synthesis," IRE Transactions on Circuit Theory, Vol. CT-9, No. 1., March 1962, pp. 38-42.
2. J.G. Linvill, "RC Active Filters," Proceedings of IRE, Vol. 42, March 1964, p. 555.

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B.A. Shenoi, "Practical Realization of a Gyrator Circuit and RC-Gyrator Filters," IEEE Transactions on Circuit Theory, Vol. CT-12, No. 3, September 1965, pp. 374-380.

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Guidelines for radiation testing

Before an engineer can start testing, he must determine the type of environment, how it can be simulated, and what dosage is needed

By Joseph T. Finnell Jr. and Fred W. Karpowich
Missile Systems Division, Avco Corp., Wilmington, Mass.

Nothing frustrates a manufacturer about to bid on space or nuclear-weaponry systems more than his staff's lack of knowledge about radiation environment and testing. True, papers have been presented and articles published on the subject. But almost all have dealt with specific problems and have been aimed at particular audiences. What's needed is a simple approach, based on the barest understanding of the environment and its effects, that any engineer can take. With this, he would know what course of action to take in testing and designing—if that be necessary.

As a starter, an engineer must determine the environment in which the equipment must function —whether the radiation is particle or electromagnetic, or both. Examples of particle radiation are fast (high energy) and slow neutrons and electrons. Included in the electromagnetic-radiation category are gammas and X rays.

If the engineer is working on a space system, his main concern would be the cause of the radiation. He must consider such steady-state environments as found in the Van Allen belts and solar flares, and those generated by nuclear propulsion systems. The amount of radiation the system will be subjected to depends on how long it stays in space. Thus, the engineer must contend with the problem of accumulative radiation dosage.

Weapons environment

An engineer working on a weapons system, on the other hand, must concern himself primarily with the effects of short bursts of high-intensity neutrons stemming from a nuclear blast.

Duplicating this type of environment is almost impossible, even with underground weapon tests; the atmospheric effects can't be simulated. A burst condition consisting of a pulse of gammas with a dose rate of about 10^{11} rads per second and neutron fluences of 10^{13} neutrons per centimeter^2 can be considered a weapons environment. And duplicating even a weapons environment is difficult with existing radiation sources.

In a nuclear blast, prompt gammas cause transient effects as well as permanent damage. Usually these transient effects fade before the neutron pulse reaches the equipment. Although accelerators or flash X-ray machines can simulate the prompt-gamma pulse and nuclear reactors can produce the neutron pulse of this environment, they can't achieve them in the exact time sequence of the actual weapons environment. As a result, testing for neutron effects is separated from that of prompt-gamma effects.

Compounding the difficulty of simulating a weapons environment is the nature of the weapons systems themselves. A fission weapon for example, has a neutron spectrum that can be approximated by a nuclear reactor, which is based on fission. But most of today's weapons are thermonuclear; fusion and fission are combined to achieve the destructive force.

Fusion, by itself, emits neutrons with energies as high as 14 million electron volts. Neutron energies generated by nuclear reactors, however, are no higher than 5 mev. Despite this wide gap in energy levels, an engineer can still predict the type of damage the 14-mev particles will cause. This is achieved by the engineer first normalizing all neutron damage to that caused by 1-mev neutrons. By measuring the damage caused by this energy level and then that caused by other neutron energies, he can find a correlation factor. Thus, the engineer can predict the damage caused by 14-mev neutrons.

Radiation sources

More often than not, data is required on the effects of the prompt- and delayed-gamma radiation in the weapons environment; prompt gammas last for nanoseconds and delayed gammas last for microseconds. Of the three major sources of radia-

Typical radiation sources

Type	Location	Maximum radiation produced n/cm²	Rads	Rads/sec. (peak)	Pulse width
Pulsed reactors					
Godiva*	Atomic Energy Commission Los Alamos, N. M.	10^{13}	5×10^3	10^7	100μs
SPR*	Sandia Corp. Alburquerque, N. M.	10^{13}	5×10^3	10^7	100μs
Kukla*	Lawrence Radiation Labs Livermore, Calif.	10^{13}	5×10^3	10^7	100 μs
Molly-G	Kaman Nuclear Colorado Springs, Colo.	10^{14}	5×10^4	3×10^8	1–10 ms
Triga	General Atomic San Diego, Calif.	5×10^{13}	10^4	5×10^7	10 ms
Accelerators					
Linac	Many industrial faciltities and universities		10^3	10^9	0.1–5μs or steady state
Dynamitron	Boeing Co. Seattle, Wash.	10^{12}	10^3	10^9	1μs or steady state
Flash X ray	Ion Physics Corp. Burlington, Mass.		10^4	10^{12}	0.02 μs
Gamma cells					
C_o^{60} source or C_s^{137} source	Hughes Aircraft Corp. Fullerton, Calif.			10	steady state

* Available only to DOD or AEC contractors

tion that are available—reactors, accelerators, and gamma cells—accelerators, particularly—the linear accelerator (Linac) and the flash X-ray machine—have proved to be effective tools. Both produce pulsed radiation, but only the linac is capable of producing either single pulses or a train of pulses that can be varied in position or width; the X-ray machine produces a single, fixed pulse. Other accelerators, such as the Van de Graaff electrostatic generator and the Dynamitron, produce either steady state or pulsed radiation.

With an output 10 times better than that of the Linac, the flash X-ray machine is capable of producing intense bursts of megavolt X-rays that are used to simulate the effects of prompt gammas. A high-impedance power supply charges a gas-insulated coaxial line, which, when triggered by a pressurized spark gap, releases this energy into an evacuated field-emission diode. The anode of this diode consists of a high atomic number X-ray target, such as tungsten, and is usually grounded. When struck by an electron beam, the anode emits X rays. An aluminum shield prevents any low-energy electrons from irradiating the device under test.

By removing shield and target anode, the electrons strike the device directly and the engineer can study the effects of permanent damage.

Since neutrons are a major consideration in a weapons environment, engineers turn to pulsed reactors. Two reactors, the Sandia Corp.'s SPR and the Godiva, consist of an unreflected, cylindrical, neutron-enriched uranium core assembly that can produce 100-microsecond pulses of fission neutrons and gamma rays. These reactors can produce 10^{13} n/cm² at the core—but the dosage decreases as the experiment is moved farther away from the core. The assembly is at the center of a room approximately 30 feet in diameter and experiments can be placed anywhere in the room; the location depends on the desired radiation dose. These reactors are shielded by concrete and mounds of sand and dirt.

The Triga pulse reactor produces greater output than SPR or Godiva. It can deliver a maximum of 5×10^{13} n/cm² per pulse near the core. Triga can be likened to a swimming pool in which the core assembly is placed in close proximity to one wall. Behind this wall is a dry exposure room where test devices are subjected to radiation. Other experimental devices can be put into water-tight containers and placed near the core or at any point within the pool, depending on the dosage required.

Pulsed neutron generators can also be used to simulate weapons environment. They provide higher-energy neutrons than reactors, but over a much smaller area for nanosecond pulses. Primary applications of these generators are in investigating the ionization effects caused by neutrons, correlating the resultant damage, and studying the rapid annealing of devices after neutron damage.

Where and when

Knowing what equipment to use is one thing, but

Measuring the dosage

Radiation Source	Radiation type	Measurement technique
Reactor (steady state)	Neutrons	Threshold detector (Radioactivants)
	Gamma ray	Compton scattering and pair production spectrometer
		Crystal absorption spectrometer
Reactor (pulsed)	Neutrons	Threshold detector (Radioactivants)
	Gamma ray	Photodiode (dose rate detector)
		Chlorinated hydrocarbon dosimeter
		Oxalic acid dosimeter
Accelerators and gamma cells (steady state)	Gamma ray	Calorimeter
		Ionization chamber
		Ferrous-sulfate dosimeter
Accelerators (pulsed)	X ray	Lithium fluoride dosimeter
	Gamma ray	Photographic emulsions
		Photodiode detector
	Electrons	Faraday cup
		Ferrous sulfate dosimeter
		Photographic film

actually using it is something else. Unless a company is either doing or planning to do intensive work in this area, it's doubtful it would go to the expense of buying a radiation source. Such equipment is prohibitively priced. Instead, the firm most likely will rent the equipment at the equipment's site. Government facilities are the least costly, but they usually aren't available to nonmilitary contractors.

Many radiation sources, however, are available for nonmilitary work.[1] Some are owned by companies, others by universities. And almost all can be either rented or leased. General Atomic, for example, maintains a Triga pulsed reactor and a Linac facility near San Diego, Calif. The Kaman Corp.'s nuclear division has a Molly-G pulsed nuclear reactor at its Colorado Springs, Colo., facilities. And in Seattle, Wash. the Boeing Co. has a variety of radiation machines, including Linac, Dynamitron and flash X ray. Flash X-ray facilities are also available at the Ion Physics Corp. in Massachusetts and at the Physics International Co. in California.

Nuclear yardsticks

None of the radiation sources presently available have built-in dosimeters. Dosimetry—the measurement of radiation levels—is one of the least precise aspects of radiation testing. Methods of measuring the radiation environment range from the simple and inexpensive, photographic emulsion, to the complex and costly, gamma-ray spectrometry. Between these extremes are a variety of methods tailored to the various user needs.

The most common method of measuring neutron fluence is the use of isotopic activation property of gold, sulfur, and phosphor. When bombarded by neutrons, these materials exhibit a sharp increase in isotope production at a particular threshold energy—the threshold depending on the type of material. If several of these activation materials are chosen, each with different activation energy thresholds, it would be possible to cover most of the energy spectrum. An accuracy of ±3 decibels can be obtained under precisely controlled conditions. But under normal conditions, ±5-db accuracy is usually achieved.

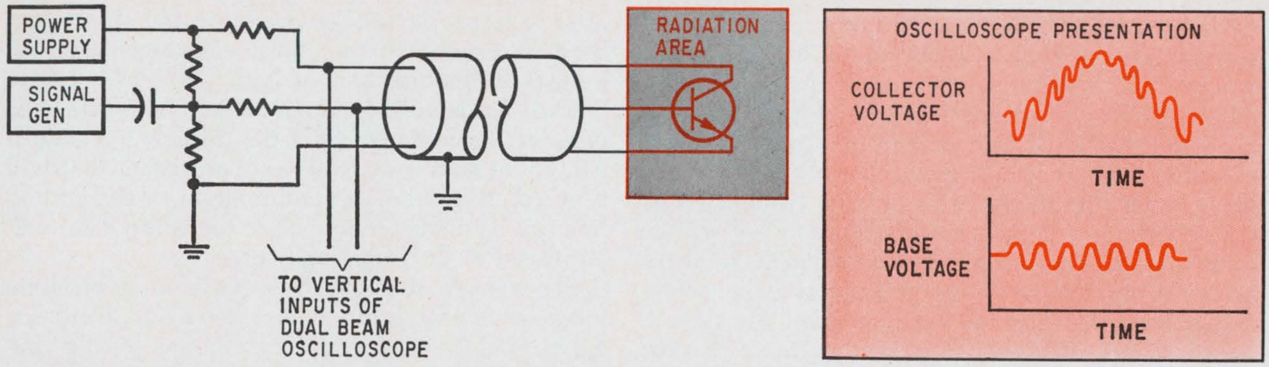
Gamma rays and other ionizing radiations can be detected by various photographic techniques. One such technique uses a photographic emulsion-film wafer exposed to radiation. Developed under precisely controlled conditions, the wafer is viewed by the engineer using an optical densitometer or spectrophotometer. By determining the opacity of the exposed film and comparing it to a previously calibrated reference film, the engineer can measure the gamma-ray dose within ±6 db.

Another type of gamma-ray dosimeter employs a lithium fluoride crystal. Irradiation of this material causes vacancies and interstitials in the initially well ordered crystal lattice structure, which produces energy levels somewhere between the valence and conduction bands. This type of crystal has energy trapping levels that absorb ultraviolet light above 5 electron volts. The amount of ultraviolet light this crystal absorbs can be directly related to

For your information . . .

Other articles dealing with radiation that have appeared in Electronics include:

- "Designing against space radiation: parts 1 and 2" [Dec. 28, 1964, p. 61, and Jan. 11, 1965, p. 70] detailed the nature of the radiation environment in space and the methods of selecting components for use in that environment.
- "Designing for the worst of worst cases—nuclear war" [Aug. 21, 1967, p. 99] looked at radiation problems from a military standpoint.
- "Equivalent circuits estimate damage from nuclear radiation" [Oct. 30, 1967, p. 73] presented device models that a circuit designer can use to calculate radiation effects on components and compute circuit response.
- "Skipping the hard part of radiation hardening" [March 4, p. 122] showed how to predict responses of circuit elements without performing any tests.



Gain degradation. A transistor biased by external resistors and a power supply is driven by a sine-wave generator. By dividing the collector voltage by the base voltage, an engineer can find the gain degradation of a transistor. How fast and to what degree the transistor recovers are determined from the amplitude of the collector waveform as a function of time.

the radiation dose. Using this method, an engineer can expect accuracies within ±6 db.

Since it is often necessary to determine the dose rate (flux), other measuring methods are necessary.

Gamma rays can be measured using a photodiode that produces photocurrents when exposed to ionizing radiation. These currents depend on the magnitude and shape of the radiation pulse. Although any semiconductor junction can be used to detect ionizing radiation, greater accuracy and sensitivity are achieved with diffused-junction, encapsulated, surface-barrier, or p-i-n structure detectors. An accuracy of ±6 db could be achieved if the effects of stray radiation are prevented from masking the relatively low diode output.

Some firms, not wishing to go through the expense of setting up their own dosimetry facilities, take advantage of a service such as that provided by E.G.&G. Inc., which calibrates its instruments and analyzes the amount of radiation the dosimeter registered. Another firm that provides a similar service is the Moleculon Research Corp. in Cambridge, Mass.

Once the method of measurement is decided on, the next decision is what components are to be tested. All components are affected by radiation, but transistors more so than the others. Usually resistor and capacitor values can be adjusted to minimize radiation effects, but this may be difficult to do for transistors.

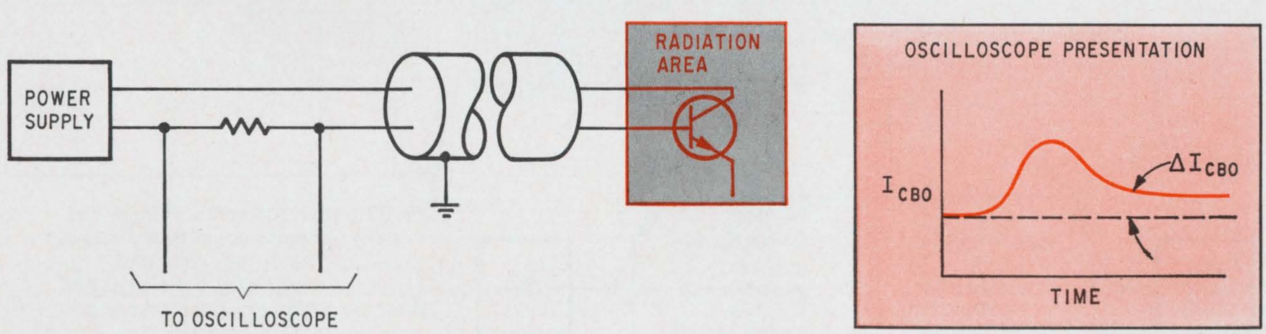
When transistors are irradiated, many of the critical parameters change. Neutron bombardment decreases the small signal gain, β, but increases both the saturation resistance, $R_{(SAT)}$, and the reverse leakage current, I_{CBO}. Gamma rays and other ionizing radiation generate primary and secondary photocurrents that change β and increase the radiation storage time.

Statistical approach

A look at any transistor specification sheet clearly indicates the wide parameter distribution inherent in any semiconductor device. A typical small signal current gain distribution of 33 2N2708 transistors ranged from 18 to 100, with approximately half the devices at 45.

Just as transistor parameters have a statistical distribution, the effect similar radiation has on these parameters also varies from device to device. Thus, radiation testing must be done on a relatively large scale if it is to be meaningful. The actual number that must be tested depends on the distribution of device parameters.

For example, 10 transistors might be considered a large lot if the standard deviation on the distribution is only 1% of the mean value; whereas, 100 transistors might be considered a small lot if the standard deviation approached 50% of the mean value. Much depends on the confidence level required and the measured parameter distribution.



Leakage current. The collector-to-base junction is reversed biased by the power supply. By measuring the current flowing through the series resistor, an engineer can determine the magnitude of the leakage current, I_{CBO}, before, during, and after irradiation.

One way to obtain some idea of what parameter distribution to expect under radiation is for the engineer to perform a pilot run. Consider, for example, 10 chosen at random suffered gain degradations distributed within ±50% of the mean. This would indicate that a large number of devices must be tested if the engineer is to have confidence in the results. But if the gain distribution fell within ±10% of the mean, the same confidence could be achieved by testing fewer transistors. The confidence level depends on how stringent the circuit requirements are and how severe the radiation environment will be.

To determine the number of transistors that must be tested to find the one percentile point with 90% confidence that 99% of these devices will have a gain greater than this, the engineer would use the equation

$$n = \frac{\log (1.0 - 0.9)}{\log (.99)}$$

where n is the number of test units, 0.9 is the confidence level required and 0.99 is the probability that any one of the test transistors lies above the one percentile point. This equation yields 230, which is the number of transistors to be tested. If a confidence level of 99% instead of 90% were required, twice as many transistors would have to be tested.

When the number of units to be tested is relatively large, semiautomatic and even automatic testing systems would sharply reduce costs and the time needed to complete the task. Turntables or sample wheels place each test device in front of the radiation source without the engineer or technician having to go into the test area.

In reactors, where several hundred components can be simultaneously exposed to a continuous barrage of neutrons and gammas, many measurements must be made in a very short time. Clearly, fully automatic testing is desired here.

But before any testing is attempted, the engineer should decide what measurements are to be made, and whether they will be made only before and after exposure or during exposure, too. Moreover, he must decide whether the measurements are to be periodic, continuous, or both.

Once he has decided on which parameters to measure, he must consider the dosage and how it will be measured, and the test equipment that will be used. Based on this information, a determination can be made on how close the component will be placed to the radiation source.

For example, the output of a flash X-ray machine forms a conical beam whose intensity decreases approximately as the inverse square of the distance between component and radiation source. But this poses a problem of uniformity.

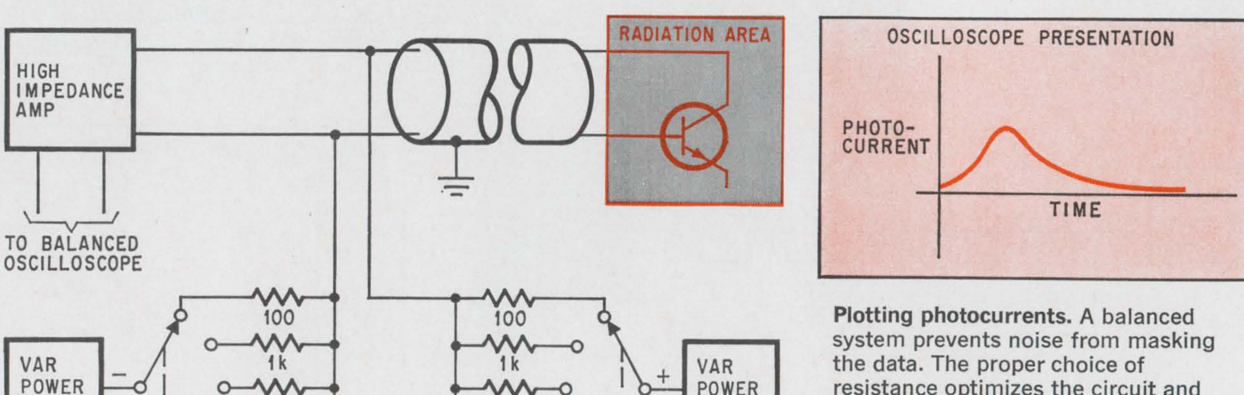
Suppose a device 5 inches in diameter is to be irradiated with 100 rads using a 2 or 3-mev flash X-ray machine. This would require the device to be placed approximately 20 inches from the machine's window. Although the device's center would receive the full dose, its edges wouldn't. Because of a conical beam, the dosage at the device's edges drops to about 95 rads. If this is satisfactory, the engineer need consider nothing else. But if greater irradiation uniformity is required, the device would have to be placed farther from the source—but at a price of decreased radiation intensity. Thus, if greater uniformity is desired at the 100-rad dosage, another radiation source should be considered.

For some components, particularly transistors, it would be best to duplicate the actual circuits with which they will ultimately be used. The reason: the amount an irradiated transistor's parameter changes can be affected by circuit impedance.

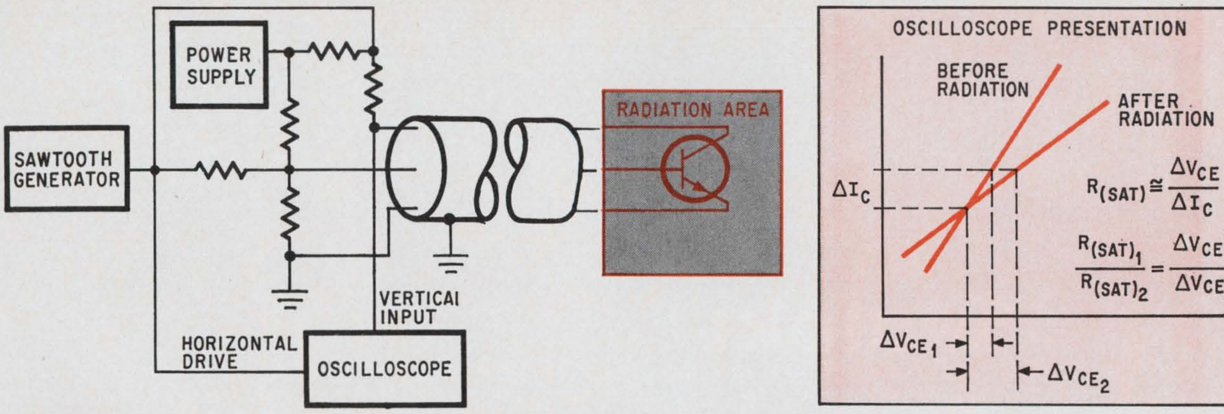
Gain, leakage, resistance

All test setups require radio-frequency shielding especially the cables that link the device and source in the test area to a control console some distance away. The type of shielding depends on the ambient noise spectrum generated by the radiation source, and grounding techniques differ for each test setup. To achieve satisfactory results, the engineer must experimentally determine the most suitable layout for each test setup.

One test setup, at top of page 125, determines



Plotting photocurrents. A balanced system prevents noise from masking the data. The proper choice of resistance optimizes the circuit and the power supplies back bias the collector-to-base junction. The amplitude of photocurrent is displayed on the oscilloscope as a function of time.



Saturation resistance. A sawtooth generator supplies a ramp voltage that is applied simultaneously to the transistor—biased into saturation—and the horizontal-drive circuits of an oscilloscope. A plot of the change in collector-to-emitter voltage for a fixed change in collector current indicates the value of saturation resistance.

transistor fast annealing and gain degradation from neutron damage. The transistor is connected as a three-terminal device and biased by an external power supply. A signal generator drives the bias of the transistor with a 10-kilohertz sine wave. A dual-beam oscilloscope monitors both the base-drive voltage and the voltage developed across the collector load resistor.

The collector waveform is a series of 10 khz sine waves whose amplitude depends on the circuit gain. Voltage gain of the amplifier is found by dividing the peak-to-peak collector voltage by the peak-to-peak base driving voltage. By noting the change in magnitude of the a-c signal as a function of time, the engineer obtains the amount of gain degradation and annealing. Although a 10-khz signal is used here, almost any frequency can be applied. However, it should be pointed out that high frequencies can create circuit layout problems.

One setup for investigating the change in leakage current is shown on the bottom of page 125. Only the long-time effects produced by neutrons are of interest, not the transient shift in the leakage current, I_{CBO}. The transistor is connected as a two-terminal device—emitter is left floating—and the change in I_{CBO} is monitored by an oscilloscope. The reverse leakage current flowing through the collector-base junction peaks shortly after the radiation pulse subsides and then gradually decreases to an equilibrium value. The change in I_{CBO} is the difference between the initial value and that after the transistor is irradiated.

To measure changes in saturation resistance, $R_{(SAT)}$, the engineer can use a test setup, shown above, in which a ramp voltage is applied to the base and collector of a transistor already biased into saturation and to the horizontal drive circuit of a oscilloscope. This changes the collector-to-emitter voltage V_{CE}, which produces a change in the collector current, I_C. The current that flows through the collector-load resistor develops a voltage that is monitored by the oscilloscope.

As the ramp voltage varies, the change in V_{CE} is displayed on the oscilloscope's horizontal axis and the change in I_C on the vertical axis. The oscilloscope then traces a line whose slope is equal to $\Delta I_C/\Delta V_{CE}$, the reciprocal of $R_{(SAT)}$. Changes in the slope—before and after irradiation—indicate the change in saturation resistance.

When it comes to semiconductors, the major effect of gamma radiation is that it generates photocurrents, which adversely affect operating parameters. Thus, engineers are extremely concerned with the pulse shape, peak, and equilibrium amplitude of the photocurrents generated by different gamma-ray dose rates. Short radiation pulses are used to observe the peak amplitude and long pulses are used to determine the equilibrium current amplitude. When measuring the pulse shape, care must be taken to prevent the device from saturating. In an experimental test setup, on page 126, used for measuring the amount of primary photocurrents, the transistor's emitter is left floating; primary photocurrents are generated only in the reversed biased collector-to-base junction.

Balanced systems are used so that Compton scattering effects and r-f noise do not mask the low photocurrent levels.

A base and collector resistance is selected to optimize the test circuit without device saturation. When the transistor is irradiated, photocurrents flow through this resistance and develop a voltage, which is amplified and displayed on an oscilloscope as a function of time.

Data handling

Because of vast amount of data that must be correlated and processed in radiation testing, engineers working in this area are turning to computerized data processing in increasing numbers. But even with a computer, the engineer must reduce the data from oscilloscope cameras using strip film and transfer it to the computer. Thus far, this has proved time consuming. Hopefully, better and faster data handling will be in the offing.

Reference

1. Radiation Effects Information Center, "Survey of Radiation Facilities," REIC report 31, Sept. 15, 1963.

Circle 270 on reader service card→

Sealok:™

new Burndy micromodular interconnection system is ultra-reliable

withstands temperature, vibration, shocks, wire training, moisture and most fluids and gases.

Whew!

Developed to provide density for critical applications, the new Burndy Sealok system eliminates current intermittencies and variations in millivolt drop.

Designed so that they are unaffected by severe training of wires, modules are protected by a rigid outer shell. Exclusive with Burndy, this protects the sealing grommet and other internal components and provides a guide for proper insertion and extraction of contacts. The inner construction (illustrated far right) insures that every contact is held firmly against the bus bar.

Sealok modules and contacts are available in sizes 20, 16 and 12, with one hybrid module which accommodates both 16 and 20. Contacts cover a wire range of 24 thru 12 and are easily and quickly installed with standard tooling. Sealing plugs for unused positions are also available. Write for catalog giving full details.

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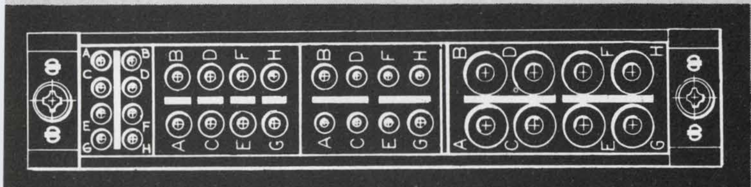
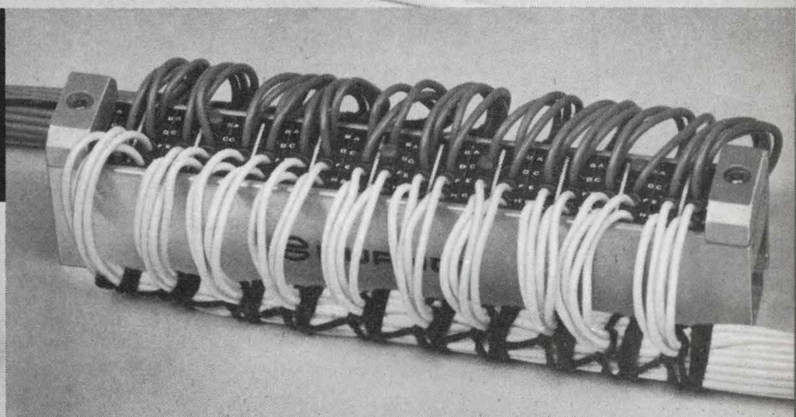
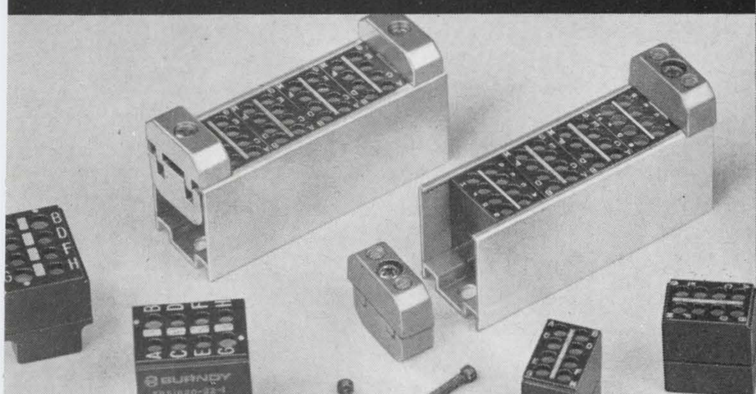
Extruded aluminum track is available in 6-foot lengths or to specification. End clamps keep modules in track and provide mechanical rigidity.

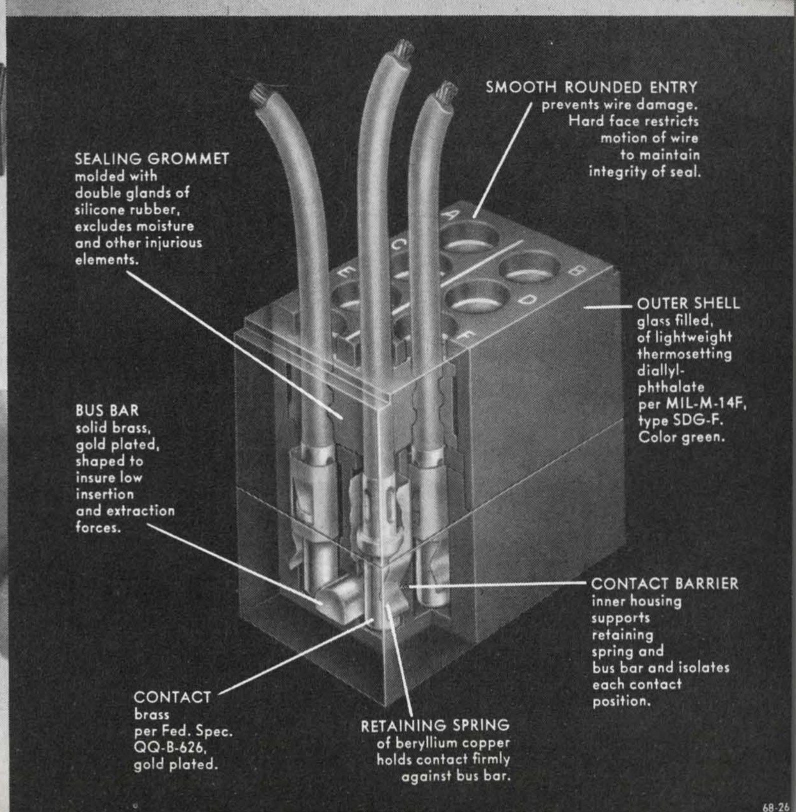
(below) Plan view of Sealok modules shows clear identification of contacts and bussing arrangements. Different bussing arrangements available in each module size.

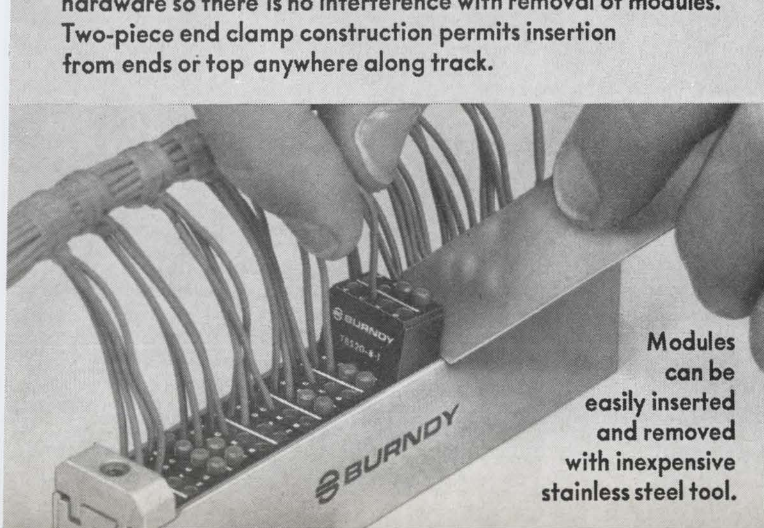






Track features recessed mounting hardware so there is no interference with removal of modules. Two-piece end clamp construction permits insertion from ends or top anywhere along track.





Modules can be easily inserted and removed with inexpensive stainless steel tool.

Vibrating angular rate sensor may threaten the gyroscope

Coriolis-force device, now being test flown, is expected to last 25 times as long as gyros and to cost about the same

By William D. Gates

Avionic Controls department, General Electric Co., Binghamton, N.Y.

Eliminating moving parts has long been a favorite solution to problems of life and reliability. And now such a solution has been made practical for the angular rate sensors used in stabilizing and controlling aerospace vehicles. The sensors indicate changes in the vehicle's rate of rotation.

The moving parts in conventional rate gyros are the ball bearings and high-speed rotor needed to obtain a high angular momentum. Attempts to improve these parts—for example, supporting the bearings electrostatically or with gas—have lessened wear and increased reliability, but haven't reduced the complex fabrication steps that boost costs.

The Avionic Controls department of the General Electric Co. designed a sensor without such moving parts. It can be made simply and at low cost and has a lifetime potentially 25 times that of the gyro or linear accelerometer. The new sensor is based on Coriolis-force principles and uses a solid, rectangular piece of metal that's made to vibrate in one plane while it senses rate changes in the other.

Several models of the vibrating rate sensor have been built. One is undergoing flight tests in the yaw damper channel aboard a Boeing 707. Another is in continuous test and has accumulated more than 4,500 hours without a failure and with a total null drift of less than 1 degree per second.

Vital statistics

It's estimated that the life of the unit could well hit 50,000 hours at a power consumption of one watt at ± 15 volts, as shown in the table on page 132. A gyro has a 2,000-hour life expectancy and a four-watt power dissipation.

The output of the new unit may range, depending on the application, from 0.04 to 0.20 volts/degree/second, with a resolution of 0.02 to 0.05 degrees/second. The dynamic range is greater than 10^5.

Right now, the packaged sensor, with its electronics, measures $3\frac{3}{16}$ x $4\frac{3}{16}$ x $1\frac{3}{16}$ inches and weighs 14 ounces. Further miniaturization using silicon integrated circuits could reduce the size to 1.5 x 3 x 0.75 inches and weight to three ounces.

The developmental models have used a combination of integrated circuits in TO-5 cans and discrete components connected with point-to-point wiring. However, General Electric is considering using large scale integration techniques to fit most of the system into as few as three flatpacks. Discrete components would still be used for such elements as feedback resistors and large-valued capacitors and for setting scale factors.

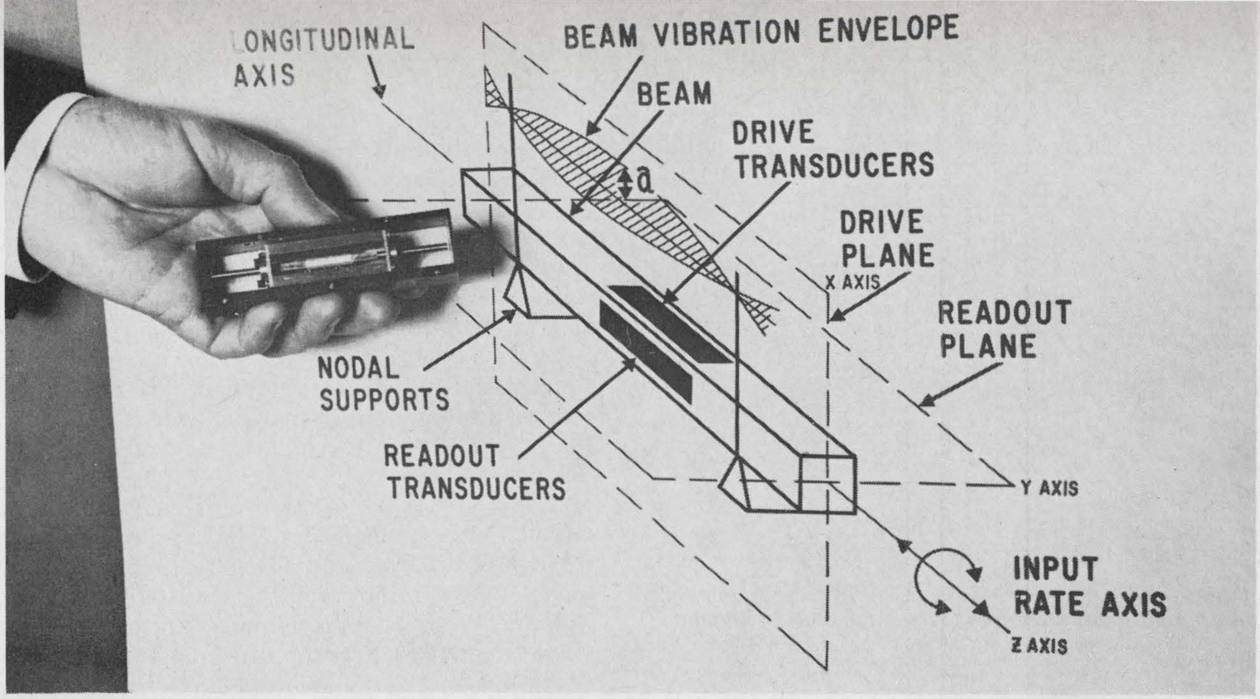
The rate-sensing beam itself is extremely simple to make. It's machined out of a solid piece of metal, but tolerances aren't at all critical. The unit may be put together in an ordinary environment; a clean room is unnecessary.

The market for the sensor could be large. Last year, for example, GE's avionics department built more than 6,000 conventional rotating rate gyros for the F-4, F-105, and F-111 fighters. What's more, similar sensors are used in many commercial airliners and it's expected that the vibrating sensor will be able to meet the price of these conventional sensors easily.

How it works

The vibrating sensor produces a voltage proportional to the angular acceleration by converting displacements caused by Coriolis forces into piezoelectric signals. The basic sensing element consists of a rectangular metal beam driven sinusoidally in one of its major planes at its fundamental bending frequency and supported at its nodal points.

With the beam vibrating, any change in angular velocity about the beam's longitudinal axis produces



Basic sense. Sinusoidally vibrating metal beam senses changes in angular input applied about its long axis. The Coriolis effect sets up a sinusoidal signal at the readout transducer that is a function of the input rate.

a sinusoidally varying force at the bending frequency—the Coriolis force—perpendicular to the drive plane. This force produces a vibration at the same frequency at which the beam is driven.

A readout circuit senses the Coriolis-induced beam motion through a piezoelectric transducer, then amplifies and demodulates the signal and produces a d-c output proportional to the input rate.

The Coriolis force

A Coriolis force turns up in the basic dynamic equations of motion for a rigid body whenever the body is moving relative to a rotating, rather than a stationary, coordinate system.

For example, the rotation of the earth must be taken into account in calculating the trajectory of a ballistic missile set to move in a straight line, or in predicting the path to be taken by a tropical storm. In these cases, the apparent deflection of both the missile and the air mass, as seen by an observer on the rotating earth, is attributed to this Coriolis force. In the northern hemisphere, the force acts to deflect the body to the right; south of the equator, to the left.

When an observer in a system rotating at a constant angular velocity $\bar{\omega}$ views a particle (or system of particles) acted upon inertially by a simple force F, the apparent force on the particle, relative to the moving observer, can be shown to be:

$$F_{eff} = F - m\bar{\omega} \times (\bar{\omega} \times r) - 2m(\bar{\omega} \times \bar{V})$$

where m = particle mass

$\bar{\omega}$ = angular velocity vector

$\bar{V}$ = particle velocity vector

The middle term is a vector normal to $\bar{\omega}$. It points outward and corresponds to centrifugal force. The last term, $-2m(\bar{\omega} \times \bar{V})$, is the Coriolis force, which exists whenever the particle is moving in the inertial frame and viewed from the rotating frame.

A somewhat crude analogy can be drawn between a gyro and the vibrating sensor.

For the gyro, there is the standard relationship between torque, τ, angular momentum, $\bar{H}$, and angular input, or precessional velocity, $\bar{\omega}$:

$$\bar{\tau} = \bar{\omega} \times \bar{H}$$

In a typical spring-restrained rate gyro, this torque is converted to an angular displacement which is, in turn, converted to an electrical signal proportional to the input angular rate. The relation among these vectors is shown in the diagram on page 132.

The vibrating sensor replaces these angular parameters with linear ones. Thus, torque is replaced by the Coriolis force, $\bar{F}_c$, and angular momentum, is replaced by linear momentum, $m\bar{V}$, so that:

$$\bar{F}_c \,\alpha\, (\bar{\omega} \times m\bar{V})$$

where $\bar{\omega}$ is the input angular velocity. For a particle moving with a linear velocity but in a rotating reference frame, then, the Coriolis force is given by:

$$\bar{F}_c = -2m(\bar{\omega} \times \bar{V})$$

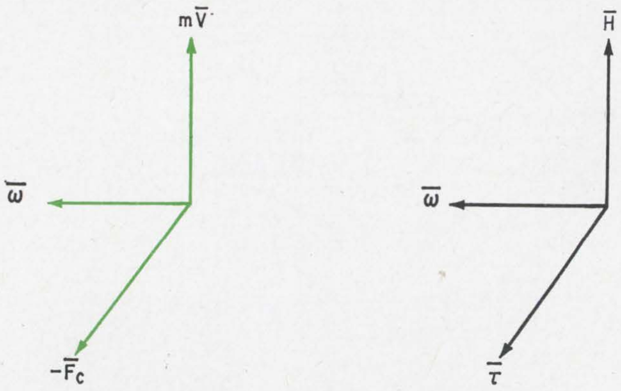
The driving force

The vibrating beam is made of Ni-Span-C, a nickel-chromium-titanium alloy. The beam is rounded outward from the nodes so it can be held by O-ring clamps at both nodal points.

The supporting structure for the O-rings is a four-bar frame also made of Ni-Span-C. This minimizes thermal stresses at the mounting points.

The force for driving the beam is applied through piezoelectric transducers bonded to the beam's surface in the drive plane. Made of lead zirconate titanate, the transducers are thin 0.90 x 0.75 x 0.02-inch rectangular plates.

Transducers are bonded to each of the other three faces of the rectangular beam. The transducer on one of the faces at right angles to the drive face senses the Coriolis-induced vibrations and provides the readout. The transducer on the face parallel to the drive face is a feedback transducer used in an electronic drive circuit to keep the beam amplitude



Analogies. Spring-restrained gyro's angular parameters, right, of torque, τ, angular momentum, H, and angular velocity, ω, have their counterparts of Coriolis force, F_c, linear momentum, mV, and input angular rate, ω, in the vibrating beam sensor, left.

constant and vibrating at the mechanical resonant frequency. The transducer opposite the readout transducer is connected to a circuit that damps the beam electronically.

Whole new way

Both the drive and readout transducers are split into two isolated halves to accommodate inhomogeneities and positioning errors in the piezoelectric material on the surface of the beam.

For example, if the transducer is not uniformly thick, or if it is not centered perfectly on the beam, the drive and readout planes may not be at right angles to each other. Splitting the transducer allows for better control of the direction of the driving motion. The readout transducer is also split in two, but this was done to allow nulling of quadrature signals resulting from drive plane motion.

Electrical connections to the transducers are varnished to the beam, laid close to the nodal mounting points, and then brought out to the sensor terminal board. Such positioning of the leads minimizes their effect on the beam vibration.

A sinusoidal voltage at the first resonant frequency of the beam is applied to the drive transducers and vibrates the beam at a constant frequency and amplitude. This frequency depends on both material and geometry, but it must be well above the highest frequency of the environmental vibration that's expected in the application. In the developmental units built thus far, beam-drive frequencies have ranged from 1,500 to 6,000 hertz, with beams two to four inches long.

Circuit design

The electronics in the sensor's drive and readout circuitry, shown on page 134, takes advantage of the versatility of the μA709, a silicon monolithic operational amplifier. This op amp is used as an inverting and noninverting voltage amplifier, and as an inverting transimpedance amplifier transducing current to voltage.

The μA709 is small but provides very high voltage gains with outputs that appear as voltage sources. It makes unnecessary the large coupling and bypass capacitors needed in conventional circuitry, as well as the transformer in the demodulators.

Its disadvantage is that it requires a plus and minus power supply, but this helps make unnecessary any large d-c bias on the transducer crystals.

Low-impedance integrator buffers connected to the readout transducer eliminate the noise and stray-capacitance problems that would crop up if the transducer fed the high-gain readout amplifier directly. Because both halves of the transducer don't produce equal quadrature signals, the buffer outputs are summed into the readout amplifier through scaling resistors. A potentiometer adjustment of one resistor provides a quadrature null control. Any in-phase null is minimized by adjusting the gain of buffers feeding the drive amplifier.

The readout amplifier, capacitor-coupled to the buffers, is an inverting amplifier with its gain adjusted for the scale factor required for low or high angular input rates. The high gain of this amplifier also increases the null voltage. This voltage is, however, in quadrature with the signal voltage and isn't passed by the demodulator. The demodulator also uses a μA709 with a pair of complementary chopper switches. The op amp is used alternately as an inverting and noninverting amplifier with equal gain in either mode. The a-c signal corresponding to the angular input rate is then a positive, full-wave rectified signal when it's in phase with the demodulator reference drive. When the signal is 180° out of phase with the reference, the demodulator output is full-wave rectified in the opposite direction. Thus, the direction of the angular input is indicated by the polarity out of the demodulator. A 10-kilohm output resistor and a 0.5-microfarad capacitor to ground are used to filter the demodulator output. A bias-offset adjustment on the demodulator allows a further d-c null adjustment of the output voltage.

The chopper and demodulator reference is obtained from the feedback transducer. This signal is phase-shifted by a passive filter and amplified before it is applied to the choppers.

The demodulator reference uses a μA709 invert-

Rating the sensor

Life (estimated)	50,000 hours
Power	1 watt at ±15 volts
Start-up time	1 second
Threshold (2 cps bandwidth)	0.01°/second
Resolution (2 cps bandwidth)	0.02-0.05°/second
Linearity	1% full scale
Scale factor (output)	0.04-0.20 volts/deg/sec
Output range	± 9v (18 volts full scale)
Null uncertainty	0.1-0.4°/second
Frequency response	40 hertz
Compensated damping ratio	0.1-0.6
Maximum angular rate	over 1000°/second
Cross-coupling	0.1%

First try: cutting Dutch roll in a 707

The vibrating rate sensor being test-flown by the Boeing Co. is in the yaw damper channel of a 707 jet. The sensor damps the so-called Dutch roll oscillation, a normal side-to-side oscillatory mode that occurs in the lateral dynamics of any aircraft.

A Dutch roll damper system is generally made up of the components shown just below. The sensor detects the yaw rate and feeds back a signal to deflect the rudder. A high-pass filter is included so that feedback occurs only for a transient input. Thus, a steady state rudder command by the pilot wouldn't be opposed by rate feedback.

Without the compensating feedback loop, the aircraft's response to Dutch roll is very lightly damped. This is shown in the s-plane plot for the uncompensated forward loop, below right. The rudder servo pole comes from the $(s+1/\tau_1)$ term in the denominator of the $r/e\delta_r$ relation; the spiral divergence pole from the $(s-1/\tau_2)$ term, and the Dutch roll roots from the final denominator expression.

The damping ratio is expressed by the cosine of the angle ϕ. The low ratio means that any disturbance of the aircraft, whether caused by a rudder command or by air buffeting, will lead to a lightly damped oscillation before the aircraft resumes a steady position. Adding the rate feedback increases the damping ratio by reducing the angle ϕ. Just what happens with the rate feedback added is shown in the figure below left. This is a root locus plot showing the possible pole locations of the closed loop roots for increasing gain.

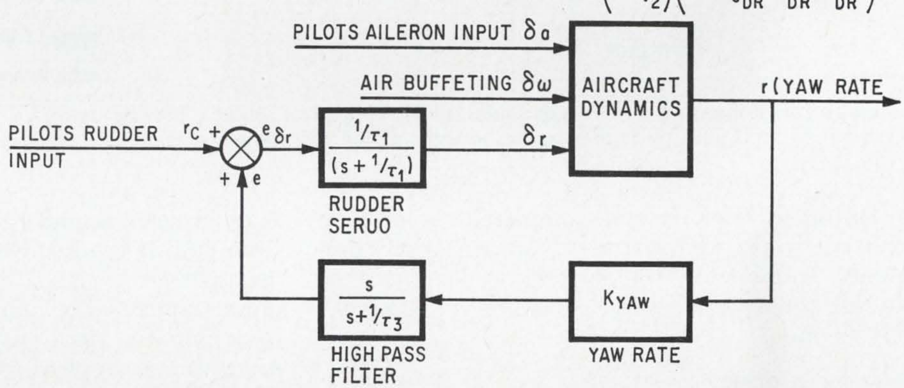
When the gain in the feedback loop is zero, the closed-loop poles lie on the open-loop poles. As the gain is increased they move out along the loci, indicated by the arrows in the figure below, left, and for infinite gain will be on the open-loop zeros.

In an actual case, rate sensor gain is chosen so that the closed loop poles for the Dutch roll response are at B and B′. The angle ϕ is reduced and the damping ratio is increased to roughly 0.85.

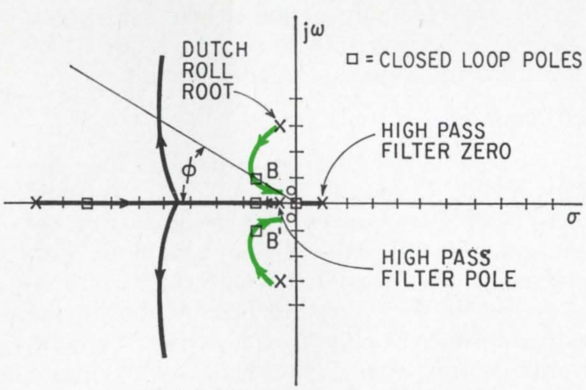
KEY

r_C	RUDDER COMMAND
δ_a	AILERON INPUT
δ_ω	WIND GUST INPUT
τ_1, τ_2, τ_3,	TIME CONSTANTS
ω_1	ANGULAR FREQUENCY
ω_{DR}	DUTCH ROLL FREQUENCY
ξ_1	DAMPING RATIO
ξ_{DR}	DUTCH ROLL DAMPING
e	ERROR SIGNAL

$$\frac{r}{\delta_r} = \frac{-k\left(s^2+2\xi_1\omega_1 s+\omega_1^2\right)}{\left(s-\frac{1}{\tau_2}\right)\left(s+2\xi_{DR}\,\omega_{DR}\,\omega_{DR}^{\;2}\right)}$$

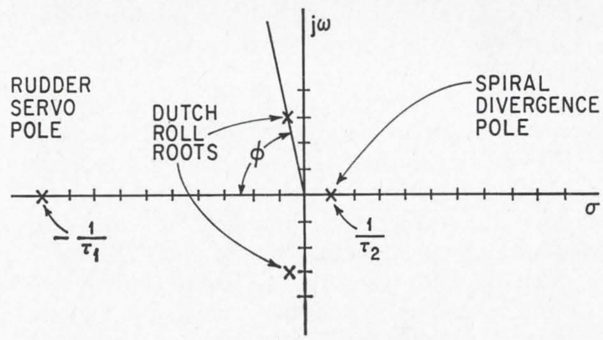


Damper system. Beam sensor is placed in feedback loop in Dutch roll damper system to sense yaw rate, help keep aircraft on an even keel. Simplified transfer functions of each element are indicated.



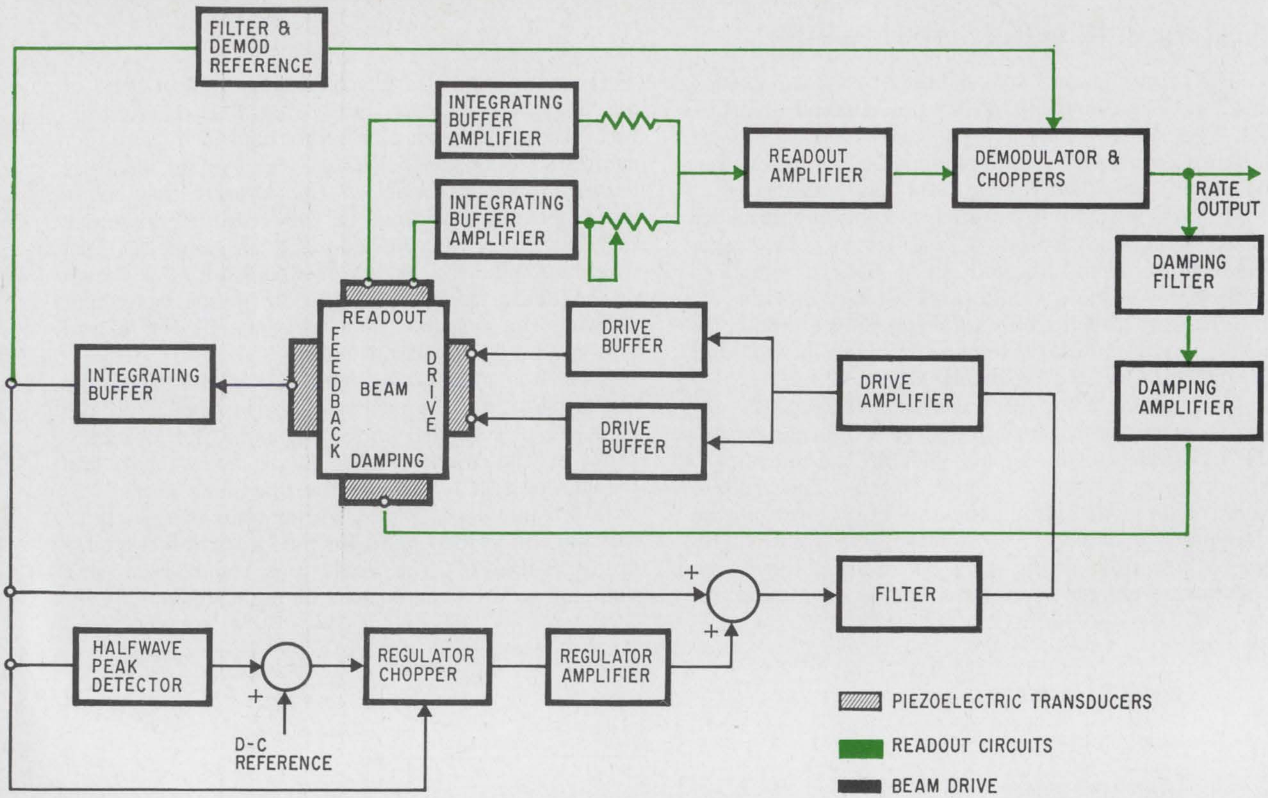
$$\frac{e}{e_{sr}} = \frac{\frac{1}{\tau_1}\left(-K\right)\left(s^2+2\xi_1\omega_1 s+\omega_1^2\right)\left(K_{YAW}\right)s}{\left(s+\frac{1}{\tau_1}\right)\left(s-\frac{1}{\tau_2}\right)\left(s^2+2\xi_{DR}\,\omega_{DR}+\omega_{DR}^2\right)\left(s+\frac{1}{\tau_3}\right)}$$

Higher damping. Root locus plot with rate sensor in the damping loop shows paths (arrows) taken by poles as loop gain goes from zero to infinity.



$$\frac{\text{INPUT}}{\text{OUTPUT}} = \frac{r}{e_{sr}} = \frac{\frac{1}{\tau_1}\left(-K\right)\left(s^2+2\xi_1\omega_1 s+\omega_1^2\right)}{\left(s+\frac{1}{\tau_1}\right)\left(s-\frac{1}{\tau_2}\right)\left(s^2+2\xi_{DR}\,\omega_{DR}+\omega^2_{DR}\right)}$$

Low damping. S-plane plot of uncompensated yaw response of the Dutch roll channel shows that cosine ϕ is low, indicating low damping ratio.



Two major functions. Beam drive and readout mechanization requires only dc power for the sensor and uses minimum power because of the resonant operation.

ing amplifier. This is run completely open loop without a feedback resistor or compensation components, minimizing the switching deadband so that the square-wave drive switches in about 0.5 microseconds.

Going for a drive

Drive power for the beam is supplied by a μA709 noninverting amplifier with adjustable gain. This amplifier, whose input is a sum of feedback and regulator error signals, feeds the two drive buffers. These buffers are adjustable emitter followers, each driving half of the drive transducer. Unequal drive signals out of the buffers minimize the phase shift of the in-phase signal appearing in the readout circuit.

The regulator keeps the amplitude of the vibrating beam constant by monitoring the feedback voltage. This is done by half-wave rectifying the feedback signal, comparing it to a d-c reference signal, amplifying the error, and summing it with the feedback voltage into the drive amplifier. The half-wave peak detector uses the μA709 as an inverting amplifier and a chopping transistor switch to provide a negative half-wave rectified feedback voltage. The detector output is a positive d-c, which is summed with a negative reference d-c at another chopper transistor point.

When the negative reference is nulled with the peak detector output, the feedback voltage is set at a nominal 15 volts peak-to-peak. This null point is capacitively connected to another μA709 noninverting high gain amplifier, which senses any deviation from null. If the feedback voltage tends to drop, a negative error signal develops and the regulator puts a square-wave signal in phase with the feedback into the drive amplifier. This increases the drive voltage applied to the beam and thus drives the feedback up to its nominal level.

Similarly, an increase in feedback voltage develops a positive error signal, adds an out-of-phase square-wave to the feedback voltage, and reduces the drive voltage. The square-wave error signal is caused by the chopping action at the null point. The nominal feedback voltage may be adjusted by varying the level of the reference signal.

Added damping

Natural damping of the sensor itself is low—the damping factor is roughly 0.2—so that electronic damping is added to prevent the circuitry from oscillating when there is an oscillatory rate input. This damping is added through the piezoelectric transducer placed on the vibrating beam opposite the readout transducer. This is an active damping method that takes some of the demodulator output signal, filters it, and applies it to the damping transducer to alter the beam's dynamic characteristics when the angular rate is changing. The damping filter is designed with an RC ladder network with a series capacitor to produce voltage rate feedback around the resonant frequency. The damping factor of the vibrating beam is increased to a value of about 0.8.

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All models feature true linear four quadrant operation, differential or single ended input operation, and excellent stability with respect to temperature and supply voltage variation. All types function in multiply, divide, square, or square root mode by appropriate pin interconnection.

Model	Type	Accuracy	X = Y = 0V Output Offset	X, Y Inputs	XY/10 Output	Bandwidth	Input Impedance	Output Impedance	Case Size	Price 1 - 9
M101	General Purpose time division	0.25%	±10 mV max	±10V, AC or DC	±10V, 5 ma	both X, Y inputs DC to 1000 Hz	X: 5 meg min Y: 75k min	1 ohm max	3" x 2" x .625"	$445.00
M102	High Accuracy time division	0.1%	±5 mV max	±10V, AC or DC	±10V, 5 ma	DC to 100 Hz	X: 5 meg min Y: 75k min	1 ohm max	3" x 2" x .625"	$495.00
M201	FET wide bandwidth	1.0%	±20 mV max	±10V, AC or DC	±10V, 5 ma	DC to 1 mHz	X: 10k min Y: 10k min	1 ohm max	3" x 2" x .625"	$545.00
M301	Lowcost general purpose, time division	1.0%	±20 mV max	±10V, AC or DC	±10V, 5 ma	DC to 1000 Hz	X: 10k min Y: 10k min	1 ohm max	3" x 2" x .625"	$245.00

SAMPLE AND HOLD

Model	Type	Sample Command	Input Range	Input Impedance	Output	Acquisition Time	Aperture Time	Output Decay	Case Size	Price 1 - 9
FS101	0.1% accuracy fast acquisition non-inverting.	on: +3.5v to +7.5v off: 0 to +0.5v	±10V, AC or DC	Sample: 500pf +100 Hold: 10^{10} ohm min	±10 V, 5 ma 0.1 ohm output impedance	2 μsec for ±10 volt, 0.1% accuracy	50 nsec.	0.1v/sec, max with internal 500 pf capacitor, provision for external capacitor	2.05" x 1.15" x .625"	$185.00

IMPEDANCE BUFFERING (Voltage Follower)

Model	Type	Accuracy	Linearity	Voltage Gain	Input/Output	Input Impedance	Input Current	Output Impedance	Case Size	Price 1 - 9
FA101	FET, Non Inverting	.05%	.005%	+.0 Unity, −.0005	±10V, AC or DC, ±5 ma out	10^{11} ohm min	30 pA max	0.1 ohm max	1.12" x 1.12" x .625"	$78.50
FA102	FET, Non Inverting	.1%	.01%	+.0 Unity, −.001	±10V, AC or DC, ±5 ma out	10^{11} ohm min	50 pA max	0.1 ohm max	1.12" x 1.12" x .625"	$68.50

ELECTRONIC SWITCHING (Multiplexing)

Model	Type	Turn-On Time	Turn-Off Time	Offset Error	Input/Output Voltage	"On" Input Impedance	Sample Command	Voltage Drift	Case Size	Price 1 - 9
ES101	Fast Diode Gate	300 nsec	50 nsec	±2 mv max	±10V, 1 ma output	20 ohms	On: +3.5 to +7.5V	50 μv/°C	1.12" x 1.12" x .625"	$65.50
ES102	Diode Gate with FET Output Buffer	300 nsec	50 nsec	±2 mv max	±10V, 5 ma output	10^6 ohms	Off: 0 to +0.5V	100 μv/°C	2.05" x 1.15" x .625"	$145.00

ANALOG TO DIGITAL CONVERSION

Model	Type	Input Voltage	Input Impedance	Output	Conversion Time	Accuracy	Temp. Drift	Power Input	Case Size	Price 1 - 9
AC101	100 KHz complete conversion rate, 10 bit successive approximation, with internal clock and reference	0 to −10.23V (0 to +10.23V optional)	10 K ohms	10 bit serial and parallel binary, complete pulse	10 μsec (includes settling time)	0.1% or 1 bit −25°C to +85°C	10ppm/°C max −25°C to +85°C	±15V, 125 mA +5V, 50 mA	3" x 4" x .625"	$995.00

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Color television scores big gains with small screens

Sales are outpacing those of monochrome sets as the industry prepares to unveil its 1969 lines; among the improvements in store are brighter picture tubes, AFT circuits, and even smaller portable receivers

By John D. Drummond
Consumer electronics editor

Color-television sets are outselling black-and-white receivers this year for the first time. Unit sales of color sets are up about 16% from the 1967 level, while black-and-white sales are just about holding at the year-earlier pace.

Why the swing to color? There are many reasons, obviously. Lower prices on smaller sets are surely a major cause—though big sets now cost more than they used to. Another important factor is the increase in color programing. Technical advances can't be overlooked here, but it must be rated as probably the least significant sales factor.

Not that there haven't been some basic improvements in color-tv circuitry during the past year or so. Most sets now automatically degauss themselves when they're turned on—a particularly important feature if a set is moved from its original installation position.

Some color sets offer preset fine tuning, eliminating the need to reset the tuning control every time channels are switched. And a few of the high-priced 1968-model receivers are equipped with automatic fine tuning to correct misadjustments by the user and tuner drift.

The latest phosphors are producing truer colors than were possible a short while ago, and pictures are generally brighter, too. Manufacturers are now going to solid state in color demodulators—the circuits that extract color information from the composite video signal—to improve linearity. Not only are the color tubes better this year, but their price tags are down a bit from 1967 levels.

And the transistor is taking on an increasing number of color-set functions—a trend that's enhancing reliability and performance. In some cases, the move to transistors has reduced power consumption by as much as 100 watts. Also to be noted is the fact that some makers are using plug-in transistors to simplify servicing. Still, about 80% of the sets produced this year will be equipped primarily with vacuum tubes.

The wide choice of screen sizes now available doesn't exactly reflect a technical breakthrough, but it certainly has helped boost sales. The big sales surge this year is in small-screen and portable color models.

Bustin' out all over

The new year comes early in the tv industry—this month, to be exact. About 90% of the 1969 models are due for a June debut.

General Electric, which has had the color-portable market pretty much to itself with its Porta Color 10V" (10-inch viewable diagonal) line, will run into some stiff competition from both foreign and domestic producers beginning this summer. Sony's much-heralded 7V" receiver with the company's Chromatron tube will soon be on the market, as will Toshiba's 11V" and two portables from Matsushita—a 12V" to be sold under the Japanese firm's Panasonic label, and a 15V" that will be marketed here by Packard-Bell.

Among the new portables due from domestic producers will be 14V" and 16V" models from RCA, and 14V" units from Zenith and Motorola. GE will add several 14V" sets to its portable arsenal, while Admiral and Westinghouse will introduce 16V" and 18V" models. It should be noted that most of these "domestic" products will be made in overseas plants.

Prices generally won't differ much from the 1968 list for sets now on the market. The lowest tag will remain the $199.95 GE is charging at the low end of its Porta Color line, according to industry insiders.

For the money, though, there will be some improvements, chief of which will be the inclusion in nearly all new color sets of an automatic fine-tuning circuit.

Good color reproduction is possible only when the r-f local oscillator is at the frequency that places the video i-f signal at the midpoint of the intermediate-frequency bandpass curve—or at 45.75 megahertz with properly aligned i-f stages. This delicate tuning adjustment is hard to make manually; hence the need for automatic fine tuning (AFT).

Screen sizes

Most set manufacturers are now specifying the viewable diagonal measurements (V″) of television screens, though some still give over-all diagonal measurements as a sales ploy.

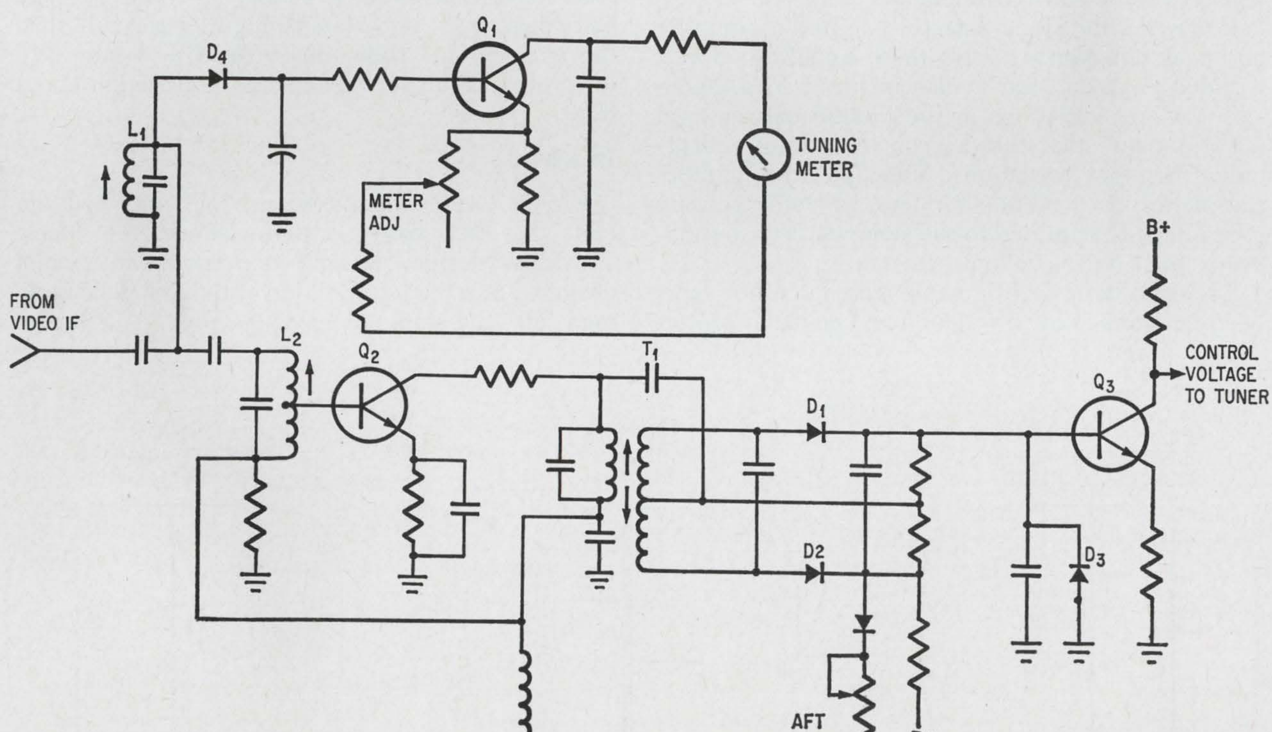
An area of 60 square inch and an over-all diagonal of 11 inches translates into a 10V″ screen. A 70-square-inch color screen with a 12-inch over-all diagonal is called an 11V″, but a 71-square-inch monochrome screen with a 12-inch over-all diagonal is a 12V″. And so on up the scale.

Fine tuning

An AFT circuit develops a d-c correction voltage that is applied to a control transistor stage in the local very-high-frequency oscillator. The transistor acts as a voltage-dependent capacitor here, so that as the correction voltage varies, it corrects the oscillator frequency and compensates for tuning errors and frequency drift.

In the typical AFT circuit shown below, the video i-f signal is sampled in the tuned circuit made up of L_1 and L_2. This circuit is adjusted to form a bandpass that peaks at 45.75 Mhz. When the video carrier falls below that halfway mark on the i-f curve, the set's fine tuning is misadjusted and the sound interferes with the picture. If it moves above the midpoint, its frequency is too low and the picture is smeared.

The i-f signal at L_2 is amplified by Q_2 and applied to transformer T_1, which is adjusted for a typical discriminator "S" curve. Diodes D_1 and D_2 conduct to develop a correction voltage only when there's a difference between the frequency of the signal across the secondary winding of T_1 and the incoming video i-f carrier signal. The correction voltage is then applied to Q_3, operating as a d-c amplifier. A temperature-compensation diode, D_3, minimizes variations in the output voltage caused by temperature changes. No correction voltage is developed if the i-f carrier holds at the



AFT circuit. Basic circuit for r-f oscillator frequency control can be used to automatically fine tune a tv set for proper color reception. Meter circuit, Q_1, indicates tuning errors.

45.75-Mhz point.

A tuning meter can be used to indicate an adjustment of the fine tuning control. In the circuit shown, the video i-f is rectified by D_4 and applied to the base of Q_1. As the signal on Q_1 varies the collector current, the tuning meter responds accordingly. When the receiver is fine-tuned in its proper position, the collector current produces maximum deflection on the meter.

An interesting variation on this basic system is employed by Westinghouse. The cathode-ray-tube screen is used to give the viewer a precise indication of the degree of mistuning; he simply observes the separation between two vertical lines produced on the screen by a flip of a test switch. One of the lines, the reference, is stationary, while the other is movable.

The reference line is generated during one picture field, the movable line during the next. The signals generating the lines are a series of narrow video gating pulses about 2 microseconds wide and synchronized to the horizontal scan rate. A reference voltage sets the position of the stationary line, while the position of the movable line is established by a control voltage whose magnitude and polarity are functions of the fine tuning control's setting.

In the circuit that generates the control voltage for the two vertical bars, the output of the last video i-f stage is fed into a high-Q tuned circuit slope detector whose center frequency is set to position the i-f picture carrier frequency at the midpoint on the curve. The slope detector's output reflects variations in the carrier frequency above and below the 45.75-Mhz point.

Following the slope detector is a buffer amplifier and peak detector to supply the d-c control voltage. A video peak detector is also included to compensate for any variations in the picture carrier level and to ensure that the d-c control voltage reflects only frequency variations. The detector monitors the picture carrier and produces a reverse polarity d-c voltage that, added to the slope detector output, keeps the control voltage constant.

At least two novel remote control units have been announced for the 1969 line. One from Motorola uses solid state "memory" modules with the stop-and-hold capability to control color, tint, and volume. Said to be the first remote control circuit to perform continuously variable functions without motor-driven potentiometers, the unit reverts to conventional motor drive for channel selection. Primary power is applied by relay action.

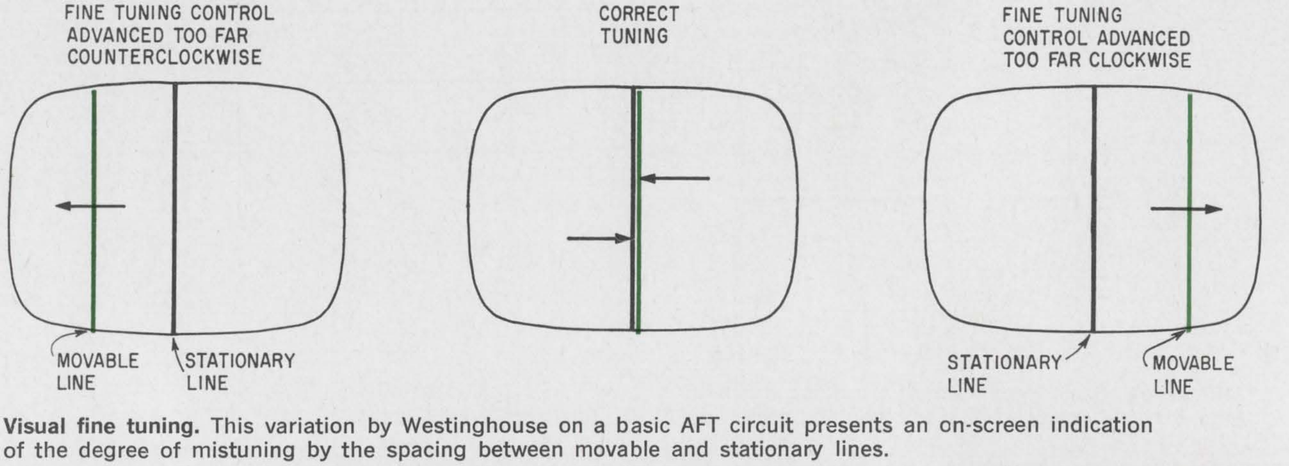
The solid state portion of the Motorola control includes a neon lamp that acts as an electronic switch and serves to isolate the timing circuit from the external charge circuit when the function switches are open. The closing of any switch causes the lamp to conduct and thus to vary the charge on the timing capacitor. An insulated-gate field effect transistor amplifies the control signal to the desired level, and this signal varies the voltage level of the controlled circuits through variable-gain amplifiers in the tv receiver.

A color remote control system from Heath employs as many as seven stepping relays with associated transistor circuitry to perform the functions of power switching and channel selection as well as to control volume, color, and tint. The Heath circuit can be adapted to any of the company's present color sets.

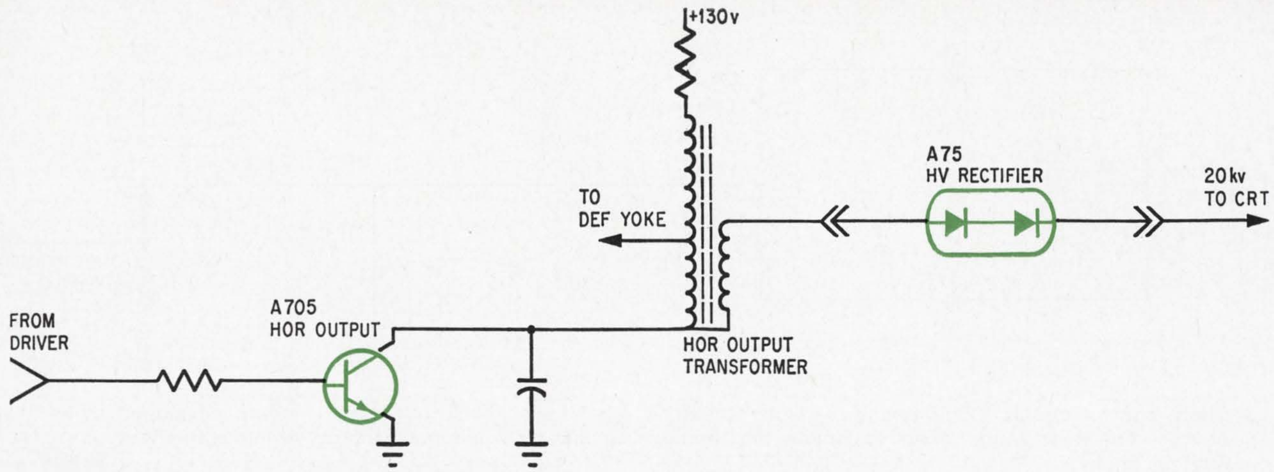
On the black-and-white side of the fence, lack of technical innovation is not deterring makers from producing sets for a dwindling market. Here again, portables are the big sellers. Prices on the 1969 models will range from the $69.95 Admiral is listing for its new 9V" receiver (GE will charge $79.95 for a set with the same size screen) to the $150 Motorola will get for a 12V" set. Several 15V" models will also be available in time for the Christmas rush, but Matsushita Electric will steal the monochrome show this year with a new 2V" integrated-circuit set expected to be priced at about $200.

In a bind

Except for the increased use of simplified circuits that cut cost—and performance, too—black-and-white designs haven't undergone any major changes since the introduction of the first American-made all-solid state receiver by Philco in 1959; this



Visual fine tuning. This variation by Westinghouse on a basic AFT circuit presents an on-screen indication of the degree of mistuning by the spacing between movable and stationary lines.



Solid state deflection. Horizontal deflection circuit developed by Amperex for a large-screen, all-transistor black-and-white tv sets operates directly from off-the-line 130-volt power supply.

was a battery-operated set with a magnified 5-inch screen. Designs are frozen because producers have arrived at what they consider an acceptable level of performance in each price range.

Also, further circuit simplification invariably hurts picture quality. This was borne out in the recent attempt by GE's tube division to get set makers to design a receiver that could be sold at retail for under $50. The GE scheme involved a five-tube arrangement with ultrasimplified circuitry. Called the "4 + 1"—there were four compactrons and one high-voltage rectifier—the set combined sync clipping and separation in a single function, used a self-oscillating horizontal scanning circuit in place of a discrete horizontal oscillator, and employed a single i-f stage and single video amplifier stage.

The demonstration receiver built by GE is unimpressive: it has poor sensitivity even within strong signal areas, poor resolution due to its extremely narrow i-f bandpass, poor contrast range due to insufficient video amplification, and poor picture stability. GE admits that no set maker has committed itself to produce the 4 + 1.

In another cost-reduction scheme, Amperex Electronic last October introduced two devices designed to eliminate the need for expensive transformer power supplies in all-transistor large-screen sets. The first is a high-voltage transistor, designated the A705, with a collector-base breakdown voltage of 1,400 volts when operated with a B+ of 130 volts. The other is a silicon high-voltage rectifier, the A75, that can handle at least 20 kilovolts. Conceding that the A75 is more expensive that its vacuum-tube counterparts, Amperex says the price would go down with volume orders.

The simplified circuit above shows the suggested hookup for the horizontal-output and high-voltage stages. Amperex built and demonstrated a receiver using this circuit design, but a recent poll of major set makers indicated only limited interest in it. At least two makers expressed a reluctance to rely on a single source of supply for the high-voltage A705 transistor.

Delco Radio offers a similar device—the DTS-402—for the horizontal deflection circuit, but it's rated at only 1,200 volts.

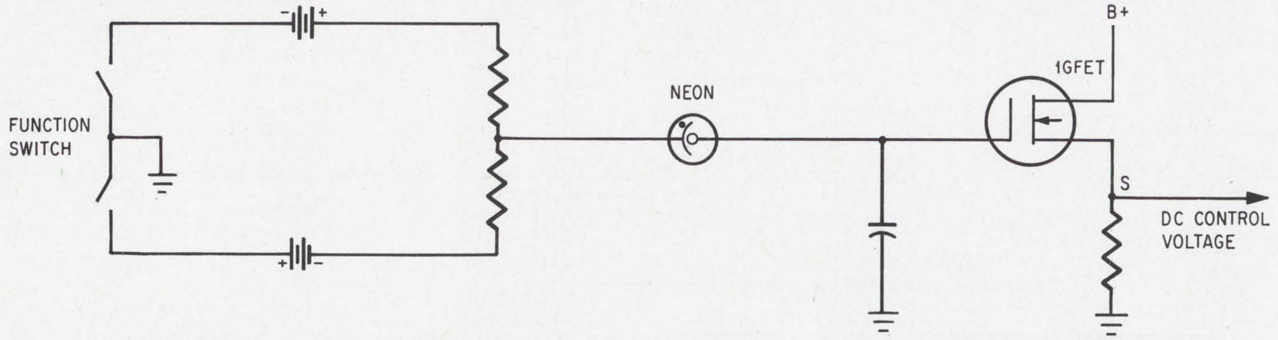
An important point made by several set makers is that although transistorized large-screen receivers may be cheaper to produce after development costs are defrayed, tube sets are less costly at present. However, manufacturers are sampling solid state voltage multipliers and high-voltage rectifiers from Varo, Amperex, Motorola, and others.

Microscreens

While domestic producers continue to concentrate on getting larger screens in monochrome portables, Japanese set makers are following their traditional road to miniaturization. The first evidence of a microscreen set came last year when Sony unveiled a prototype with a 1½-inch screen at the Consumer Electronics Show. Although the company insisted at the time that it hadn't decided on definite production plans, the latest report from Japan is that these sets are presently in full-scale production.

Sony's venture is now being seconded by the 2-inch set from Matsushita Electric. In this model, eight hybrid integrated circuits perform all the functions of the video i-f, the video amplifier and output stage, the sound i-f amplifier, the audio amplifier and video automatic gain control, the sync separator with horizontal amplifier and automatic frequency control, the vertical oscillator and output stage, the horizontal oscillator and output stage, plus the job that would be handled by an active power-supply filter with automatic voltage regulation.

Matsushita says it chose hybrid circuits over monolithics to get greater design flexibility at less cost for small production runs. The IC's contain metal glaze resistors as well as semiconductor and capacitor chips fabricated on a ceramic substrate. There are 34 transistors and five diodes in the IC's.



Remote control circuit. Continuously variable functions are handled by a "memory" module developed by Motorola. The neon lamp serves to isolate the timing elements from external circuitry when a function switch is open.

The receiver that will be introduced this year can only get stations in the vhf band. But Matsushita is working on a uhf tuner it says will be ready for the U.S. market next year. Both tuners feature varactor-diode tuning; the vhf unit has three such diodes.

The high-voltage section contains a tiny flyback transformer that accepts 40-volt pulses from the horizontal output stage, steps them up to around 400 volts, and delivers them to a multiplier circuit. This multiplier boosts the pulses to the 5,000-volt level required by the picture tube. The tube's screen size is actually only 1.5 inches across its diagonal; a magnifying glass is used to obtain the 2 inches.

The set operates from four rechargeable nickel-cadmium cells whose output is regulated at 5 volts. The total current drain—1.25 amperes—makes for a total continuous playing time of two hours. The receiver, with battery, weighs 1 pound, 6 ounces.

Toward solid state

Among the new devices applicable to both color and black-and-white receivers is a solid state high-

Video tape recorders

When Sony introduced a $995 (less camera) home video tape recorder in late 1965, it created considerable excitement among dealers. But sales have so far been disappointing.

The fact that vtr's cost so much more than home movie systems is the major reason for consumer indifference. On the other hand, since most top-of-the-line color-television combinations and some high-fidelity sound systems are priced in the same range, the experts are trying to determine what other factors, if any, are keeping the customers away.

A spokesman for Matsushita states that less than 1% of the company's nonprofessional-type vtr's are sold as home entertainment equipment. And an Ampex spokesman explains that "with the public attuned to color, monochrome vtr's, like black-and-white home movies, aren't going to create any excitement."

Expensive hobby. Nor can the high vtr operating costs be overlooked. On the average, the price of an hour's show is $40 for half-inch tape and $60 for 1-inch tape.

The nonprofessional-type video tape recorder employs the helical-scan principle. Longitudinal-scan (fixed head machines) aren't being produced at the present time, although three firms—Arvin Industries, Newell Associates, and Winston Research—say they will have fixed-head vtr's on the market late next year or early in 1970.

Helical-scan recorders are produced in the U.S. by Ampex and the International Video Corp. Nearly all other private labels are made in Japan. GE's recorders are made by Sony, and Concord Electronics gets its from Matsushita. Other domestic labels—Bell & Howell and RCA, for example—buy their recorders from International Video. Sony and Matsushita, as well as Norelco, produce and market recorders under their own brands.

Demanding. Most video recorders aren't self-contained; they have to be operated with a receiver for off-the-air recording and with a playback monitor. This calls for a rather elaborate setup beyond the technical skills of most consumers. So far, no one has produced a portable home recorder for outdoor use. GE is marketing a battery-operated recorder that weighs only 15 pounds—including camera—but this system requires a separate playback unit; the whole setup sells for $2,200.

There's one exception to the higher prices on vtr's. It's Arvin Industries' CVR-XXI, which will start rolling off the assembly line late next year. Employing a longitudinal scan principle, the unit serves both as a standard color tv receiver and a recorder. It will be priced between $1,000 and $1,500, and will be capable of either direct off-the-air recording or live recording from a black-and-white or color camera.

Other color vtr's being offered include: Ampex' model 7500-C, which is priced at $4,495 plus $695 for a color monitor/receiver for off-the-air recording and playback display; International Video's IVC-800 recorder, priced at $4,700 and requiring a monitor costing $935 and a receiver; Sony's EV-210 with a CLP-1 color attachment, priced at $4,550 plus $1,150 for a color monitor/receiver; and Matsushita's Panasonic NV-204C, priced at $4,250 plus $1,750 for the required color adapter and monitor.

voltage rectifier rated at 25 kilovolts and higher. Developed by Motorola and due for a summer debut in the company's 1969 color sets, the all-silicon rectifier combines a large number of series-connected diodes in a single plastic package designed for plug-in mounting.

With its new rectifier, Motorola becomes the first set maker to produce an all-solid state large-screen tv set—black-and-white or color.

To replace the standard vacuum-tube rectifier with the low-capacitance solid state device, the horizontal output transformer must be designed with high stray capacity if optimum tuning of the horizontal frequency third harmonic is to be achieved. A comparison of the tube and solid state circuits is shown below.

Economics rather than technology appears to be the major factor keeping set producers other than Motorola from employing a greater number of transistors. But Motorola's director of television engineering, Richard A. Kraft, while conceding that it costs more to produce an all-solid state color set, asserts that the increased reliability far outweighs that added expense. "We now plan to commit perhaps as much as 50% of our color line to the all solid-state concept," he says.

Some small-screen portable color sets, especially the imports due from Japan, will be solid state throughout, except, perhaps for the high-voltage rectifier. But larger-screen models—18V" and up—will be of hybrid or vacuum-tube design.

William T. Buschmann, Sylvania's marketing vice president estimates that only 3% of all color sets produced this year will be all-solid state. He estimates that 14% will be of the hybrid variety with the rest using tubes.

Sylvania itself is moving towards a greater use of transistors in its color line. Last year, for example, the D12 chassis installed in most of the firm's 23-inch sets had 17 vacuum tubes and 19 transistors. The updated chassis for the 1969 line contains only nine tubes—all in the deflection circuit—and 28 transistors.

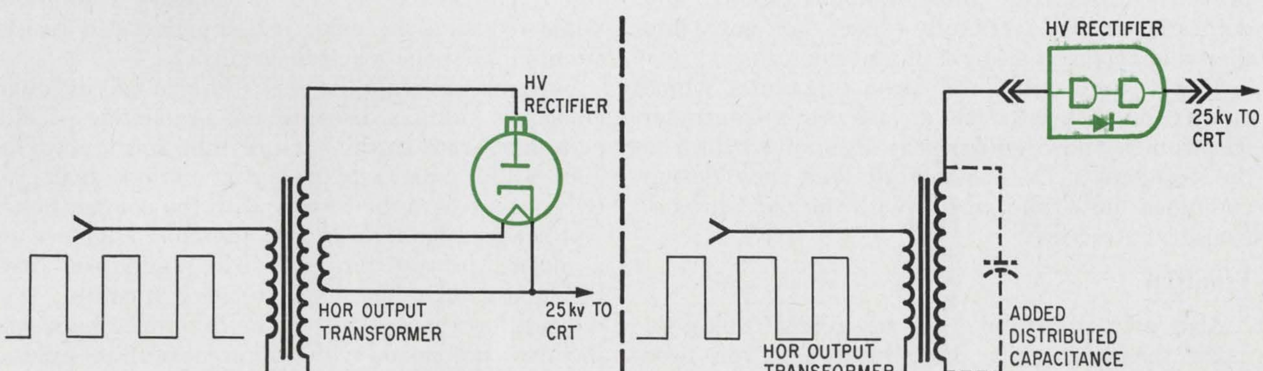
Sylvania's top entry in the high-priced field is a combination color-tv set and slide projector [Electronics, May 13, 1968, p. 42]. The photographic slides are rear-projected on the set's screen by a flying-spot scanner. Another development due from Sylvania—but probably not this year—is a tv set that can be used to display color movies in the home.

Meanwhile, some vacuum-tube producers are trying hard to reverse the trend to transistors. At this month's Spring Conference on Broadcast and Television Receivers in Chicago, GE will introduce an all-tube color set called the "8 + 1". Like its black-and-white counterpart—the 4 + 1—the 8 + 1 is designed to sharply reduce costs. The set uses eight compactrons plus a high-voltage rectifier and a 10V" color tube. Costs are cut by eliminating the vertical output transformer and by using a direct-drive vertical deflection circuit, a self-oscillating horizontal output tube, and a two-stage video i-f amplifier combined in a single compactron. All of these components are mounted on a standard Porta Color tv chassis.

Tuners

There'll be no major tuner innovations in the initial 1969 models, but the middle-of-the-run units produced sometime early next year will have new tuners. These will be combined uhf/vhf tuners with either detent or slide-rule uhf tuning with band-spread features. There will also be a Sylvania unit that uses hot carrier diodes in the mixer circuit. And we're in for some form of electronic tuning, too, including both uhf and vhf varactor-diode tuners from Matsushita. Similar tuners are in use in a number of European sets, although U.S. producers say that considerably more field testing and improvements are needed before the electronic tuners can find a place in the domestic market. All-solid state tuners are available and will be used in increasing numbers, although the vacuum-tube camp insists that they're plagued with cross-modulation problems.

Integrated circuits will continue to be used in the sound section, but, for the time being at least,



High-voltage rectifiers. By switching to the solid state design at the right, Motorola has eliminated the filament winding required in the flyback transformer of the vacuum-tube setup at left.

Hi-fi

There are few surprising sounds in store for hi-fi buffs this summer. For having succeeded in developing all-solid state audio amplifiers with enough power to shred speakers, burst eardrums, and shatter windows, audio engineers are now concentrating on less audible features.

They talk of better stereo separation and of lower capture ratio—the measure of a receiver's ability to reject interference. In an industry that now speaks only in terms of solid state designs, advertisements boasting of field effect transistor front ends, or integrated-circuit i-f amplifiers are no longer impressive.

The trend continues toward all-in-one stereo receivers lumping together tuner, phono preamplifier, and power amplifier. William F. Glaser, sales manager of H. H. Scott, estimates that these f-m stereo receivers account for about 60% of hi-fi industry sales, compared with not more than 18% for the separate-component sets.

Small package. Next in popularity is a compact music system that puts a record changer or tape recorder and an f-m receiver in the same cabinet. Designed to fit in a small space, it accounts for about 20% of the industry's sales.

The latest automatic turntables track at 1 gram or less and protect against "skating." Speakers are generally smaller and more efficient, though some audiophiles insist that large speakers achieve higher efficiency with less driving power from the amplifier. With the power available from present solid state amplifiers, however, the trend towards smaller speaker systems should continue.

At the front. Except for the Marantz Co.'s model 18, which will retain the Schottky-barrier diode mixer in its front end, the latest f-m stereo receivers will feature FET front ends. But solid state filters will begin to replace conventional i-f transformers in higher-priced receivers. First used by the Heath Co. in its AR-15 receiver, the filters are going into the STR-6060F Sony receiver this summer.

Integrated circuits will dominate in the i-f strip and the f-m detector and limiter. Built-in electronic crossover circuits will also appear this summer or fall, as will integrated operational amplifiers in stereo receivers. And H.H. Scott will unveil an a-m/f-m stereo system featuring a patented autodyne oscillator circuit.

they will make very little headway in other areas. For all the talk about the benefits of IC's in the video i-f, the theory won't be tested to any extent until microcircuits producers come up with a single device that can provide the needed 70-db gain with an automatic gain control range of at least 60 db. This seems a long way off since present technology has been unable to produce chips with gains of more than 50 db. As for video amplifiers, most of them put out from 2 to 3 watts to drive the picture tube—far beyond the capability of monolithic IC's.

But IC prospects are exepected to change drastically next year, now that Texas Instruments' joint venture with Sony has been approved by Japan's Ministry of Trade and Industry. This approval opens the way for the licensing of Japanese IC makers, and such giants as Mitsubishi, Nippon Electric, Toshiba, Hitachi, Sony, and Matsushita are reportedly ready to sign up. The Japanese are proven leaders in microminiaturization, and domestic set producers fully expect their entry into this field to result in new product designs.

Sony's single-gun Chromatron color tube, which created much excitement at last year's Consumer Electronics Show, will appear in modified form in the company's 7V" color sets. The new design combines the Trinitron gun with the old Chromatron grid structure.

Trinitron

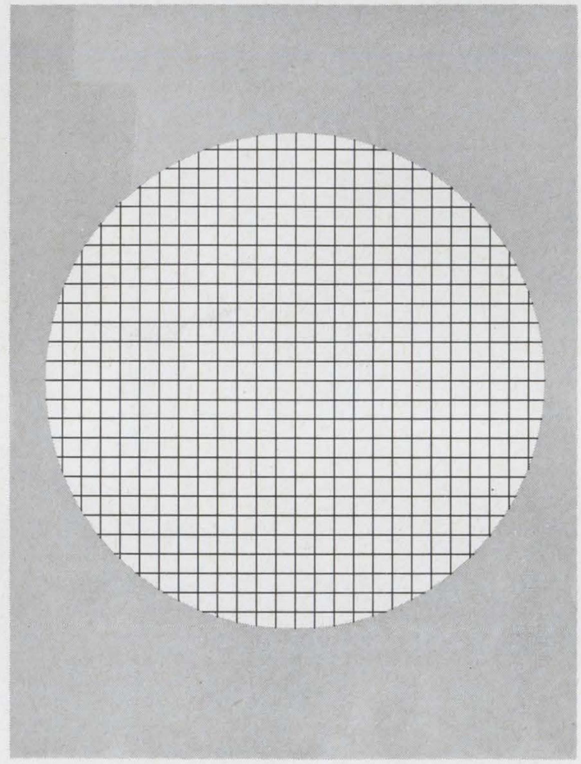
Also new from Sony will be a 12V" color set using the single-gun, three-beam Trinitron tube [Electronics, April 29, p. 145]. Unlike the Chromatron, which uses a grid-like structure to replace the conventional shadow mask, the Trinitron has an aperture grill made up of an array of vertical slots positioned in front of vertical phosphor strips on the picture-tube face. The three separate beams used to excite the red, blue, and green phosphors are directed by five control grids.

The principal feature of the Trinitron is that it is self-converged; there's no need for converging magnets on the picture-tube yoke or any complex dynamic convergence circuitry. Sony says the tube uses one-third the number of parts required for a three-gun arrangement, yet produces a beam current more than 50% higher than those generated by conventional tubes of the same size. The result, says Sony, is a sharper and brighter picture than that produced by the shadow-mask tube.

Sylvania last February introduced a color picture tube called the Color Bright 85. Most set producers who have sampled the unit agree that it's brighter than all previous color tubes, as claimed by Sylvania, and does produce more vivid colors. The Color Bright 85 employs a newly developed electron gun that is said to improve resolution while reducing the color fringing that can result from out-of-shape electron beams.

Sylvania is using the new tube in all its own color sets and has discontinued production of the europium "rare earth" picture tube introduced in 1964. Will most set producers switch over to Sylvania's color tube to stay with the competition? Not necessarily, according to the chief engineer at a major Midwest producer. He points out that brightness, like hue, is a relative quantity; it's difficult for a viewer to tell the difference between pictures produced with different tubes unless they're compared with identical control settings under the same lighting conditions. Regardless of the merits of Sylvania's tube, therefore, it isn't likely that it will appear soon in rivals' sets.

how fine is a fine screen?



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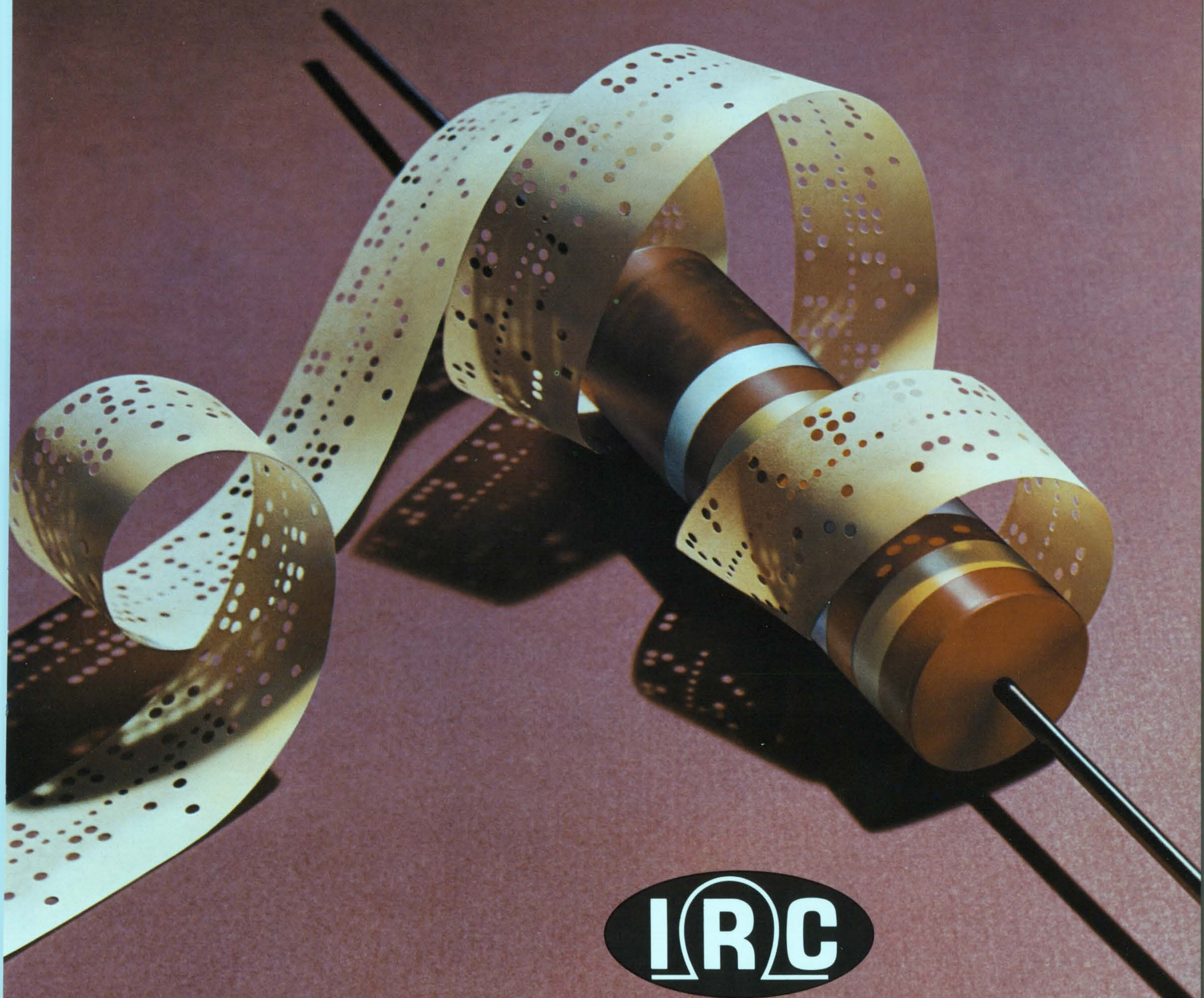

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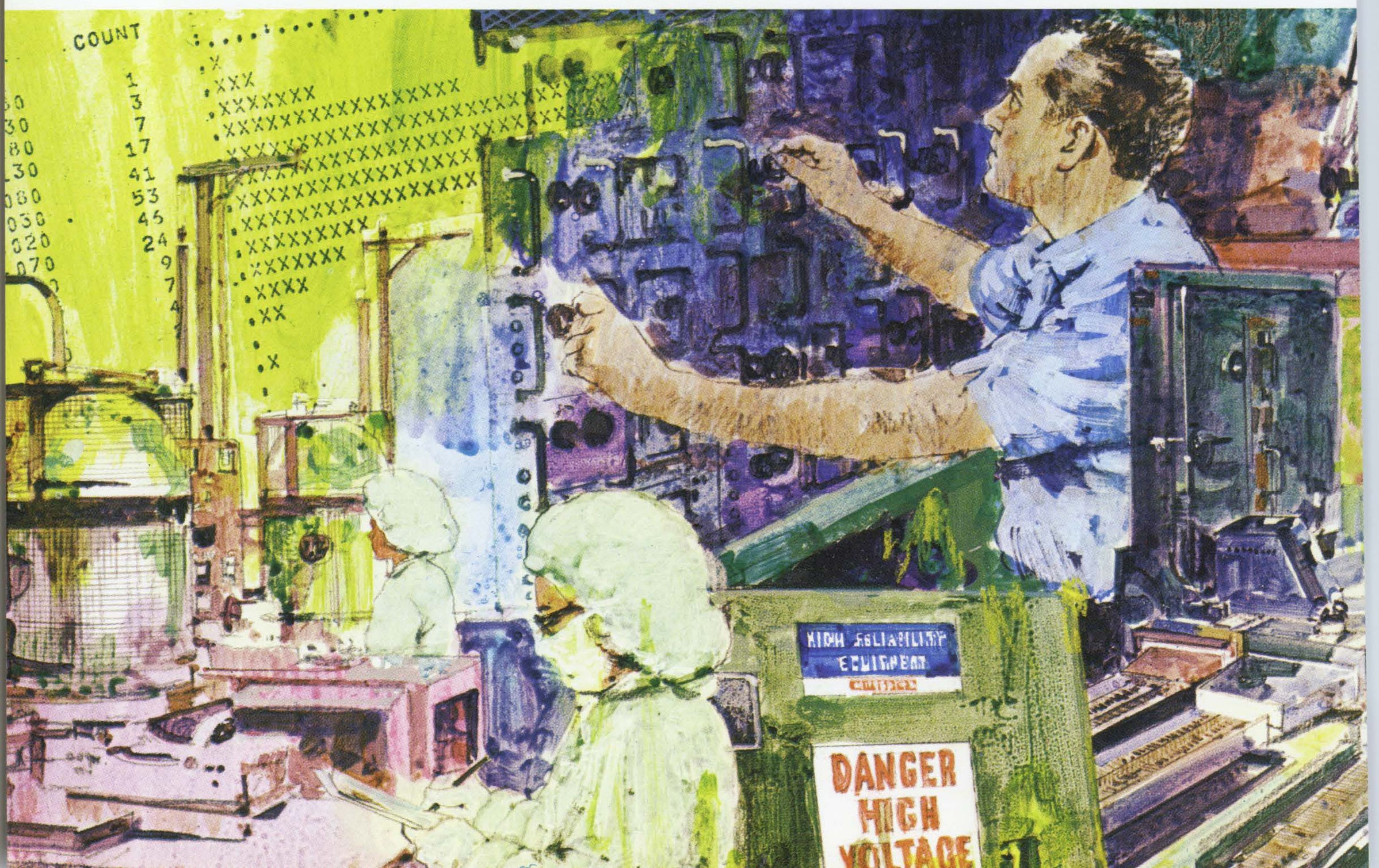
WHAT SCREENING ACCOMPLISHES

Screening is 100% non-destructive testing to a predetermined level of stress. Its purpose is to detect, and eliminate, those devices which are prone to early failure. The test is successful in reducing failure rate only to the extent that the selected screening test actuates the mechanism responsible for early failure. Obviously, the result depends largely on the selection of the test. Less obvious, but inescapable, is the fact that the failure rate after screening is a function of the failure rate before screening.

ECONOMIC CONSIDERATIONS OF SCREENING VS TEST OBJECTIVES

The cost of screened parts is affected by the number



and types of tests and the level of reliability desired by the user. The choice of a screening test, or a battery of tests, represents a trade-off between the additional reliability gained compared to the additional cost of the screening tests.

There are two basic costs associated with screening tests.

1. *Actual cost of conducting the test.* This is a function of the time, equipment, and labor involved. For example, a stress test at room temperature requires less costly set-up than the same test at elevated temperature.

2. *Fall-off, or loss of units due to the test.* This is a function of test efficiency and test effectiveness. Using metal film resistors as an example, these costs can be demonstrated by a comparison of short-time overload and current noise.

	SHORT-TIME OVERLOAD	CURRENT NOISE
*Effectiveness	.71	.74
*Efficiency	.65	.09
Inefficiency	.35	.91

Since effectiveness is a measure of the extent to which screening tests improve the failure rate, it can be seen that both tests reduce failures approximately 70%. Yet, the relative inefficiency of the two tests is 2½ times greater for current noise than for short-time overload. Stated another way, the current noise test rejected 2½ times the number of good units.

Since the cost of both tests is approximately the same, short-time overload is in this case a much more cost-effective technique.

SCREENING TESTS AND LEAD TIMES

IRC is fully staffed and facilitated to perform screening tests to all military specifications and to virtually any specifications required by the user. IRC supplies components, not test equipment. Therefore, where test specifications have not been established, we can provide unbiased assistance in determining the most meaningful screening tests for specific application needs.

Because of the many controls needed to assure the validity of the screening test, production lead times may be somewhat longer than for standard product line parts. Lead times depend on the complexity and duration of the desired screen test. However, increased facilities and computerized test analyses enable IRC to supply screened parts faster than anyone else in the industry today.

WE WELCOME INQUIRIES

Like all IRC services, screening started with a customer need. That need was for a more economical approach to reliability in resistors, potentiometers, and semiconductors. IRC invites inquiries on the cost, delivery, and capability for 100% lot screening.

Inquiries should be sent to Vice President-Reliability, IRC, Division of TRW Inc., Department 201, 401 North Broad Street, Philadelphia, Pa. 19108.

*These terms developed by IRC to measure screening tests. They are fully explained in our new applications handbook, "AN ANALYSIS OF SCREENING." Copy available on request.

IRC FOR TOTAL SCREENING SERVICE

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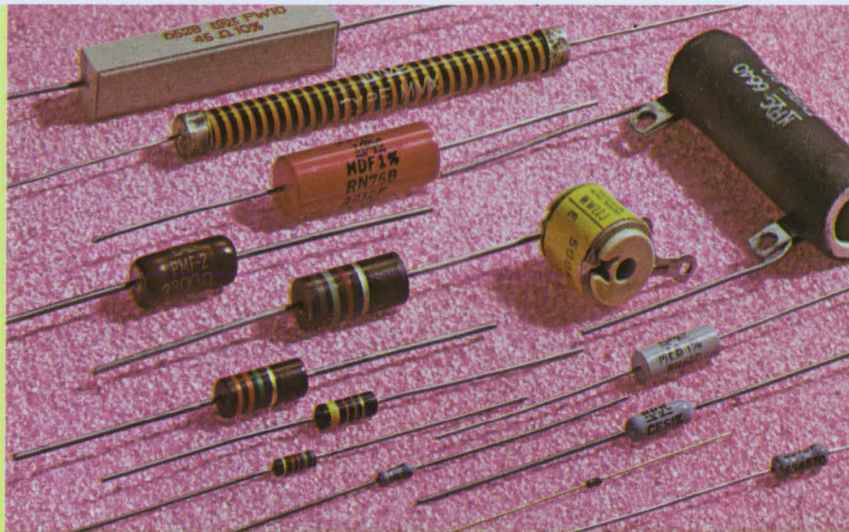
- General purpose carbon composition
- General purpose wirewounds
- Power types
- Special applications types



TRIMMER SCREENING

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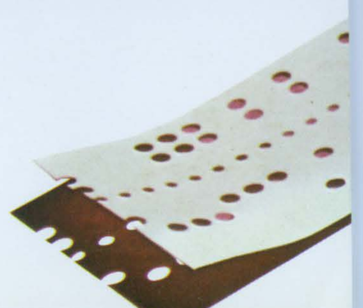

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General Electric's thoria-coated iridium filament is the only one on the market that's guaranteed—and for two years at that. On top of that, we offer three-way micro-second burnout protection that cuts our filament off faster than anybody else's.

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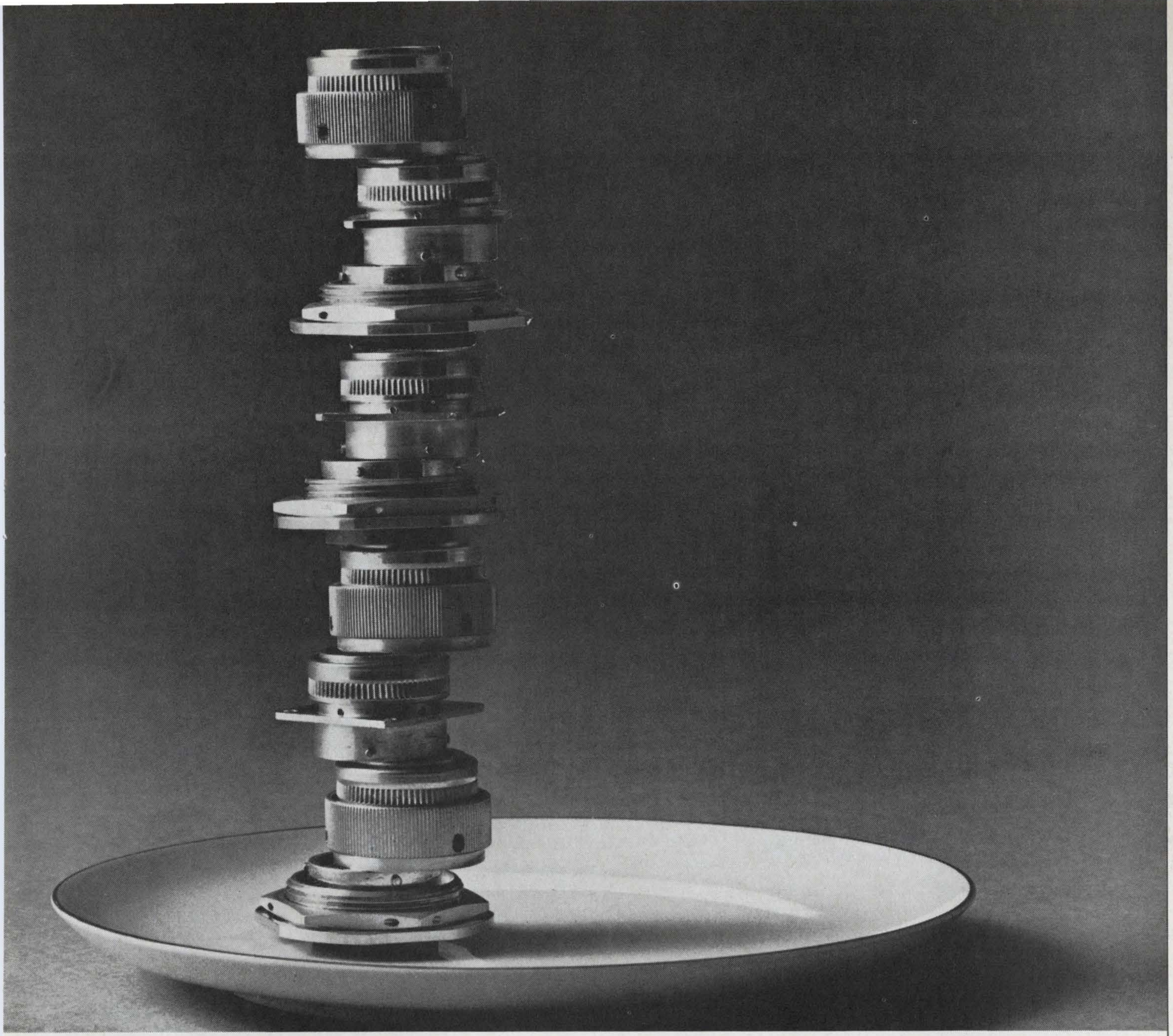

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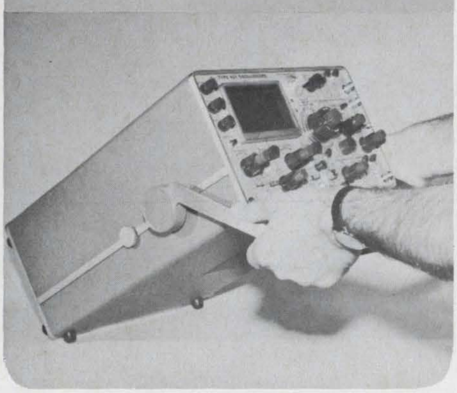

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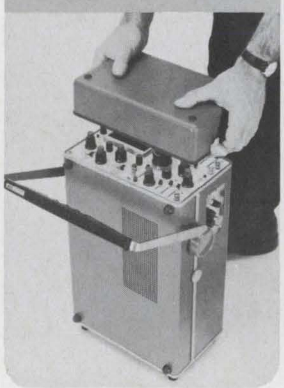

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Take it anywhere. The rain/dust cover is a standard accessory and carries the complete manual and optional viewing hood.

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Probing the News

Integrated electronics

LSI still chases its press clippings

Solid progress is being made toward enlarging arrays, but acceptance in the marketplace is slowed by both technical and economic hangups

"We're walking toward large-scale integration, not running," says Orville Baker, vice president for product planning at the Signetics Corp. "There's no demand for LSI, per se; our customers talk to us about functions and products. Perhaps some day, we'll look back on what we accomplished and then pin a name on it."

Few in the electronics industry are this blunt. But Baker's exasperated outburst does underscore a fact that many observers have lately taken pains to point out: LSI is an evolutionary, not revolutionary, technology. And while the market potential of large-scale arrays is big, so are the technical and economic problems.

Nonetheless, the concept of LSI is having a profound impact upon semiconductor makers and users alike. Big money is being spent. And fundamental changes are being made not only in production techniques but in sales activities.

What's in a name? Clair Thornton, director of research and development at the Microelectronics division of the Philco-Ford Corp., feels semiconductor houses may well have mousetrapped themselves by making 100 gates per chip an arbitrary standard for LSI. "Users bought this promotional ploy, and we may just be stuck with it," he says.

In the same vein, Joseph Nola, product planning specialist at the Semiconductor division of Sylvania Electric Products Inc., says, "I'm disturbed by the pressure to put a name on something at the expense of honest definition. The psychology behind this is bad; LSI isn't best for all applications, no matter how you define it." Nola believes that practical monolithic LSI assemblies are two or so years away since it will take that long to produce well-defined specifications and develop standardized test procedures. And even then, he says, the larger-scale arrays are going to carry fancy price tags because makers will find it necessary to write off R&D expenses.

Room at the top. Neither is LSI's gain necessarily going to represent another field's loss. Samuel Harper, who heads the microelectronics development department at Honeywell Inc.'s Computer Control division puts it this way: "Each new step in technology curtails the growth potential of whatever it replaces. But the replacement is never complete. There are still plenty of tubes around, and even after LSI is established, integrated-circuit sales will continue to increase substantially."

In general, both users and makers agree that computer-aided design is an integral and important

A little lexicon of LSI

The term "large-scale integration" has almost no specific meaning. What you're talking about depends on whom you're talking to.

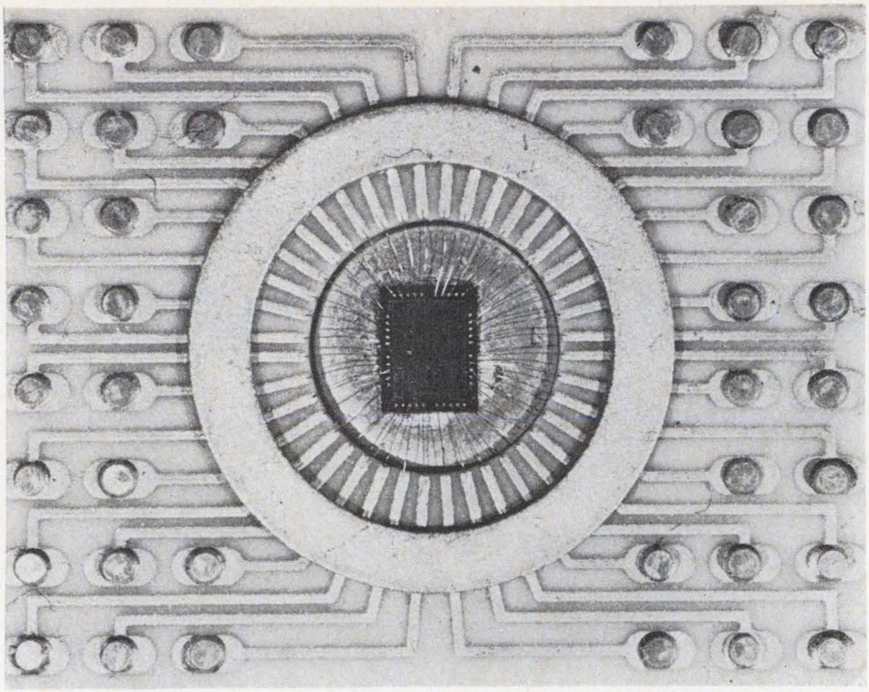
Fairchild Semiconductor, for example, has advanced a philosophical definition: an LSI device, it says, is a complex array that requires two-layer metalization and computer-aided design, and which in some way affects the relationship between the maker and the buyer. But Richard Petritz of Texas Instruments takes a tautological approach, describing LSI as "a system of technologies underlying products called integrated electronic components." In other words, LSI is that which yields LSI products. (The distinction between an integrated circuit and an IEC in TI argot is that the latter results from interconnecting circuits within the structure; an IC results from interconnecting devices within the structure.)

Succinct. At Motorola, LSI is described like this: the simultaneous realization of large-area circuit chips and optimum component packaging density for the express purpose of reducing costs by maximizing the number of system interconnections made at the chip level.

But TRW's Norman Grannis says an array can be ranked in the LSI class when it has 100 gates or 400 elements per chip. Alden Stevenson of Litton submits that once "several hundred active devices" becomes established as the principal LSI criterion, it doesn't much matter how many gates or standard cells make up the assembly.

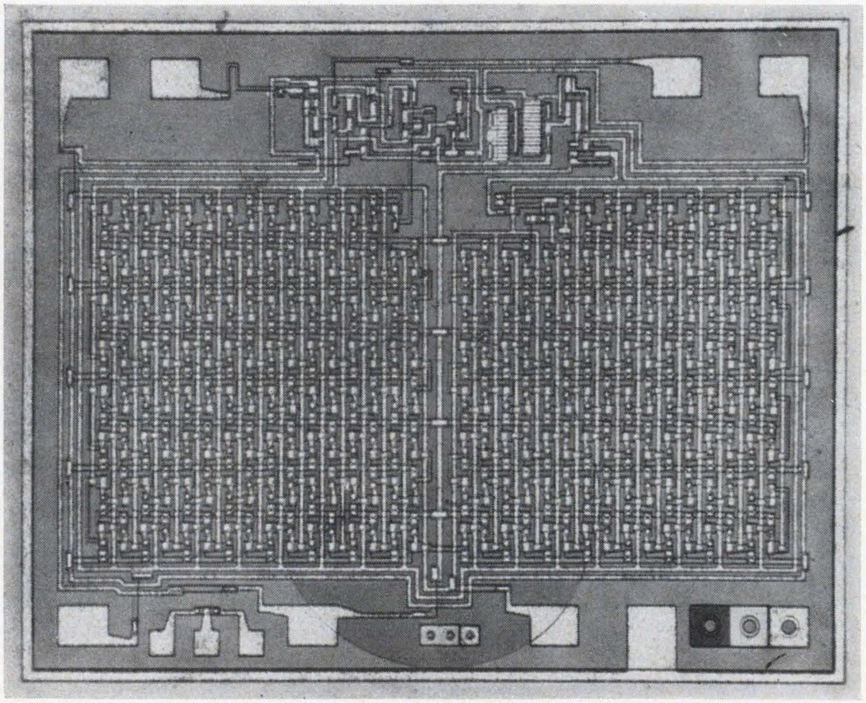
A Honeywell spokesman puts it this way: "We arbitrarily consider 50 to 200 components as a functional array; 200 to 1,000 represents the medium-scale integration level. Anything beyond 1,000 is LSI."

Moot point. Some sources get positively peevish when approached on the subject of LSI definition. "Using the number of elements per chip as a figure of merit is misleading since one firm may be able to do a job with less devices, but be downgraded when compared to a less skilled outfit that had to use more components," says a Sylvania official. Orville Baker of Signetics prefers to avoid the topic altogether. "By the time you get that complex, you've got a subsystem," he says.



Symmetry. Digital differential analyzer, built by Autonetics, has 864 metal oxide semiconductor p-channel transistors combined to form the equivalent of 310 gates.

part of the LSI development process. Mask production, as well as programs to determine the optimum topology for minimum power dissipation, shortest wire runs, or the like, are among the applications cited by Sylvania's Nola. "CAD is a must for fast turnaround time," he says. Arthur Lowell, assistant director of research and engineering at the Autonetics division of the North American Rockwell Corp., believes CAD can help eliminate process variations because the techniques used for multilayer boards are readily adaptable to metal oxide semiconductor layouts. "Pretty soon we'll be able to go from logic equations to the finished chip design in two weeks; a computer will generate the tape for making the masks as well as one for the tests to be performed," he says.



Test case. Experimental 128-bit recirculating shift register, made by TRW, has 780 metal oxide semiconductor transistors. It won't be put on market.

Motorola Inc.'s Semiconductor Products division is also using CAD techniques in an attempt to generate LSI masks automatically. But Walter Seelbach, manager of IC research and development there, is a good deal more cautious on the subject than many of his industry fellows. He emphasizes that a lot more work has to be done before computer-aided layouts as sophisticated as those required for LSI become a practical reality. When component densities approach the 90,000-per-square-inch level, Seelbach says, it becomes all but impossible to interconnect the array with two interconnection layers.

Two-way stretch. If there's an industry consensus on the importance of the computer in LSI processing, there's also a certain amount of controversy over how it's best applied. One school—led by Texas Instruments—favors the so-called discretionary wiring approach, in which a number of gates or flip-flops are built on individual wafers. Each is tested, and the good ones are interconnected by alternating metal and insulating layers to form the desired function. The interconnection masks are designed by a computer from the test data. Discretionary wiring's advantages are comparatively short turnaround times on the necessary artwork and better yields because only the good cells are used. However, probing each cell requires contact pads, and this reduces the amount of chip real estate that can be used for circuitry.

An alternative method favored by the Semiconductor division of the Fairchild Camera & Instrument Corp. and Motorola, among others, is the 100%-yield, or fixed-interconnection-pattern, approach. The fabricator simply assumes that all the cells on a wafer are good; testing is left until after metalization. Because probing isn't required, more can be put on the chip.

Cost-conscious. So far, most of the industry leans to the 100%-yield approach. "We're committed to fixed patterns of interconnection because they give the most repeatable characteristics and simplify testing," explains Sylvania's Nola. "Discretionary wiring builds unknowns into every wafer," he goes on. "Varying wire runs can lead to some very subtle problems with parasitics, and the user shouldn't have to worry about such matters."

A spokesman for another semiconductor maker notes that the price of a new mask for parts made with discretionary wiring techniques can be prohibitively high. Autonetics' Lowell agrees: "The single-chip nondiscretionary wiring technique looks like the best way to go because it costs less."

Honeywell says it's keeping an open mind on the subject until such time as one approach displays a clear economic advantage over the other. Harper says both methods are being checked in the company's own laboratories "to learn some of the things vendors don't like to talk about in much detail."

Room for two. But while the discretionary wiring and 100%-yield approaches are mutually exclusive, it would appear that metal oxide semiconductor and bipolar techniques will coexist harmoniously at most companies for a while anyway. Philco-Ford's Thornton expects MOS technology to dominate LSI at the outset because of size advantages. However, he concedes that its comparatively slower speed will be a drawback. "Right now, true LSI means MOS," says Jerome Larkin, marketing manager for LSI at Fairchild Semiconductor.

Richard Stewart, who heads the advanced technology department at the Hughes Aircraft Co.'s Data Systems division, feels the only real question here involves applications. "In radar signal processing equipment, bipolar assemblies would get the nod," he says. "For space applications where low power is critical, MOS would be favored."

Sylvania is another firm that finds room for both MOS and bipolar LSI efforts. "There's a slot in moderate or low-speed applications where you might want peak element density at low power," says Nola. "This is tailor-made for MOS. Applications might include long shift register chains, low-power counter circuits, and a few analog-to-digital functions."

Motorola's Seelbach believes that high-speed LSI assemblies will re-

. . . LSI packages must be improved for higher speed assemblies . . .

quire at least three layers of connections—two for signal interconnections and one for power-distribution and component intraconnections. The company has a two-layer system in pilot production and is developing a three-layer setup. Two layers of metal are used in the firm's recently announced XC-157 12-gate diode-transistor-logic circuit [Electronics, April 1, p. 105], and in a flip-flop that will be part of the MECL 3 line [Electronics, April 15, p. 46].

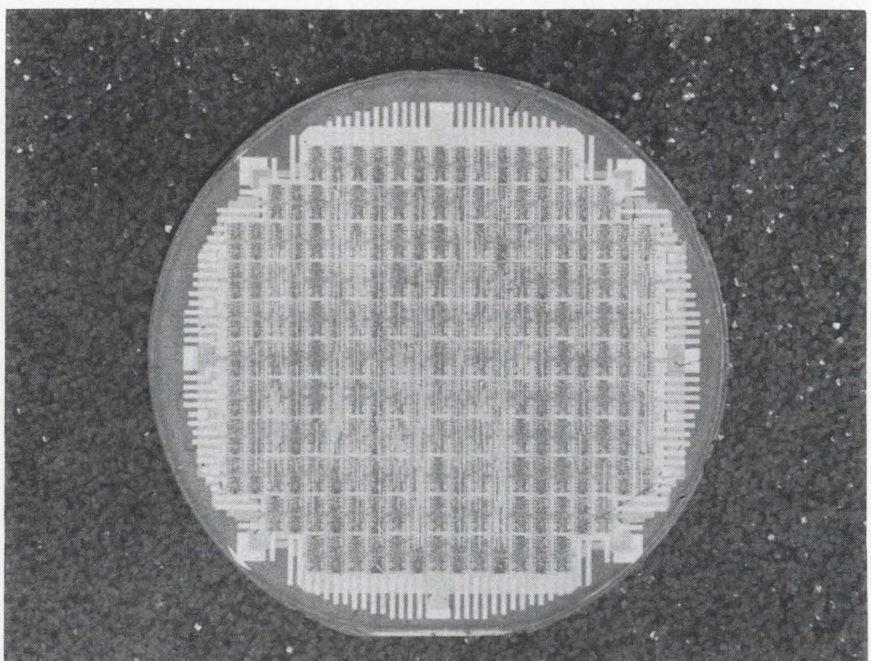
For higher speeds, Seelbach says, packages will have to be improved. And present production techniques—yielding spacings of 0.2 mil and greater—will, when combined with optimized component and circuit densities, push against the limits of conventional cooling techniques. "Liquid cooling or some combination of liquid and conduction cooling may be the answer to this particular LSI problem," says Seelbach.

Self help. The Systems Group at TRW Inc. is in the unusual position of being both a user and a maker of LSI circuits. The unit's microelectronics center, which has the primary manufacturing responsibility in this area, is currently concentrating on nonstandard arrays that the Systems Group can't purchase from outside suppliers. Norman Grannis, a section head at the center, says the facility's activities have so far been limited to single layers of metalization with diffused crossunders. However, a two-layer program has recently gotten under way.

The center has decided on a 22-pin round metal or ceramic flatpack as its standard. "We've found that if we go to a package larger than 3/8 inch square, we have trouble sealing it," says Grannis. Eventually, however, we'll probably use larger packages."

Autonetics is working on assemblies it likes to call integrated subsystems rather than LSI arrays. By this, the company means it is working toward optimum compartmentalization of subsystems to come up with functional building blocks. By way of example, Lowell cites a digital differential analyzer that's a single-chip monolithic circuit with 864 MOS p-channel transistors combined in such a way as to be the equivalent of 310 gates.

Lowell anticipates MOS inte-



Wire at will. Large-scale array with third-level metalization from Texas Instruments was produced with discretionary wiring techniques.

grated subsystem packages are smaller than bipolar LSI assemblies. And within the next two to four years, he expects beam-lead techniques to put large-scale arrays into smaller packages. "Since the beam-lead device has a passivated sealed junction, no external package is needed," he explains. And Lowell sees direct plug-in beam-lead assemblies farther down the road.

But for all the glittering promise of LSI, a number of difficulties remain. "Bonding's a problem even after the design is mastered," says Signetics' Baker. "If you make one mistake on a single die, the whole thing is lost. There's got to be a better way to put the chip in a package." Baker figures some sort of flip-chip bonding may be the answer. Another LSI problem area he cites is removing heat from the chips.

Brave new world

LSI advocates are apt to wax eloquent when it comes to assessing the technology's potential. Says Philco-Ford's Thornton: "LSI should not be construed as a means of building computers for less. In other words, it won't make any particular inroads into IC domains. Using LSI will require a complete restructuring of design, a move that will lead to new functions and applications."

Bipin Kapadia, product manager for large-scale systems at Honeywell's Electronic Data Processing division, has much the same attitude, pointing out that LSI isn't likely to play a big role in small computers since there are few repetitive functions in such machines. "But LSI could compete with software in a more imaginatively designed computer," he says. "Some repetitive operations could be realized in hardware, making the machine a bit more 'intelligent.'" Kapadia feels that LSI offers the possibility of a dynamic response to the progress of a program, making a read-only memory appear different at different moments during the routine. The content of the memory would change in response to prior read-in commands.

Autonetics' Lowell believes that virtually all computer input-output units are candidates for integrated subsystems—his company's version of LSI—as are small general-purpose processors and calculators. However, Lowell believes it will be some time before LSI assemblies get into computer main frames because the real-time performance of such equipment requires clock speeds greater than 10 megahertz. Litton's Stevenson notes that while conventional MOS assemblies are still down around the 1-to-2-Mhz level, complementary—combined pnp and npn—devices are already at 10 Mhz.

Chipper. A number of people, though, including TI's Petritz and TRW's Grannis, believe LSI will compete across the board with IC's and discrete components. Grannis also looks to LSI for systems that can't be built now because of their complexity. As a case in point, he cites a billion-bit memory. "There's little probability of achieving such a unit with core techniques," he comments, "but it could be made with large-scale arrays."

Sylvania's Nola sees good possibilities for LSI in the display field. "Storage, translation, and drive units could be combined. And as instrumentation becomes increasingly digital, the market could grow," he says.

Checkmate

If the market for LSI wares is a dreamy proposition, writing specifications and testing such assemblies is still something of a nightmare for all parties. "One of the reasons that LSI will gain acceptance gradually, rather than by leaps and bounds, is that users can't really test what they're buying," says Philco-Ford's Thornton. "The lack of effective checks has retarded progress severely."

Sometimes, it's a matter of no checks at all. Sylvania owns to having a customer "who runs no incoming tests; he puts it all together, and looks for smoke." Not too surprisingly, most of the company's other customers aren't so disposed to gamble. "They're cautious, interested, and definitely not demonstrative," says Nola. "They want reliability history. And we still don't have really hard figures on integrated circuits."

Easy answer. TRW's Grannis believes the typical LSI product will probably be a 50-50 mix of combinational and shifting logic that will be tested in about the same way as modules. But Hughes Aircraft's Stewart scoffs at the idea of a "typical" LSI product and says testing assemblies is definitely an extremely complicated proposition.

In the case of a multiplier Hughes built, a portion of the output signal is fed back through the input and a comprehensive exercise program for the part is generated, without external testing. A computer is used to calculate what the output should be, Stewart says, so the self-test feedback loop becomes a practical mode. Variations of this scheme can be applied to testing other LSI units with arithmetic functions, he says.

Softer sell. At least partially in response to users' demands, LSI makers have been overhauling their marketing programs. "At this stage, LSI can't be sold to purchasing agents," says TI's Petritz. "We're strengthening the engineering section of our marketing staff."

Motorola plans to market standard LSI arrays in the usual way—through salesmen armed with spec sheets. But Jack Jordan, the company's manager of digital IC marketing says complex assemblies will be moved by getting together technical teams from the supplier and user to iron out requirements.

Broader view. And other notable shifts are occurring back at the shop. Because of advances in LSI, the engineers at Hughes Data Systems division—to take but one example—are required to be more versatile these days. "Our people must now be checked out in systems, logic design, packaging, and related fields," says Stewart. "Moreover, they must appreciate the tradeoffs between recurring and nonrecurring costs. In short, specialists must develop a feel for areas once beyond their ken."

Likewise, TRW has its systems designers take a course in LSI at the Integrated Circuit Engineering Corp. "They have to know what goes into the chip," says a TRW official. "They formerly designed one lumped transistor to feed another. Now, they may not know where the crossover is."

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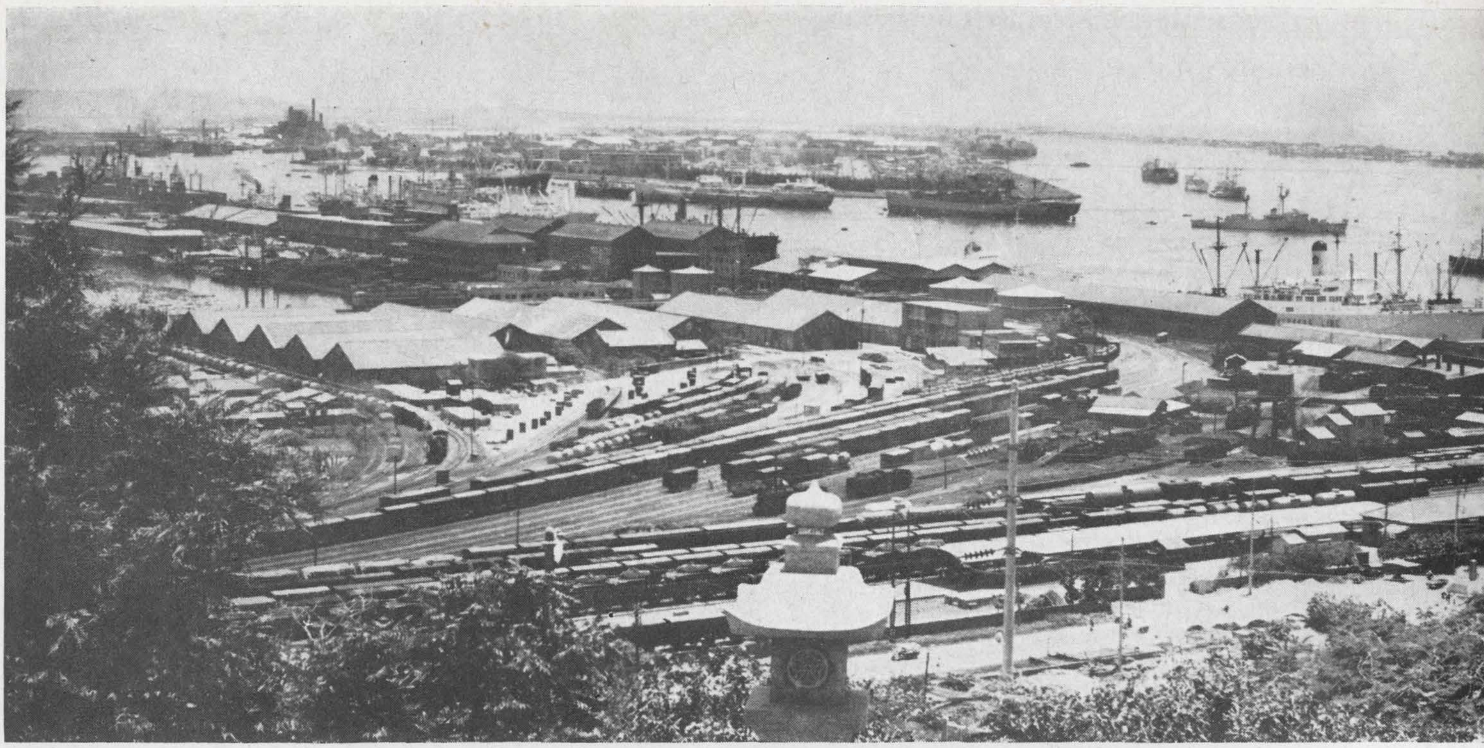


Industrial electronics

For Taiwan, a changing image

Chiang Kai-shek's fortress island is fast becoming an electronics center as both U.S. and Japanese firms set up plants in increasing numbers

By Wes Perry

Hong Kong news bureau

Lured by a favorable climate—tax, political, and labor—foreign firms have found Taiwan an island paradise for manufacturing.

Generalissimo Chiang Kai-shek's fortress lying about 110 miles off the Chinese mainland is in the midst of an electronics boom. In the last two years alone, plants have been rising at a rate of almost one a month. Including the 14 installations now in various stages of completion, foreign interests have thus far invested about $50 million in 43 installations that can turn out $180 million worth of products annually—ranging from transistors to television sets. And more plants are in the offing.

Last year, the 20 foreign electronics firms that were in operation for at least six months reported exports of $28 million, according to Nationalist China's official Industrial Development & Investment Center (IDIC). And then there are parts imported for assembly and then exported. This accounts for another $12 million. Locally owned firms turn out about $24 million worth of products, and export about 20% of them according to IDIC, whose job is to woo foreign investment.

Geopolitics. Roughly the size of Massachusetts, Connecticut, and Rhode Island combined—240 miles long and 40 miles wide—Taiwan is about 350 miles from Hong Kong. Chiang moved his Nationalist government to the island in 1949 after the Communist takeover of the Chinese mainland. With him came 2 million of his followers. Protected against a Red invasion by the U.S. Navy's 7th Fleet, Chiang initiated sweeping land reforms and launched an ambitious industrialization program. To help him, the U.S. poured in $1.5 billion in economic aid between 1951 and 1965. Private capital was coming in, too.

Japanese and overseas Chinese interests have invested some $110 million. And by the end of 1967, private investment by U.S. companies had reached $128 million.

Attractions

American electronics firms' enchantment with Taiwan began with a seemingly endless supply of low-cost labor—production line workers are paid $20 a month. But there are other reasons:

- Unlike Hong Kong and South

. . . the General Instrument Corp. led the move into Taiwan in 1964 . . .

Korea, which have been plagued by either Communist rioting or Communist troop infiltration, Taiwan has a somewhat tranquil atmosphere. Hong Kong is further burdened by rising wage rates and a growing shortage of technicians. And South Korea, according to some U.S. firms, lags in technical know-how.

▪ The Taiwan government offers such liberal incentives as permission for 100% foreign ownership and 100% repatriation of earnings, remission of 15% of invested capital per year after two years, guarantees against expropriation of foreign-owned plants for 20 years, a five-year income-tax holiday, largely duty free imports of machinery, a maximum income tax rate of 18%, and a duty-free export zone (KEPZ) in the port city Kaohsiung.

▪ The labor force isn't given to strikes. Moreover, because of the island's late start on industrialization, most plants are relatively new and modern. This leads to significant economies of operation.

But industrial life on Taiwan isn't completely blissful for the overseas entrepreneur. For one thing, the domestic market is limited. For another, competition in the Far East is becoming increasingly stiff. In addition, there is still a lot of red tape involved in setting up shop on Taiwan. Also, the island's ports are crowded, but this situation is being solved with several big expansion projects.

On the line. Pretty production worker checks circuit boards at the radio and television plant opened on Taiwan by the Philco-Ford Corp. in 1966.

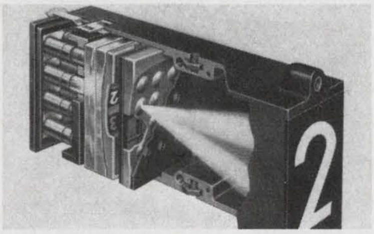
Number one. The General Instrument Corp. led the move into Taiwan in 1964 when the company built a plant to make transformers, transistors, diodes, and related components. Taiwan General Instrument is still the island's leading electronics employer with a work force of over 4,000. But the real take-off point occurred in mid-1966 when the Philco-Ford Corp. put its $5 million radio and tv plant onstream. The company has since increased its investment to about $11 million, and now accounts for 15% of Taiwan's electronics exports. A second Philco-Ford plant is making integrated circuits and transistors in the KEPZ and shipping them to the U.S. Philco-Ford was followed by such companies as TRW, Admiral, RCA, and Ampex. As in Hong Kong, these companies are all light manufacturers and assemblers. There is no research and development activity on Taiwan.

On the island, for example, Philco-Ford makes seven lines of transistor radios, its entire line of 12-inch tv sets, discrete semiconductor components, and multiplex tuners and terminal assemblies that go into color-tv receivers. Admiral will be doing about the same when it gets into full production later this year.

Local markets. All of the U.S. firms export their entire production as do most of Taiwan's 16 Japanese companies. However, the Japanese dominate the local market, mostly through joint ventures. Typical is the Tatung Engineering Co. that, among other things, makes tv sets with the Tokyo Shibaura Electric Co. (Toshiba). On the side, Tatung also makes memory cores for International Business Machines Corp. computers and electric fans under the Westinghouse Electric Co. brand name.

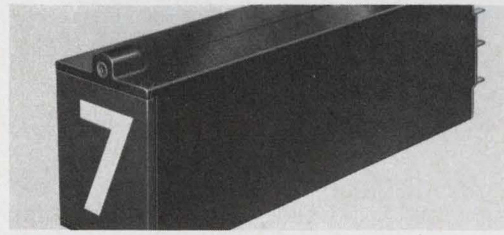
T. S. Lin, Tatung's president, says sales of tv sets in Taiwan have soared 500% since 1963. Lin, who considers himself a typical Taiwanese businessman, works in an austere Dickensian office and teaches economics courses at the Tatung Technical College. He points out that his company's sales will reach

Quick guide to bright, legible, wide angle readouts

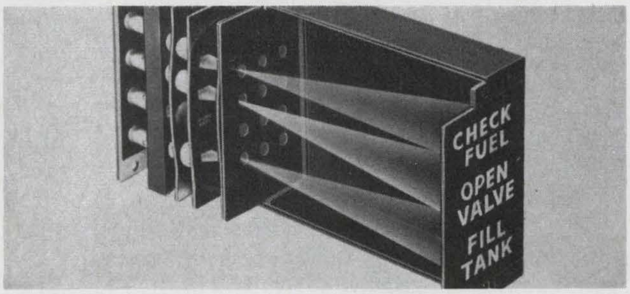


Series 360H Displays 2″ high characters easily read from over 50′. Yet unit is just 3″ H x 2″ W x 7.75″ D. New lens system provides bright, crisp display.

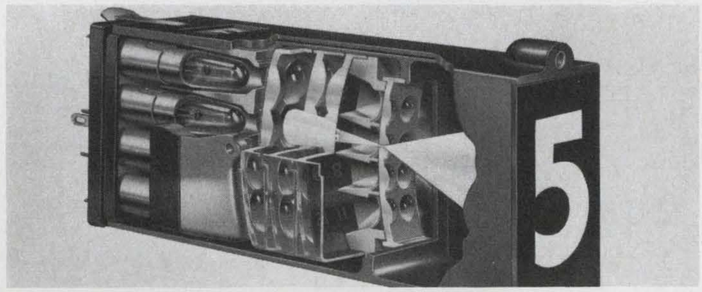
CRT Display 10-gun CRT projects single-plane digital or word displays onto fluorescent screen. Easy reading, even in direct sunlight. Wide viewing angle. Ideal for instrumentation applications.



Series 160H Exceptionally large viewing area (1.56″ H x 1.12″ W for overall size. New lens system increases character brightness; reduces chance of reading error. Message lines may be displayed simultaneously with symbols.

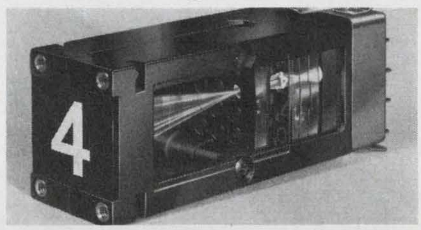


Series 80 Large screen unit particularly suited for annunciator applications . . . factory call systems, production control boards, etc. Message or character 3⅜″ high; can easily be read at 100′, 160° viewing angle.

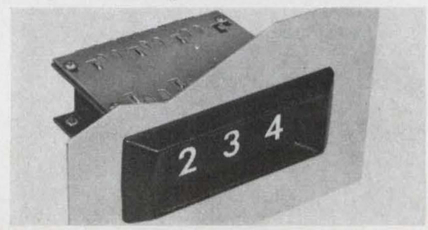


Series 10H World's most popular readout. And we've improved it. Double condensing lens provides exceptional character brightness. Greater clarity at wider angles and longer distances, even under high ambient light. .937″ H x .937″ W viewing area. Mil-spec version available.

Series 345 IEE's smallest rear-projection readout. Viewing area .38″ H x .34″ W. Based lamps. Low cost. Individual readouts plug into permanently wired housing for quick message change. Easy front panel access.

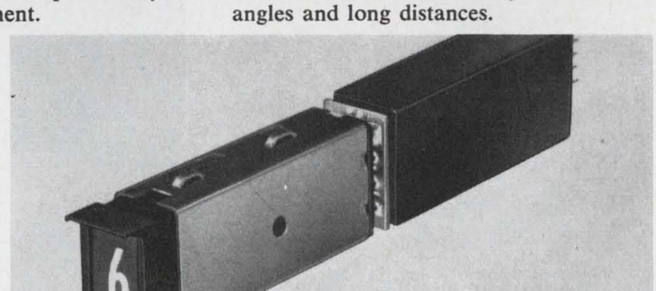


Series 120H Miniature (.62″ H x .62″ W) rear-projection readout. New lens system increases character brightness 50%. Easily read from 30′ even with high ambient light. Quick disconnect lamp assembly for speedy lamp replacement.



Series 220H Miniature, plug-in, rear-projection readout meets MIL-R-39027. .62″ H x .62″ W viewing area. Special lens system increases character brightness 50%. Excellent readability from wide angles and long distances.

Series 875 Miniature, 24-position, rear-projection readout with .62″ H x .62″ W viewing area. Overall size just 1.39″ H x .90″ W x 3.095″ D. Exceptional character brightness and clarity. Quick disconnect lamp assembly for easy replacement.



IC Driver/Decoders Small, solid-state units for IEE Series 10H, 120H, 220H, 340 and 360 readouts. All models accept a variety of binary codes for decimal conversion. Take normal signal voltage. Draw less than 2 ma. (Many options, including memory.)

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Circle 167 on reader service card

. . . vertical integration of Taiwan's electronics industry is under way . . .

the $23 million mark this year, compared with $7 million in 1964.

Deficiency. The prime short circuit in Taiwan's electronics manufacturing has been the lack of support industries. A United Nations project to establish an electronics technology research center to upgrade the efficiency of locally owned plants has yet to get off the ground. Chinese officials point out that there are over 800 kinds of finished products, components, and parts that aren't—but should be—produced in Taiwan.

Today only 18% of the components going into finished products exported from Taiwan is made on the island. About 70% of the remainder is imported from Japan and the rest is shipped in from U.S. sources.

Philco-Ford's resident general manager, William B. Scott, figures that the 18% will climb to roughly 65% within the next couple of years. A big step will be taken when Taiwan begins making its own tv picture tubes and cord. There is still no cord made locally that is approved by the Underwriters Laboratories.

Says Scott: "The first move for the government was to get the plants here in the first place. Step 2 is the vertical integration that's going on right now, and I think it's moving along very well. We should be able to make electronics goods here cheaper than anywhere else in the world when vertical integration is further along."

Looking ahead

Both IDIC and most private operators estimate that in about 10 years Taiwan will be exporting about $500 million to $600 million worth of electronic goods annually. Given Taiwan's peculiar political situation, no one tries to project further ahead than a decade. Some Nationalist leaders still firmly profess that they will be running the mainland again by that time. And while more sober officials have abandoned this point of view, to plan otherwise means going against official policy, realistic or not.

Births and jobs. On the plus side, there is no shortage of comparatively inexpensive labor in sight. The government has been battling the island's 4% annual birth rate with some success for the past couple of years, but still must find jobs for 160,000 new workers annually. That is why government policy is aimed at luring such industries as electronics. Wage rates went up 3¼% in 1967 and are expected to climb at a comparable rate for the

Concentration. Assemblers work at Tatung Engineering, a joint venture set up by Japan's Toshiba and Taiwan interests to serve the local market.

Geography lesson

Taiwan is an island 110 miles out from mainland China. The Philippines are to the south and Japan to the north with the China Sea on the west and the Pacific Ocean on the east. The Nationalist Chinese government uses the term Taiwan, which is known as Formosa in the western world, to cover 14 other nearby islands as well as the Penghu (Pescadores) group. Taiwan's principal harbors are Kachsiung, Keelung, and Hualien.

Tradeoff. Taiwan was ceded to Japan by China in 1895 following the Sino-Japanese War. However, it was restored to China in 1945 after Japan's surrender.

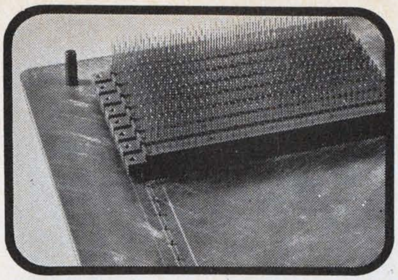
A range of mountains forms the backbone of the island. The eastern side is steep and craggy. But the western slope is flat and well cultivated. Crops include rice, tea, sugar, sweet potatoes, and jute. Among Taiwan's mineral resources are gold, silver, copper, and coal.

Taiwan's economic growth has averaged 7% to 8% annually in recent years. In addition to electronics, the island's principal industries include flour milling, tobacco, oil, lumber products, textiles, machinery, and glass.

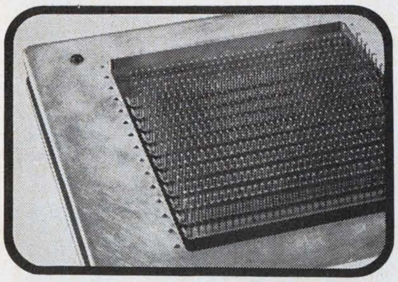
next seven years or so.

Nationalist China's economy is one of the world's fastest growing. The gross national product has more than trebled since 1953 and now tops $3.5 billion; per-capita income has risen to $209 at current prices during the same period. Industrial production, which increased about 13% annually between 1952 and 1966, posted a 19% jump in 1967. Foreign trade in 1967 reached $1.5 billion, up 26% from the year before. Foreign investment, now totaling $245 million, has grown steadily from just over $1 million in 1952 to $66 million last year; last year's level is almost double that of 1966.

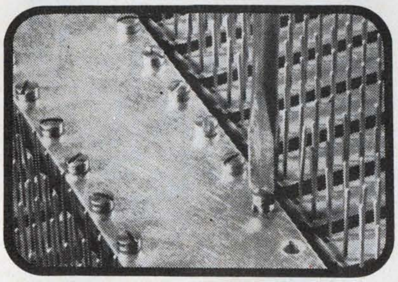
New battle plan. Government incentives aren't the only explanation for this spectacular growth. Chiang Kai-shek's saber-rattling had kept some potential investors at arm's length for years. And it has been only since he grudgingly admitted that he cannot win a military battle for the mainland that he began fighting the economic struggle of



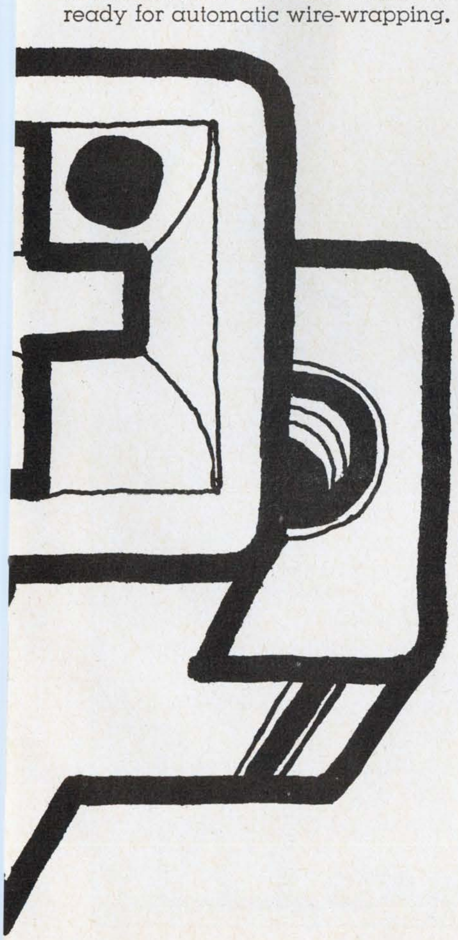
Alignment holes in HW Series connectors are polarized for fast, sure alignment.



With the connectors in position, a wiring frame is added.



Connectors are attached with machine screws and the frame is ready for automatic wire-wrapping.



. . . Taiwan has an abundance of skilled management and engineering personnel . . .

the island in earnest. To be sure, the fight for the mainland goes on, at least in the minds of the Nationist old guard, but it's become essentially "political" rather than "military."

Chiang still makes the final decisions in all important matters, but a greater load is being put on the shoulders of others—primarily C. K. Yen, premier and vice president, who is Chiang's heir to the presidency. Yen, 62, was minister of finance during the days of the land-reform program. Most of Taiwan's new leaders have given up the idea of returning to the mainland, and are now preoccupied with the development of the island's economy. As a result, foreign businessmen are confident the present trend of economic growth almost wholly dependent on foreign investment will continue.

Drawbacks. But there are liabilities. The main complaints are the mountains of red tape involved in dealing with a bureaucracy designed to serve the whole of mainland China. In addition, there is still corruption at some levels of government. There are the inevitable tales of investors who have looked to Taiwan only to be driven elsewhere by the heavy-handed bureaucracy.

Observers like Philco-Ford's Scott acknowledge that such problems exist, but claim the government is doing a good job of improving the situation. At the KEPZ, for example, such activities as customs inspection and clearance, foreign-exchange settlement, and the issuance of permits and certificates have all been streamlined considerably.

Talent. More important, says Scott, is the abundant supply of good management and engineering personnel. "Hong Kong electronics companies place want ads in Taiwan papers for engineers," he says.

Adds another American plant manager: "The caliber and quality of personnel here is excellent. In fact, it is so good, we've had to be careful not to overhire. It is no good employing an engineer to do a technician's job." Most engineers and technicians are Japanese or American trained.

Only one small foreign firm is ready to toss in the towel. But industry insiders believe it's because the firm's U.S. market didn't pan out as expected and not because of the operating environment of Taiwan. The company, Parsons Electronics, located in the KEPZ, is now up for sale.

Heir apparent. C.K. Yen is considered by many as Chiang Kai-shek's presidential successor.

Advocate. The marketing chief of a Taiwan operation opened by an American firm within the last two years believes the island stacks up favorably when compared to any other area in Asia.

The manager of another plant recently opened in Taiwan believes that the island is a whale of a lot better than many other countries at the same stage of development. "An American businessman who can't operate here, can't operate anywhere on earth," he says.

Speeding diplomacy's messages

New ITT system for the State Department cuts average elapsed time between reception and distribution from eight hours to one

By Howard Wolff

New York bureau manager

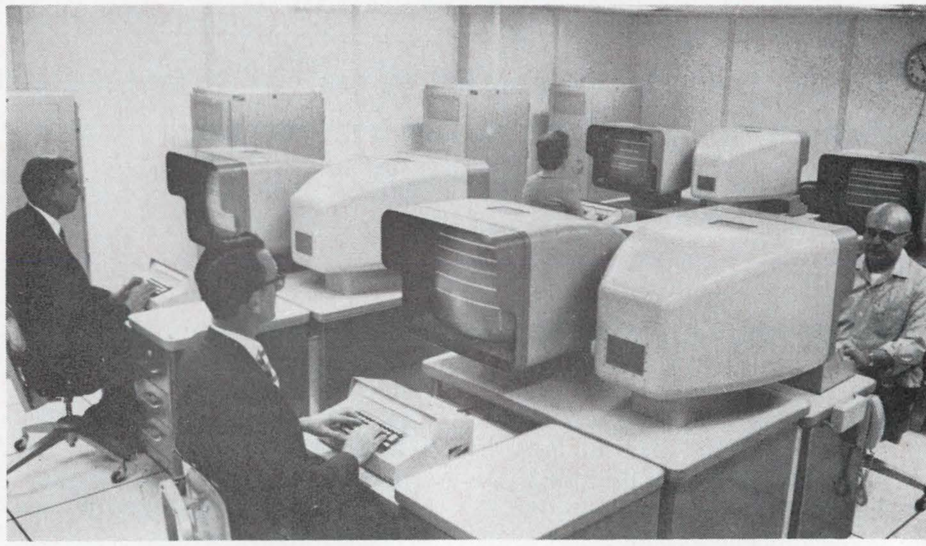
"Of course," says Ambassador at Large W. Averell Harriman, "we are in close touch with Washington." To newsmen besieging him outside the Hotel Majestic in Paris, where Harriman was meeting North Vietnamese representatives, the reminder was superfluous. But to the State Department it sums up three years of work—costing $3.5 million—on one of the most up-to-date message-switching arrangements of any Government agency.

Keeping in touch with scores of embassies, consulates, and missions has always been an expensive and time-consuming job for the communications people at the State Department. The department has 15 major relay centers scattered around the world—in such embassies as those in Rome, Athens, Bonn, and London.

Riding herd on the network are 237 communications personnel in Washington handling 13 million words a month and watching their message volume rise 10% a year. Add to that volume the tangle of red tape—each message, no matter how inconsequential, goes to an average of 125 people and other Government agencies (some are copied for as many as 500)—and it's easy to understand that until ITT installed its 7300 Automatic

Cortex. View toward the two ITT 7300 message processors that are the nerve center of State's communications center in Washington.

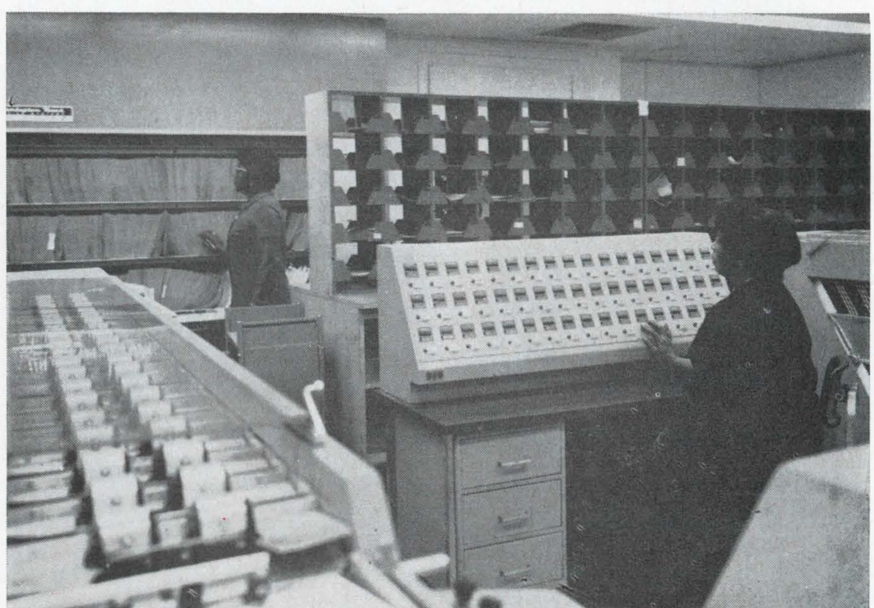
. . . old torn-tape system involved handling and rehandling transmissions for hours . . .



Seeing the light. Message analysts—the men who determine just how secret a telegram is and who should see it—do their editing and place routing instructions on messages, flashed on display, via keyboard. Displays replaced hand-typed copy.

Terminal Switching system, an ordinary message would spend as many as eight hours traveling from the old torn-tape center to an official's desk. It had to be decoded, analyzed (read and routed), typed, corrected, retyped, duplicated, and —at long last—sent on its way.

Yesterday. The old eight-hour process was a model of wasted motion. A message arriving on paper tape would be fed into a readout printer. The hard copy and tape would then go to an analyst for editing, which involved not only correction of spelling and grammatical errors but also "translation" from diplomatic cablese into readable English and routing. This corrected copy would go to a tape-



Taking the high road. After the analysts get through with a message, it is duplicated (the average is 125 copies; the outer limit is about 500) and each copy is placed in the proper mail receptacle by this Remington Rand Lektriever.

punch operator who punched out clean copy for a second printout. The route then would carry the message to a battery of clerks who typed multilith stencils, to the multilith department itself, and finally to the mailroom for distribution by hand or through pneumatic tubes.

The disadvantages were obvious. Not only did the handling and rehandling, the reading and rereading, and the punching and repunching eat up time, but the operation generated mountains of paper.

Changing times

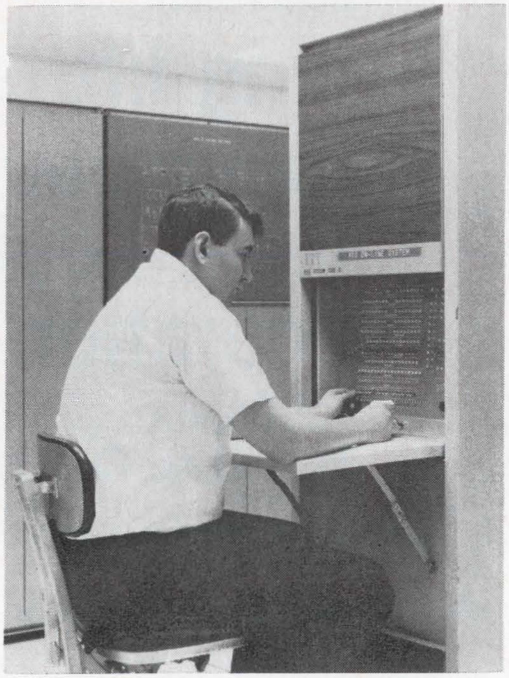
But all that is in the past tense. The recently accepted ITT system, installed by the company's Defense Communications division, has cut average elapsed time from reception to delivery to about an hour; in special cases that figure can be four minutes. Of course, the highest officials—such as the Secretary and under secretaries—see messages in seconds.

The communications center, on the fifth floor of the main State Department building, now can serve as the prototype of a global network's center. Completely shielded from radiation or electromagnetic interference, it is top secret. Visitors—and there are many who are anxious to see it—usually are admitted only on Sundays, when there is little message traffic. State Department officials say they have logged 300 visits, mainly from other government agencies and industry, in the past year. Presumably, those visitors had guides, because the center is so hush-hush that its door is unmarked except by the presence of an armed security.

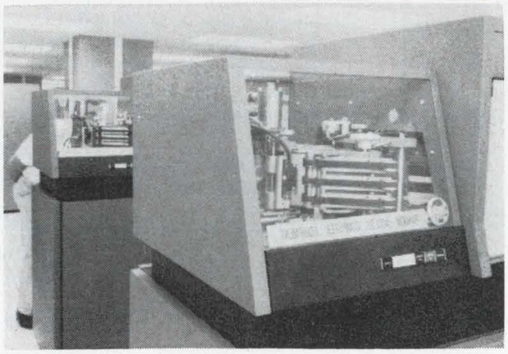
Inside, two ITT 7300 message processors (one is a redundant standby machine) are the heart of the operation. The processor, using discrete components throughout, stores 48,000 to 60,000 18-bit words and has a 6-microsecond cycle time. The four drums have a capacity of 256,000 words. Two high-speed printers eliminate the first typing, transferring a message directly to multilith mats for reproduction.

The message goes three ways at the same time: to a journal, two RCA Random Access Computer Equipment (RACE) installations, and to one of 10 displays made by

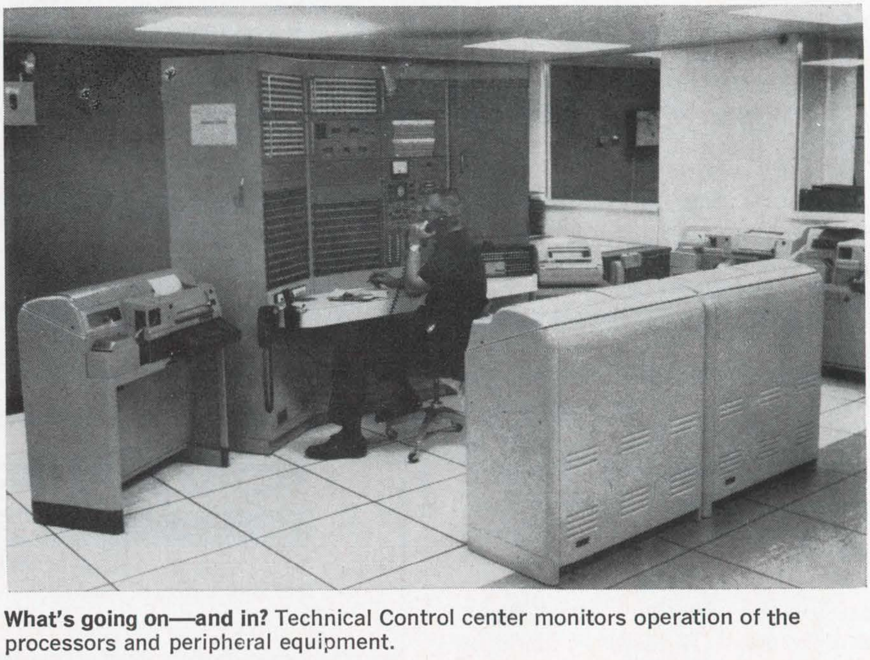
. . . system offers instant retrieval of 30 days worth of messages to 'Secstate' . . .



Silent service. Here's a closeup of the 7300. Two of them, in redundant operation, chug away constantly.



What day? RCA's Random Access Computer Equipment gives State's officials the capability of checking back over 30 days.



What's going on—and in? Technical Control center monitors operation of the processors and peripheral equipment.

the Laboratory for Electronics Inc.

Read all about it. The journal logs incoming messages. RACE provides quick retrieval of 30 days' worth of input, a feature that's considered vital by State Department officials. "As a matter of fact," says an ITT engineer, "now that they can go back into the files so easily, they're finding it more and more necessary—up to 30% or 40% of a day's traffic."

The 23-inch displays are probably the biggest savers of time and work in the system. The analyst, who once had to edit hard copy, then have it repunched and retyped, now sits before a screen. The incoming message appears before him with some distribution instructions on it; he can add others with his keyboard. In the same manner, he can correct spelling. When all is satisfactory, he presses a "transmit" button and the message goes to a high-speed reproduction printer for transcription on a multilith mat. For outgoing transmissions, the analyst does the required editing, then sends the result to an automatic encoding device and out over the State Department's lines or over the air.

Background. Other peripheral equipment for the new system includes an off-line message-preparation area of government-furnished equipment. Here there are 10 reperforators, 10 readouts, and two high-speed readers—all used to decode and encode input and output.

The system is designed to handle 10,000 messages a day containing 2,500 characters per message. The actual volume now is 5,000 to 6,000 daily.

Whither?

The State Department's William H. Goodman, deputy assistant secretary for communications, points out that a great advantage of the system is that fewer people are needed to handle the increased volume. For example, since State accepted the system from ITT, 26 employees have been transferred elsewhere. And, Goodman says, automation of other centers is just beginning. Work in Paris has been completed—but a new circuit is being installed—and Bonn is getting a system. The present system also has outlets at the United Nations Mission in New York, the

. . . but bottlenecks still slow work . . .

Agency for International Development in Washington, and the White House.

ITT engineers have their eyes on two bottlenecks that still exist in the State Department's installation. One is the message-preparation area—one engineer says, "That's like having a tortoise run the first leg of a relay race for a team of hares." The other, which holds up operations on messages coming into the capital, is the multilith area with its nine printers. "When you go from the 7300 to those chug-chugging printers you feel as if you're going back in time about 20 years," says the same engineer.

Waiting in the wings. Even the ITT people are champing at the bit in their desire to replace the 7300 processor itself. One of the marketing men puts it this way:

"When we started working on the State Department job three

What's new?

All messages sent from embassies, consulates, or missions to the State Department in Washington are addressed to the Secretary of State—or "Secstate" in the compressed jargon known as cablese. Naturally, Secretary Rusk can't possibly read, or be interested in, the thousands of words sent to him daily, so it's the job of the message analyst on the fifth floor of the main State building to decide who sees what.

For instance, a report from the economic officer in our Iceland Embassy on the effects of a forthcoming election on the pickled-herring industry would be addressed "Secstate." The analyst would decide that the report is neither secret nor confidential and that it is of little or no interest to Rusk. So he would key it for distribution to State Department aides—such as the European Desk—and other interested government agencies, in this case probably the Department of Agriculture, Bureau of Fisheries, Department of Commerce, Treasury Department, Customs, and the CIA (which seems to be interested in everything). There are 148 potential destinations in the capital.

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IA-113

Circle 179 on reader service card

. . . engineers envision faster processor . . .

years ago that 7300 was the fastest thing we had, and it was plenty fast enough for the boys in Washington. But I'd sure like to give them our 9300 with its 2-microsecond cycle time. With that baby we'd have messages in the 'in' baskets almost before they were finished transmitting from Bangkok, New Delhi, or wherever."

Busy line

The Paris talks with the North Vietnamese have, of course, generated a lot of traffic in the new communications center, although State Department officials are loathe to say just how much. They do point out, though, that the Paris show isn't the biggest one the new system has handled. That honor belongs to last year's Arab-Israeli crisis (during which the system received its baptism of fire), with place money going to the Cyprus flare-up.

What's the hurry? However, they'll find that the State Dept. is a tough nut to crack because there is a limit to how fast a message can be sent to someone's desk and just how much message space is occupied by diplomatic bombast and verbosity.

In the first area—speed—transmission time will remain the same no matter how many 9300's whir away in Washington, State Department spokesmen say. Therefore, the only additional speedup can come by cutting down on the time it takes to handle incoming or outgoing copy and the department isn't sure that the time saved would be worth the expense.

Secondly, State's communication officials have been waging a campaign to have Foreign Service personnel around the world—and at Foggy Bottom—cut down on the excess verbiage. As with previous campaigns of this sort, admonitions usually fall on the deaf ears of bureaucrats who are apt to judge their own importance by the length and complexity of the telegrams they can fire off.

FAIRCHILD

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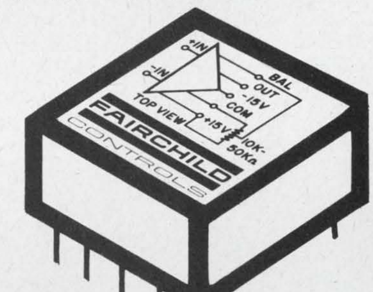
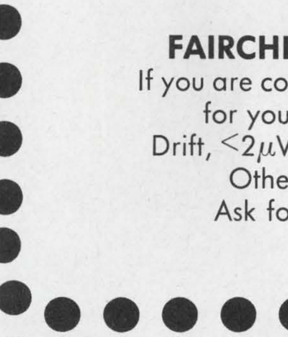
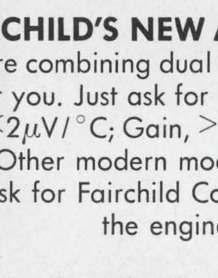


FAIRCHILD'S NEW ADO-26B FET OP. AMP.

If you are combining dual FETs with an IC op. amp., let Fairchild Controls do it for you. Just ask for the new ADO-26B. Guaranteed Specifications: Drift, $<2\mu V/°C$; Gain, $>100{,}000$; Drift vs. supply, $<100\mu V/V$; CMRR, 86 db. Other modern modules guarantee $<5\mu V/°C$ and $<50\mu V/°C$. Ask for Fairchild Controls' new amplifier catalog available from the engineering representatives listed below.





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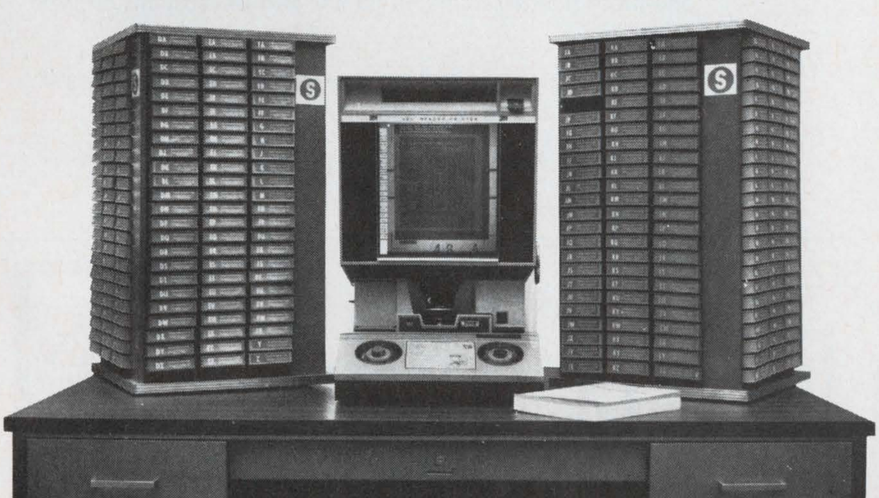

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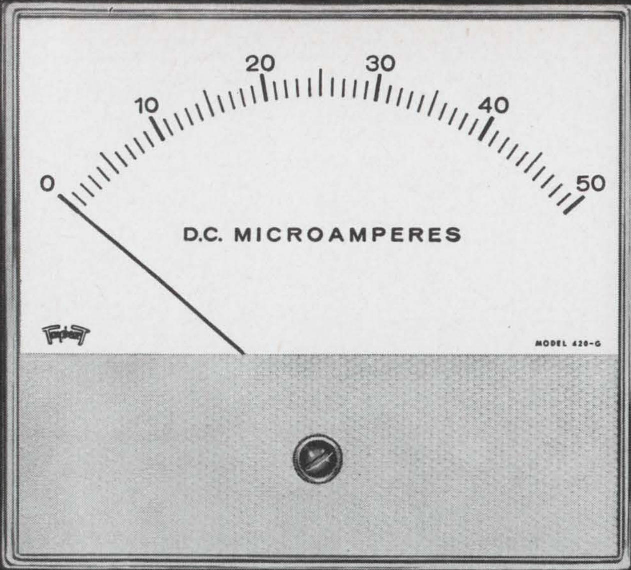
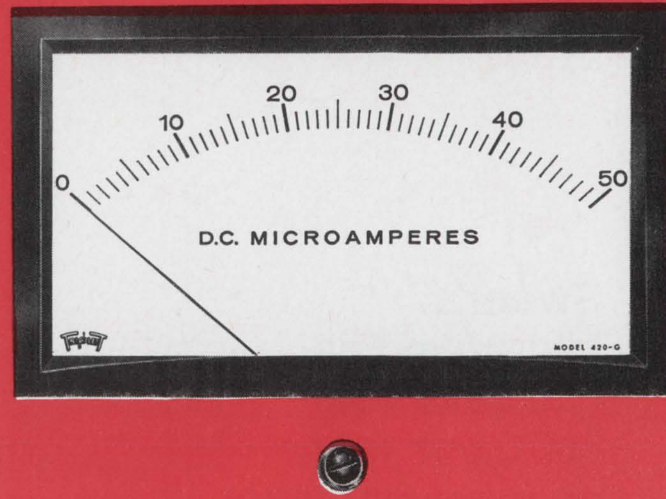
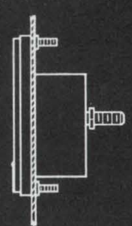
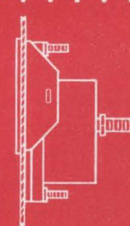
Circle 183 on reader service card





now you see it *now you don't*





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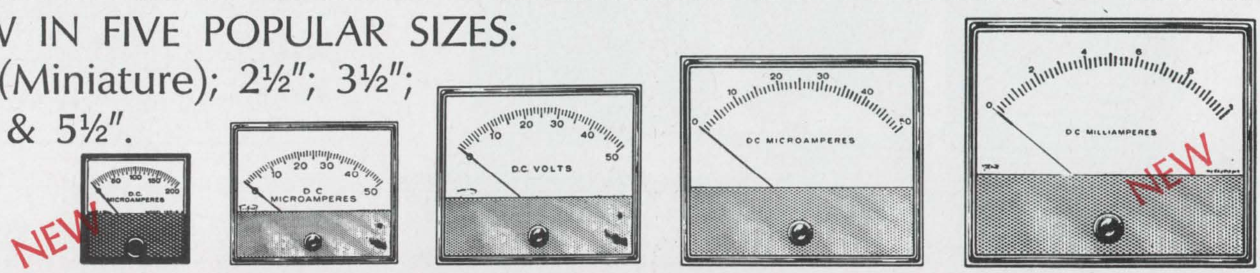
New Triplett G-Series Panel Instruments offer a modern design that features a greater degree of flexibility and interchangeability. **1** Two types of mounting are available—conventional flush type or behind-the-panel with a bezel for modern picture window appearance. **2** The insert shield on the front of the meter can be custom painted or printed to meet customer's requirements. **3** Triplett's famous self-shielded Bar-Ring magnet, with one-piece die-cast frame, in all DC and DC suspension type instruments.

In five popular sizes: 5½″ DC and AC; 4½″ DC and AC; 3½″ DC and AC; 2½″ DC and AC; 1½″ (conventional flush mounting only) DC and AC rectifier type.

Circle 184 on reader service card

NOW IN FIVE POPULAR SIZES:
1½″ (Miniature); 2½″; 3½″;
4½″; & 5½″.



TRIPLETT ELECTRICAL INSTRUMENT COMPANY, BLUFFTON, OHIO

New Products

Avionics

Accelerometer has cut-rate price

A simplified force-balance design and such mass-production techniques as chemical milling enable Endevco to offer single-axis units for $800

By Alfred Rosenblatt
Avionics and space editor

It was Earl Jacobs' wristwatch—of all things—that gave him ideas for producing accelerometers with bargain-basement prices.

"How can Timex turn out a timepiece as complicated as my watch, retail it for as little as $10, and still make a profit?" wondered Jacobs, who is vice president of the Endevco Corp., a subsidiary of Becton, Dickinson and Co., and manager of the Inertial Instruments division, Santa Ana, Calif. "In our field, we make accelerometers that are no more complex, but we charge upwards of $2,500 for them."

Using his watch as a guide, Jacobs developed a low-cost accelerometer by applying the simplification and mass-production techniques that have been so effective for the General Time Corp. "Our guiding rule in designing the accelerometer was to try to keep it as simple as possible," Jacobs says. "We didn't try to solve problems by adding a part—we tried to subtract a part."

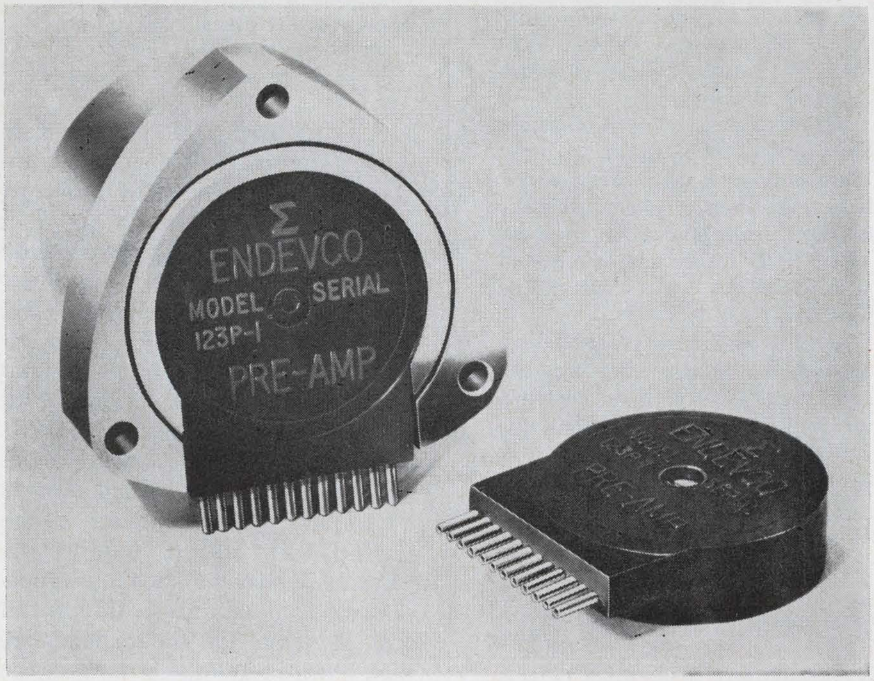
Familiar form. The result—a miniature, single-axis accelerometer—is being produced as the OA-123 series and priced from $500 to $800 in volume lots. Single units are available for evaluation at $1,650.

This unit is equivalent to or better in performance than any other currently available navigation and guidance accelerometer, Jacobs asserts. The only exception, he says, is the expensive pendulous integrating gyroscope accelerometer.

The Endevco unit works along the force-balance principle used in conventional Eyestone-Wilson types of accelerometers. However, Jacobs' approach centered on production; he wanted to apply the force-balance principle in such a way that the unit could be made as simply and cheaply as possible.

Inside job

In the Eyestone-Wilson sensor, a pendulously supported proof

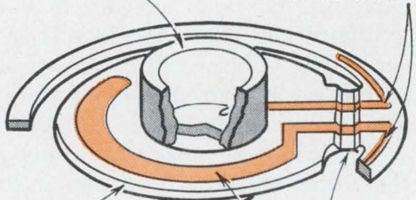


Modular. Accelerometer has an isolation preamp that plugs into the bottom of the package. A servo quantizer will be available in the fall.

"... we use chemical photoetching techniques similar to those in the semiconductor field ..."

mass is allowed to move with one degree of freedom about an axis. The slightest displacement of the proof mass is sensed by a pick-off connected to a servo circuit. When a current passes through a torquer coil, the coil allows an exactly linear force to be applied to the proof mass. The servo circuit controls the current in the coil in response to the pick-off signal so that the resulting electromotive force exactly balances the inertial reactive forces. Thus the current in the torquer coil is an exact measure of the acceleration.

In Endevco's Q-Flex design, the proof mass and the flex joint about which it moves are made from a single blank of chemically processed quartz.



One piece. Proof mass, flexture and support are chemically milled from a single quartz blank.

A slot is cut in the blank to form a ring-shaped section, and a central disk is connected by a narrow bridge. The disk serves as the proof mass, the bridge as a flexure, and the ring-shaped section as the flexure support. There are no jewel pivots or bearings. Nor, says Jacobs, are there the hysteresis, instability, and fatigue associated with metal flexures.

Bridgework. The bridge section is chemically milled to increase its compliance perpendicular to the central disk and to improve its physical characteristics. A vapor-deposited metal film on the central disk is used for the capacitance pick-off. Conducting leads from the pick-off, across the flexure, and to the torquer coil are also made of thin metal film. Attaching the torquer coil to the central disk completes the proof-mass assembly, which is then clamped between the magnet structures.

The balanced capacitance-bridge pick-off is formed by the metalized part of the quartz proof mass and the plates of the magnetic structure. A small gap between the magnet housing and the proof-mass assembly yields a high degree of gas damping.

Something borrowed. "In fabricating the proof-mass assembly we're using chemical photoetching techniques that are similar to those in the semiconductor field," Jacobs says. "By carefully controlling the process we're able to get dimensional accuracies down to 10 microinches. One big cost-cutting advantage is that we don't have to make any measurements along the way, as we do with a machined part. There are no adjustments, no compensations. We complete a part using our standard procedures, and then see what we've got."

The dynamic range of the accelerometer is ±20 g's, according to Endevco. Short-term bias stability is 10 micro-g, long-term stability 50 micro-g. Resolution is better than 1 micro-g.

The accelerometer is now available with an isolation preamplifier that plugs into the bottom of the package. In the fall, the unit will be available with a self-contained analog servo and servo quantizer plug-ins, which can be easily removed from the accelerometer housing for modification or repair.

Specifications

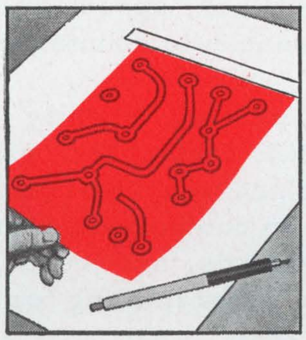
Typical dynamic characteristics

Range	±20 g
Sensor power	0.4 mv/g^2
Scale factor	1.0 ma per/g nominal
Nonlinearity (error)	less than 5 micro-g/g^2
Bias	less than 1 milli-g
Bias stability	10 micro-g (short term) 50 micro-g (long term)
Bias repeatability	25 micro-g
Bias temperature sensitivity	10 micro-g/°F
Initial axis alignment	better than 1 min arc
Threshold	less than 1 micro-g
Resolution	better than 1 micro-g
Cross-coupling coefficient	10 micro-g/g^2

Endevco Corp., 3015 South Kilson Dr., Santa Ana, Calif. 92707 **[338]**

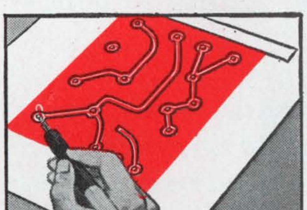
HERE'S HOW...

THE ELECTRONIC INDUSTRY IS USING THESE FAMOUS ULANO FILMS IN ULTRAMINIATURE MASK TECHNOLOGY AND COMPLEX PRINTED CIRCUITRY

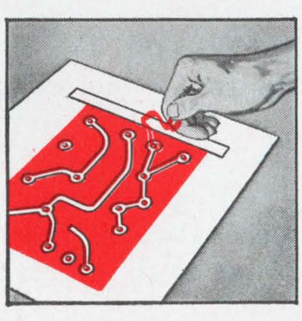


Cut a piece of the desired film large enough to cover area to be masked. Tape it down firmly at the top *with dull-side up.*

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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SCIENCE/SCOPE

The BADGE air defense system which will safeguard Japan against aerial attack was completed on schedule. Its network of sites extends from the northern tip of Hokkaido to the southern end of Kyushu. System was accepted in Tokyo recently by the Self Defense Agency of Japan.

Nerve center of BADGE is its high-speed Hughes computers. In seconds they will enable the system to detect, pinpoint, and identify a potential airborne threat... tell pilots and missilemen its altitude, speed, and direction... and automatically select the best defensive weapon to counteract it.

A new underground air defense center completed recently in Belgium is the first operational link in the $300-million NADGE system that will provide 10 NATO nations with an integrated early-warning and weapons-control system extending from Norway to Turkey. It will be used in conjunction with command centers Hughes will build in Belgium, The Netherlands, and West Germany. Hughes is providing data processing computers and programming for the entire NADGE system.

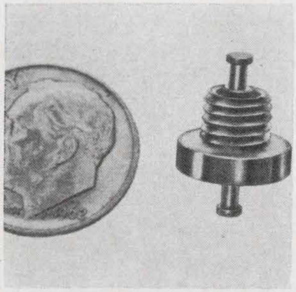
Three promising uses for lasers developed by Hughes include: 1) A laser trimmer for the manufacture of precision hybrid microcircuits. Trimmer uses a gas argon laser, is ideal where a probe-type tool is undesirable. 2) The first tank fire-control system that integrates a laser rangefinder with a high-speed analog computer. It is now being tested on the Belgian army's Mark 47 tank. 3) Color TV transmission by laser beam. New system has been demonstrated on an 18-mile link over land and water, and shows a remarkable ability to penetrate smog and haze.

The Collier Trophy for significant achievement in aeronautics and astronautics in 1967 has been awarded to Lawrence A. Hyland, representing the Surveyor program team at Hughes, Jet Propulsion Laboratory, and associated organizations. Hyland is vice president/general manager of Hughes.

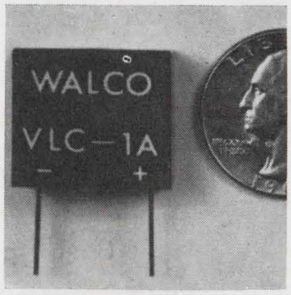
The Surveyor program for which Hyland received the award set the amazing record of five successes out of seven launchings -- including three soft landings on the moon in 1967.

A new mass sensor demonstrated recently by Hughes research scientists is the first instrument that is sensitive enough to measure extremely small gravitational forces -- yet can be made rugged enough to fly on an aircraft or spacecraft.

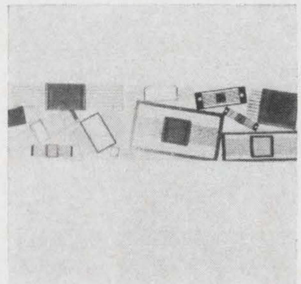
Potential uses for the sensor would be aboard an airplane, to make a fast, gravitational-field survey of the earth to detect oil or mineral deposits; aboard an orbiting satellite, to map the mountains, valleys, and craters of the moon.



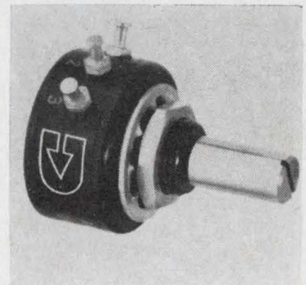
EMC/RFI filters series 75000, for use in low voltage circuits, combine high capacitance-low voltage ceramic capacitors and high current inductors in a sealed device. Measuring 0.400 in. diameter x 0.370 or 0.100 in. body length, units have max. d-c resistance at 25°C of 0.1 or 0.01 ohm, respectively. Electro Materials Corp., 11620 Sorrento Valley Rd., San Diego, Calif. [341]



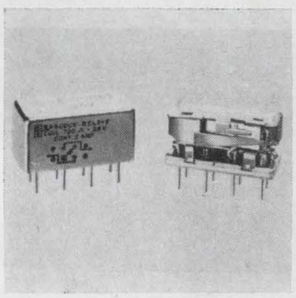
Solid state variable current limiters allow the user to obtain a continuously variable constant current with a ranging capability of 50 to 1. Current limiting capabilities are from 1 μa to 50 ma with input ranges from 5 to 35 v. Level stability is an order of magnitude better than that of fixed current limiters. Wall Electronics Co., 3821 Commercial N.E., Albuquerque, N.M. [342]



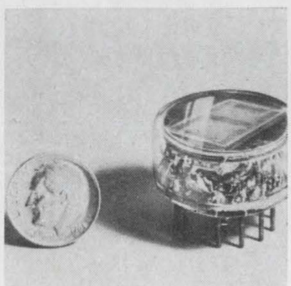
Flat Pak packages for IC's, discrete components and hybrid circuits are designed to meet critical military and industrial requirements. A wide variety of standard and special package sizes are available from 14 to 30 leads, from 1/4 x 3/8 in. to 0.85 x 0.2 in. sizes. Units conform to MIL STD 705A. Space Ordnance Systems Inc., 25977 Sand Canyon Rd., Saugus, Calif. 91350. [343]



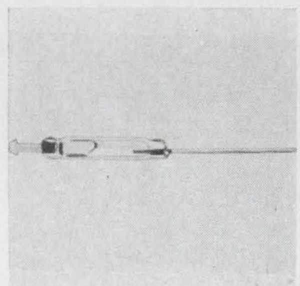
Precision pot model 1090-1001 offers advantages in applications involving high signal frequencies and need to minimize noise during adjustment. Specs include max. capacitance of 1.5 pf, max. inductance of 0.15 μh, total resistance of 1,088 ohms ±10%. Linearity is 1%, temperature coefficient +20 ppm/°C. Digilog Electronics Corp., 701—3rd Ave. North, Seattle 98109. [344]



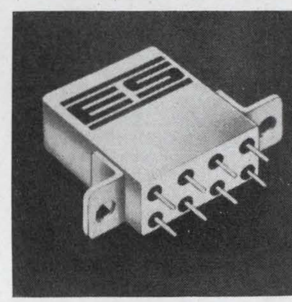
Welded half-size crystal can relay BR 26 features single-coil design and meets MIL-R-5757. Universal contacts permit operation from dry circuit to 2 amps with the same contact set, at coil voltages of 6, 12, and 26 v d-c. Max. operate/release time is 4 msec. Temperature range is −65° to +125°C. Babcock Electronics Corp., 3501 Harbor Blvd., Costa Mesa, Calif. [345]



The Digivac readout tube has 7 triodes with a common anode and cathode sealed in a rugged glass envelope. The anode of each triode forms a segment about 8 mm x 1 mm which is covered with fluorescent material that ensures high visibility characters. Viewing distance is over 40 ft.; viewing angle, 150°. Tung-Sol Div., Wagner Electric Corp., 1 Summer Ave., Newark, N.J. [346]



Reed switch WR126 is a mercury wet, spst Form A type that is bounce free and completely stable in its contact resistance and pull-in sensitivity. It is 1.63 in. in over-all length and 0.130 in. in diameter. Contact ratings are 50 w (d-c resistive), 50 va (a-c resistive). It switches 1 amp at 50 v d-c for 50 x 10^6 operations. Gordos Corp., 250 Glenwood Ave., Bloomfield, N.J. 07003. [347]

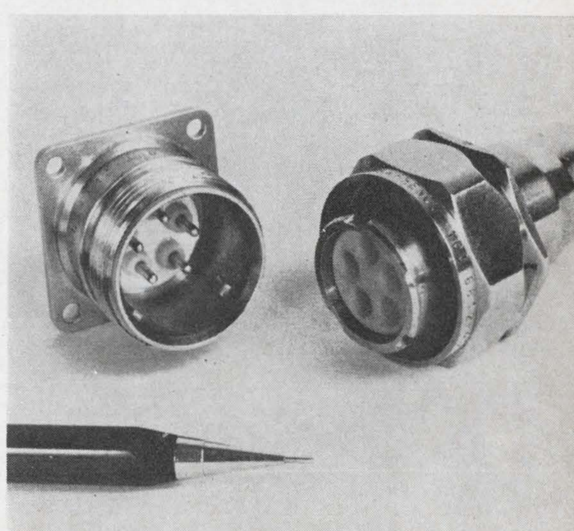


Military-type crystal can relay 79N is a low-cost, 2pdt dry circuit-to-3 amp unit that switches minimum current (100 ma to 0.5 amp) with the same reliability as dry circuit and load current. A new contact design permits the relay to meet a 100,000-cycle, no-failure test over its full range. Electronic Specialty Co., 19000 N.E. Sandy, Portland, Ore. 97200. [348]

New components

Connector withstands high temperature

Designed for aerospace applications, high-voltage unit is completely sealed



The aerospace industry has been pushing for the development of new connectors to withstand the severe environments encountered in outer space. One of the problems has been developing high-voltage units that can operate at high temperatures. Amphenol Corp. has developed a unit that, the company says, solves part of the problem. It's a five-contact, hermetically sealed power connector that withstands 50 cycles of thermal shock over a −65 to 1,000°F range.

While other 1,000°F connectors have been developed, says William

. . . connector is sealed on all sides . . .

Mashek, engineering project manager for Amphenol Connector, these haven't been hermetic configurations capable of handling high power under severe environmental conditions, such as in aerospace application. Amphenol's connector is specified for corona-free operation at 80,000 feet at 450 volts d-c, and has a service life of more than 50,000 hours.

Alumina insert. The prototypes each contain five size 16 pin-and-socket contacts with an alumina ceramic dielectric insert. The ceramic is metalized on selected areas and then brazed to the contacts and shell to effect the hermetic seal. The alumina is sealed to the shells and contacts through an intermediate member that compensates for differences in thermal expansion characteristics. The back shell is then tightly packed with magnesium oxide powder to both support and insulate the conductors and fill all air voids.

Integral insulating risers and depressions provided on insert faces around each contact increase the electrical path and improve over-all voltage-handling capabilities.

The prototype connector's socket contacts are tinned, encircled with a C-shaped Inconel X-spring band to assure pressure without relaxation at 1,000°F, and then provided with a cylindrical hood. Various types of contact terminations are available.

Power contacts, shells, and coupling rings are constructed of type 347 stainless steel, a superior kind that provides excellent carbide stability and better corrosion and elevated-temperature properties.

More seals. The connector is coupled through a threaded ring constructed with wrench flats. When the ring is tightened, a seal in the shell is pressed into place. The pin contacts are fully recessed in either plug or receptacle shell, eliminating the possibility of misalignment damage.

Two additional seals—one at the cable-connector junction and one as an interfacial seal—contribute to high environmental performance.

Amphenol Connector Division, Broadview, Ill. **[349]**

Delay line is IC size

Screw-adjusted unit has a range of up to 40 nsec and a resolution of 2%

No one has yet put control knobs on integrated circuits, so an engineer working with IC's has to build into his system some way of making final adjustments. If he uses adjustable components, they must be small if the size advantage of IC's is to be kept.

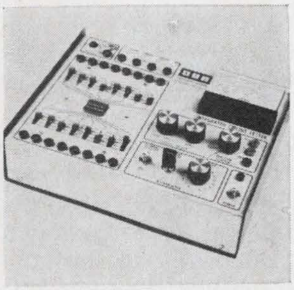
For circuitry that can be adjusted by changing delay times, Bel Fuse Inc. is offering a delay line that's hermetically sealed in a 3/8x1/2x 3/4-inch case and is continuously adjustable up to 40 nanoseconds.

Called the model DV, the unit is priced at $5. "Compared to flip-flops, delay lines are an inexpensive way of delaying signals in a logic network," says Stanley Sandler, Bel's chief engineer. Sandler notes that small, adjustable delay lines like the DV are particularly useful in close-tolerance systems.

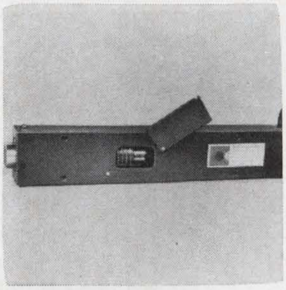
Smaller and smaller. The DV is an electromagnetic unit. When the adjustment screw is rotated, a contact slides over a coil, changing the delay time. The DV is 1/20th the size of units with similar performance characteristics, according to Sandler, but he says there's no dramatic reason why Bel was able to get the size down. The only explanation he can give is that the company makes all the parts that go into the DV, and thus was able to continually modify the components during development.

The delay line comes in four models. The DV105 is adjustable to 5 nsec and has a 100-ohm impedance and a 5-nsec rise time. The DV220 goes to 20 nsec, its impedance to 200 ohms, and rise time to 15 nsec. For the DV330, the delay is 30 nsec, impedance 350 ohms, and rise time 20 nsec. The figures for the DV540 are 40 nsec, 500 ohms, and 25 nsec.

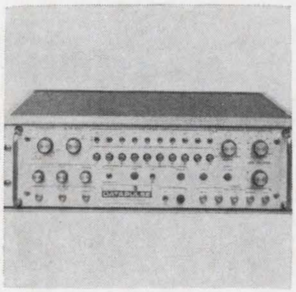
Bel Fuse Inc., 203 Van Vorst St., Jersey City, N.J. 07302 **[350]**



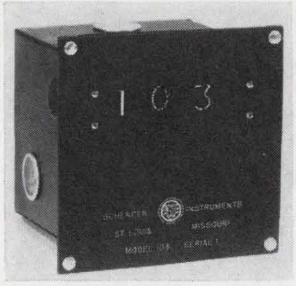
IC tester model 101 is a laboratory unit featuring two independent power supplies for collector supply voltage (V_{CC}) and logic level "1". The two supplies are so designed that logic level "1" can be no higher than 0.5 v below V_{CC}. Range of the V_{CC} supply is 1 to 15.5 v and for logic level "1", 0.5 to 15 v. Price is $275. AEI Instrument Co., 3691 Lee Road, Cleveland 44120. [361]



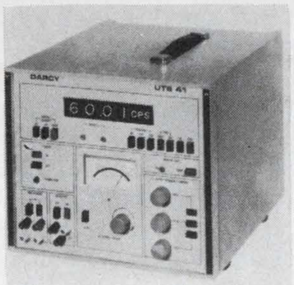
Variable set point pressure transducer model 107A is completely self-contained and can be manually set anywhere in the range from 0 to 120 psig. It produces a nominal output of −1.5 to +1.5 v d-c over a range of −20 psi to +20 psi about the set point. Linearity is better than +1.0% over the ±20 psi range. Robinson-Halpern Co., 5 Union Hill Rd., West Conshohocken, Pa. [362]



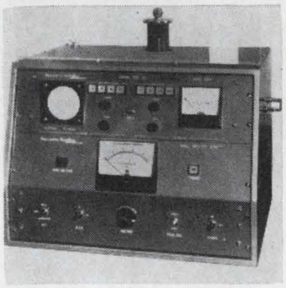
Random data generator 213A features pseudo-random word lengths to 1,023 bits and bit-for-bit error detection and display. The unit is suited for worst-case pattern testing of memory elements and data transmission links. Clock rates are available to 10 Mhz. Price is $2,285; delivery, 8 weeks. Datapulse Inc., 10150 W. Jefferson Blvd., Culver City, Calif. 90230. [363]



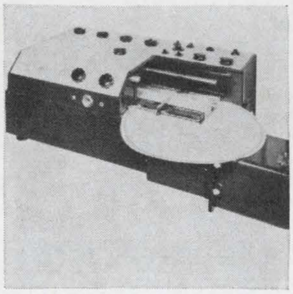
Digital clock model 103 measures elapsed time, accurate to 1/100 sec. Interchangeable with standard-size electromechanical timers, it is silent, contains no moving parts to wear out and stays accurate to within 0.01% at all times. Nixie tubes display elapsed time, continuously recycling when clock reaches 9.99 sec. Scherrer Instruments, 5449 Delmar Blvd., St. Louis, Mo. [364]



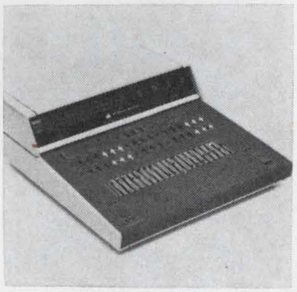
Utility test set UTS-41 combines capabilities of as many as 6 different devices (power supply, alternator, rheostat, counter and/or timer) formerly required for use such as calibration and performance testing of under-and over-voltage frequency relays. It features 100 msec power frequency measurements. Darcy Industries Inc., 1723 Cloverfield Blvd., Santa Monica, Calif. [365]



Corona test set model 4074 incorporates a Hypot with a 10 kv at 0.25 kva maximum continuously variable corona-free output. Output voltage crest factor is better than 5%. The corona detector consists of a scope with a verticle amplifier sensitivity of 3 mv/in. at max. gain. The 4074 is priced at $2,250. Associated Research Inc., 3777 W. Belmont Ave., Chicago. [366]



Polar charts can be slaved directly to an external positional control signal with the model 130 servo-chart drive. The unit is for use in concert with the model 2305 level recorder, capable of accurate signal levels over 2 hz to 200 khz. Typical uses include recording of frequency response measurements of tape recorders. B&K Instruments Inc., 5111 W. 164th St., Cleveland. [367]



IC tester model 1740 provides parametric and functional operational measurements. Applications include incoming inspection, wafer sorting, and final inspection. The unit is capable of forcing voltages or currents and performing the measurements either go/no-go or readout, utilizing a front panel mounted dvm. Miracle-Hill Electronics, 320 Martin Ave., Santa Clara, Calif. [368]

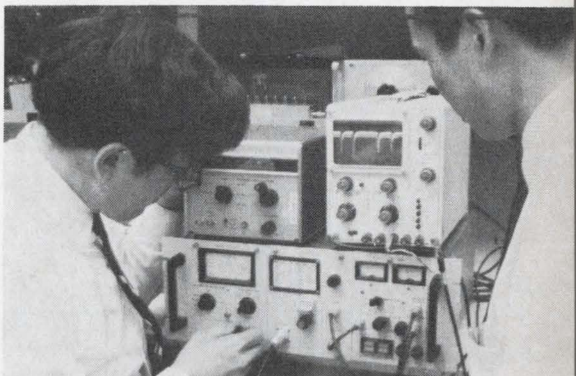
New instruments

Spectrum analysis for only $1,300

Modulation meter system can be used with scope for testing applications

Spectrum analyzers are expensive. Prices of $10,000 are common, while adaptors for oscilloscopes cost about $2,000 or $3,000.

But for engineers working in telemetry, testing receivers, or analyzing and calibrating communications links, low-cost spectrum analysis is possible with a series 2000 modulation meter system. Built by the New London Instrument Co., a division of the Crescent Communications Corp., the 2000 is a modular system that allows users to make a variety of measurements, at a variety of frequencies and at sev-



Modular. Instrument system can be used to perform many functions.

←Circle 192 on reader service card

. . . performance is good for on-site testing . . .

eral degrees of accuracy—all depending on the user's choice of plug-in radio-frequency, video, or intermediate-frequency units.

Now the firm has added a new i-f module that can turn the least costly oscilloscope into a spectrum analyzer capable of displaying a carrier, its sidebands, or its modulation waveshape. Dispersion is variable, and ranges as high as ±3 megahertz; resolution is about 5 kilohertz at the −60 decibel points.

Although specifications and flexibility can't match those of $10,000 analyzers, any lack in this area is said to be offset by the extremely low cost. And besides, say New London engineers, performance is easily good enough for the on-site calibration and signal-study applications suited to the system.

The real cost. To use the series 2000, one must buy an i-f module anyway—and New London offers six that cost as much as $1,500. The model 2004 costs about $1,000, while the 2005—with exactly the same specifications plus the ability to turn your low-cost oscilloscope into a spectrum analyzer—costs only $300 more. Not a bad premium when compared with the $10,000 price for all-purpose spectrum analyzers.

The 2005 includes a sweeping, voltage-controlled local oscillator in its i-f circuitry. If the oscillator is swept, the output of the i-f strip sweeps too, and this swept i-f product is available at a front panel jack on the 2005.

If the local oscillator were fixed in frequency, the output from the i-f strip would be proportional to the deviation of the frequency-modulated signal being studied. However, when the oscillator is swept, it will show, as does a spectrum analyzer, frequency versus amplitude on an oscilloscope.

Metamorphosis. The sweep signal is taken from the user's oscilloscope. Almost all oscilloscopes have a sawtooth wave output jack on their front panels, and this can be patched to the "mod & sweep input" jack on the 2005. A second cable connects the vertical output jack on the 2005 to that input on the scope. Now the user rotates the selector switch on the 2005 to the "spect" position, and his scope has become a spectrum analyzer.

With an f-m signal fed into the modulation meter-oscilloscope combination, the display is a quick way of spotting peak deviation by nulling or "Besseling out" the center frequency and doing some quick computation with a known value of modulation rate. Simultaneously, the 2005 can display incidental amplitude modulation on one of its two panel meters.

Deviation measurements can become complex if the modulating signal isn't a pure sine wave; it can even be difficult to determine the exact center frequency of the modulated signal with useful accuracy. But the addition of a calibrated peak detector can solve this problem with the meter-oscilloscope combination. The detector allows inputs to be measured and displayed as if they were sine-wave-modulated, regardless of the actual modulating waveshape. For the curious, the true shape of the modulating waveform can also be displayed through the 2005 and the user's scope.

Specifications

I-f frequencies	5 and 30 Mhz
Bandwidth	4 and 20 Mhz
Discriminator	5% linearity, 6 Mhz
Calibration	Internal-external, and external (scope)
Price	$1,300

The New London Instrument Co., a division of the Crescent Communications Corp., 153 California St., Newton, Mass. 02158 **[369]**

New instruments

Computing counter can measure rpm

Control is fully automatic and low-frequency readout is direct with this machine

A fully automated computing counter with five-digit resolution between 1 hertz and 10 megahertz has been developed by the Time Systems Corp. The new unit, the

. . . direct readout at low frequencies . . .

model 272, is able to provide direct readout of low frequencies—rather than just period measurements—and can measure revolutions per minute.

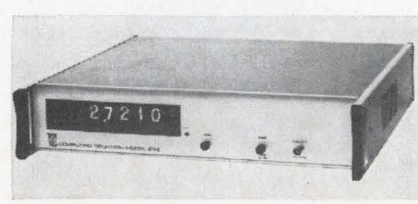
"At low frequencies," explains Al Malvino, a Time Systems vice president, "users until now have had to read in microseconds and then figure out what the frequency of the signal was. All we did was add a digital computer circuit to find the reciprocal of the time unit. That reciprocal appears as the frequency readout."

To measure rpm, light from a single reflecting dot on a rotating shaft is converted into a pulsed or waveform signal with which the counter can work. "Optical tachometry is a very simple operation," Malvino notes. The counter will measure between 10 and 99,-999 rpm.

Integrated. The circuitry is 85% to 90% integrated and is mounted on four boards. Two are for the counter, one for the computer, and one for the autoranger that automatically illuminates the correct decimal point and "khz" when the readout goes into the kilohertz range. Binary coded data and negative or positive logic outputs are available as options.

As important as the direct low-frequency readout and rpm measurements, says Malvino, is the automated control feature. Sample measurements are automatically held in the memory and the computations are read out approximately once every second. "This not only means the user isn't plagued with constant flickering, but that display time intervals are absolutely fixed," he says.

"We've set those controls that were once manually operated at their optimum positions," he continues. The memory is always on, the slope is preset to positive, and



the trigger point is set at zero.

The trend, according to Malvino, is toward completely automatic control of counting instruments. "The more we can automate the counter, the better off we'll be. Not only does automatic control simplify the work to be done with the counter, but it means that anyone can use it. You don't have to be able to adjust the trigger point and you don't have to know what a reciprocal is." The model 272 has only a power on/off switch and a readout reset button in the way of manual controls.

First jobs. The counter should find a variety of applications. Malvino says it has already been used by the International Business Machines Corp. to measure the rpm of peripheral equipment, and by the Navy to check out gyroscopes. Electric-power utilities may soon use it to stabilize 60-cycle current, he adds.

The executive expects the counter to be employed in velocity measurements, oscillator stabilization, doppler shift, flow measurements, vibration testing, and in medical instrumentation.

Priced at $1,500, the unit will be available on 30-day order. It weighs 15 pounds and is 3½ inches high, 16¾ inches wide, and 16 inches deep.

Time Systems Corp., 2239 East Middlefield Rd., Mountain View, Calif. 94040 **[370]**

New instruments

System keeps eye on noise

Level in signals received in nets is measured, compared to limits

When the question is how much noise should be tolerated in international communication nets, it's in every country's interest to agree. And most nations go along with the maximum noise levels suggested by the International Telecommunications Union in Geneva.

←SEE PAGE 195 SEE PAGE 199→

. . . power is computed by a square-law device . . .

As the number of communications links between Europe and the U.S. increases, the U.S. will probably rely more and more on the ITU standards.

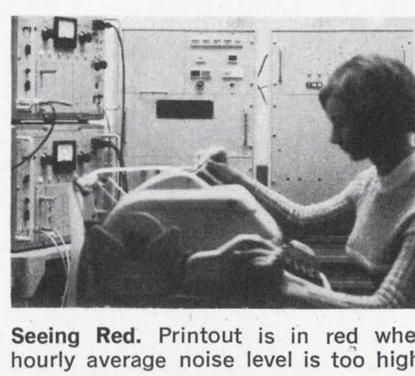
With this in mind, Siemens AG of West Germany has introduced in the U.S. its noise integrating measuring setup, type K1003, which measures noise power in either radio-link or carrier-frequency systems and compares it to preset limits.

Siemens has already delivered some units to European customers. In most countries the government monopolizes the communications industry, so sales so far have been to government agencies, says Alfred Oprotkowitz, a Siemens sales engineer in the U.S. "But in the U.S. we expect to interest companies like Bell Labs, ITT, Western Union, and RCA."

There are five components in the K1003—two noise level meters, a computer, a printer, and a cabinet containing an analog-to-digital converter and control unit. In carrier-frequency systems, the noise level meters are replaced with psophometers.

Slot check. The level meter measures noise in the baseband and in two narrow slots, one just above and the other just below the baseband. There are three outputs—a baseband noise signal, a slot noise signal, and a weighted slot noise signal, one that has been compensated to account for ear sensitivity.

The weighted signal is amplified and fed to a square-law unit whose output voltage is proportional to input power. The square-law output goes through the a-to-d converter to the computer. Every 60 seconds



Seeing Red. Printout is in red when hourly average noise level is too high.

. . . 2,700-channel systems can be monitored . . .

the computer calculates average noise power for the past minute and the past hour, and compares minute power to some preset value between 47,000 and 50,000 picowatts, and hour power to two separate preset values, both between 100 and 96,000 picowatts. The three comparative values are read into the computer through the printer's keyboard and can be changed during operation.

The unweighted signal is amplified, squared, and integrated over a 5-millisecond period. The integrator's output is compared to a reference voltage, and the number of times the reference is exceeded in a minute is counted and stored by the computer.

The baseband signal is compared to a reference voltage every second and the number of times this reference is exceeded in a minute is also counted and stored. The reference can be attenuated from 0 to 3 decibels, allowing the K1003 to handle systems with 60, 120, 300, 600, 960, 1260, 1800, and 2,700 channels.

For the record. Of the four possible printout formats, only one is continual; every minute the system records the date, time, average power for the minute in picowatts, a one or zero to indicate whether or not this is over the limit, and the number of times the baseband limit was exceeded in the minute.

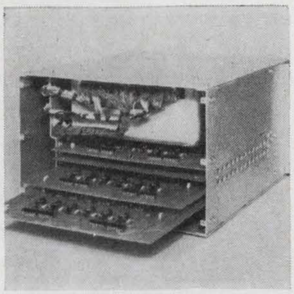
In the other formats, information is released only when one of the limits for weighted-noise power is exceeded. Average power for the preceding hour, whether the lower and upper hourly limits have been exceeded, and the number of times the output of the 5-msec-integrator exceeded the reference can be printed in addition to what's shown in the continual format. If the minute or lower hour limit is exceeded, the printout is black. If the average noise power for a 60-minute period goes over the upper limit, the printout is red.

The K1003's delivery time is six months and the cost in the U.S. is $60,000.

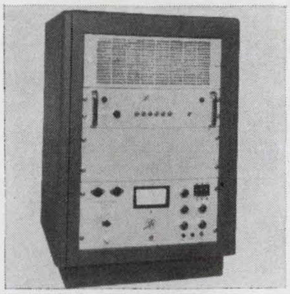
Siemens America Inc., 350 Fifth Ave., New York 10001 [371]

←SEE PAGE 197

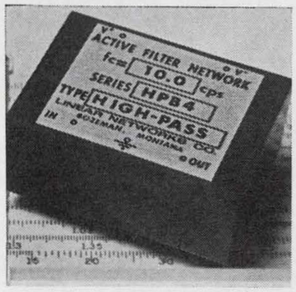
New Subassemblies Review



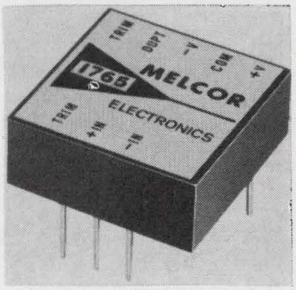
Compact, 8 K x 40 random access core memory series 500 has a 2 μsec full cycle speed and features an 800 nsec access time. Only 19 x 11 x 5¼ in., the memory contains 3 circuit module types. All modules and the memory stack are plug-in units that can be replaced quickly. The system is designed for commercial use. Sanders Associates Inc., 95 Canal St., Nashua, N.H. [381]



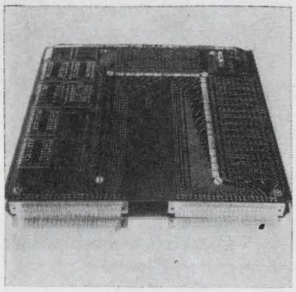
Amplifier system M402 is suitable for driving broadband antennas in testing rfi susceptibilty. Capable of pumping 50 to 100 w of power into a 50-ohm load over a frequency range of 10 khz to 220 Mhz (nearly 15 octaves), without tuning or bandswitching, it creates the fields required by MIL-STD-826A and -461. Instruments for Industry Inc., 151 Toledo St., Farmingdale, N.Y. [382]



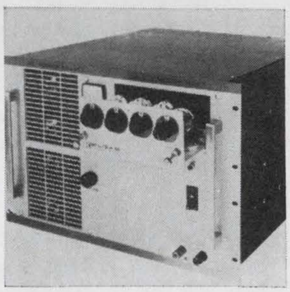
Active high-pass filter networks series HPB4 features the 4-pole Butterworth gain and phase frequency response characteristic. Attenuation over the operating temperature range of −40° to +71° C is 3±0.5 db at cutoff frequency and 24±2 db at one-half cutoff frequency. Standard cutoff frequencies are from 1 to 1,000 hz. Linear Networks Co., Box 1103, Bozeman, Mont. [383]



Low drift, FET input operational amplifier 1765 features high common mode rejection ratio, high power bandwidth, and high slew rate. It can be operated over a wide range of supply voltages and has an output swing of up to ±21 v. Applications include control instrumentation and data logging. Melcor Electronics Corp., 1750 New Highway, Farmingdale, N.Y. [384]

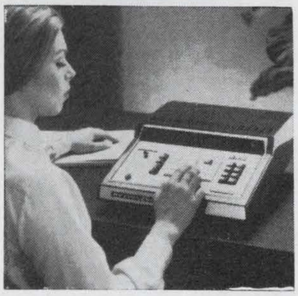


Ferrite memory core stack has a capability of 4,096 words with 16 or 18 bits/word and a fast 1.2 μsec cycle time. It was developed for small-scale, low-cost, computers intended for process control data terminal applications. It contains 65,536 individual 30-mil ferrite cores in the 16 bit/word configuration. Data-Ram Corp., Route 206, Princeton, N.J. 08540. [385]



Power source model 1000 delivers 0-1,000 va, single phase. Units may be stacked for 2- or 3-phase operation. The basic unit is a power amplifier that will accept any of 40 interchangebale plug-in oscillator modules. These provide fixed or variable output ranging from 45 hz to 5 khz accurate from ±0.1 to ±0.0001%. Elgar Corp., 8046 Engineer Road, San Diego, Calif. [386]

SSB transceiver CA-34 features automatic programming with simplified controls for ease of operation by nontechnical personnel. It is a 100-w unit developed as a multipurpose radio communications system for aviation ground stations. It will operate efficiently under temperature extremes from −30° to +65°C. Communication Associates Inc., 1208 Third Ave., New Hyde Park, N.Y. [387]

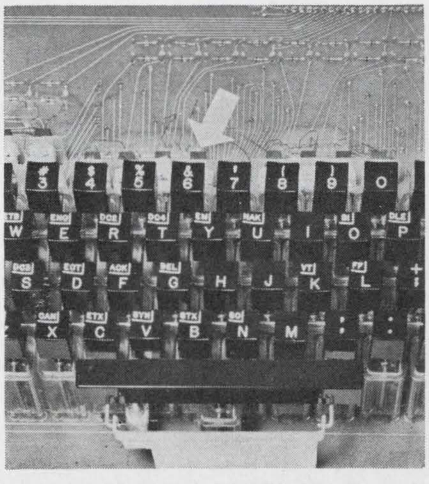


Electronic calculators series C3000 bring silent, instantaneous computing power to the desk top. The C3350, top model in a series of four, which can automatically extract a square root in less than ⅓ sec, features 2 independent core storage memories. Each memory provides 16 digit, 8 decimal storage capacity with minus total. Burroughs Corp., Detroit, Mich. 48232 [388]

New subassemblies

Keyboard with Ascii output costs $500

Unit uses 13 magnetic cores instead of diodes to generate the 128 symbols of the American Standards Association code



Split. Arrow indicates core with metal conductors passing through it.

Cross-country conversations between computers, displays, and other systems are now commonplace. What isn't so common is the language these devices speak and understand. And the keyboards used for computer communications are as diverse—and customized—as the languages.

The closest thing to a universal language is the code developed by the American Standards Association for digital systems communications. Called Ascii—American Standard Code for Information Interchange—it has 128 symbols, each made of seven coding bits and one parity bit.

Those who have adopted Ascii usually build their own keyboards or have them custom-made. But if, as seems likely, the Government adopts Ascii as its standard, other companies will be clamoring for off-the-shelf equipment. With this in mind, the Navigation Computer Corp. has developed the 1067, an Ascii keyboard with a base price of $500.

Key to the core. The 1067 works the same as most other digital-output keyboards. It has a driving circuit, coding matrix, and buffer. Push a key and a switch closes, connecting the driver to the matrix. The path the driver current takes through the matrix is determined by the key that's pushed and whether or not a shift key is depressed. The matrix output, specifically associated with the pushed key, goes to the buffer where it's shaped for transmission.

The matrix of most keyboards is a diode array. But Navigation Computer engineers found they would need 225 coding diodes to produce all the Ascii symbols—a number that would mean high production costs and poor reliability.

So out came 200 diodes and in went nine magnetic cores, one for each of the eight bits of a symbol and one for a strobe signal. Each core comes in two pieces. Navigation Computer engineers mount the core by cutting two holes in the printed-circuit board and bonding the core pieces together through these holes. When current flows in a printed lead passing through a core, a pulse is generated and is transmitted from the core to the buffer. In the 1067, each Ascii symbol is associated with a specific path through the cores.

"But there was still a problem," recalls David Aiken, one of the engineers who designed the keyboard. "It wasn't possible to fit in all the codes on just eight cores. There just wasn't enough room to put down the conductive paths for all the Ascii symbols." So in went four more cores.

It seems that the 1067, unlike a typewriter, has three shift levels. Some of its 63 keys produce just a lower-case symbol, others a lower and an upper, and a few handle three symbols. Aiken took advan-

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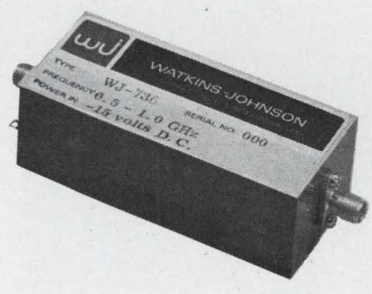

W-J has the production capability for standard-setting ultra-low-noise transistor amplifiers that perform as ordered. All of these devices are designed to satisfy the general requirements of MIL-E-16400 and MIL-E-5400. Perhaps the type you need is listed here. If not, we would appreciate a chance to review your specifications!

GUARANTEED SPECIFICATIONS

	Standard Versions		Integral Power Supply		TWT Replacement	
	WJ-736	WJ-737	WJ-738	WJ-739	WJ-740	WJ-741
Frequency Range	0.5 - 1.0 GHz	1.0 - 2.0 GHz	0.5 - 1.0 GHz	1.0 - 2.0 GHz	0.5 - 1.0 GHz	1.0 - 2.0 GHz
Noise Figure	4 dB Max.	6 dB Max.	4 dB Max.	6 dB Max.	4 dB Max.	6 dB Max.
Saturated Gain	25 dB Min.	25 dB Min.	25 dB Min.	25 dB Min.	25 dB Min.	25 dB Min.
Saturated Power Output	—3 dBm Min.	0 dBm Min.	—3 dBm Min.	0 dBm Min.	—3 dBm Min.	0 dBm Min.
Size (Inches)	1.0 x 1.3 x 2.9	1.0 x 1.3 x 2.9	1.3 x 1.9 x 2.9	1.3 x 1.9 x 2.9	1.9 x 3.3 x 3.3	1.9 x 3.3 x 3.3
Weight (Ounces)	3	3	6	6	10	10

Information in more detail available from representative in your area, or from Applications Engineering...

WATKINS JOHNSON

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tage of this. He laid out the keyboard so that regardless of how many symbols a key represents or which of the three cases the keyboard is in when the key is pressed, the first four bits associated with a given key's symbol are the same. Two or three symbols can thus share the same path through the first four cores if they share the same key. One core handles each of the first four bits and two cores split up the heavier traffic for each of the last four bits.

Optional clicks. All the 1067's circuitry is mounted on two p-c cards, one for the driver, matrix, and keys, and the other for the buffer. Each key is a Navco KRM—a reed switch and a small p-c board packed in a plastic case. Pushing the key moves a magnet that trips the reed. It's all silent, but there's an attachment available that clicks reassuringly every time a key is punched. The keys are soldered to the p-c card, and can be easily replaced; their lifetime is 100 million operations.

The driver circuit contains a comparator that senses the amount of current being drawn and locks the keyboard when the level runs too high. The more keys pressed, the higher the current. One key can be pressed when another is down, but pressing a third when two are down causes lockup.

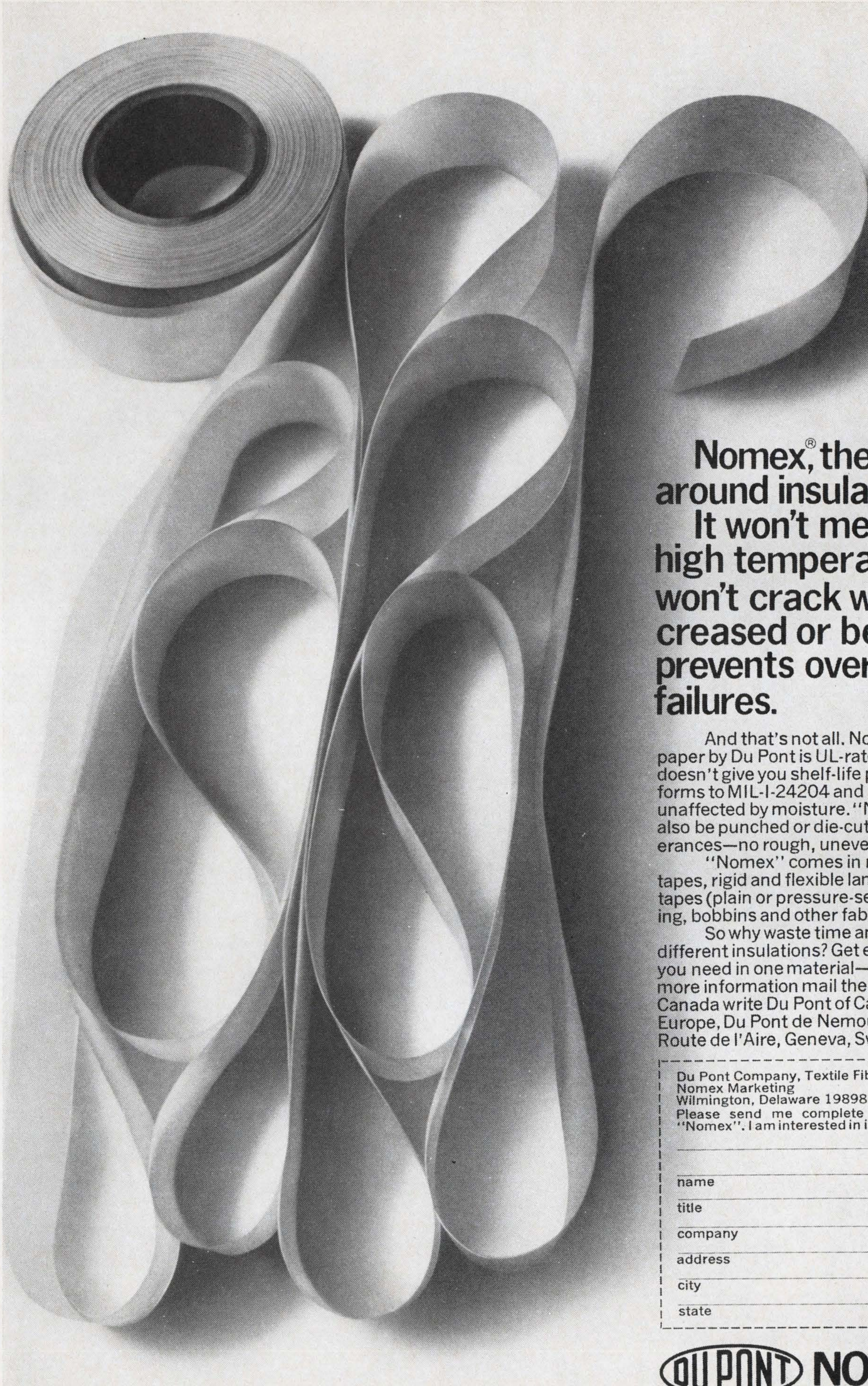
The buffer, which is made up of transistor-transistor-logic integrated circuits, produces pulses whose amplitude can be adjusted from 2.4 to 4 volts.

To increase the 1067's flexibility, Navigation Computer offers a variety of outputs in either serial or parallel formats. In one parallel machine, a data-ready signal appears along with the data signals at the output. Other units generate two strobe pulses with adjustable widths. And one has a serial output in Teletype format.

The 1067 comes in a desk-top package or a panel, or in special packages for original-equipment manufacturers.

Navigation Computer, which until now has made only customized Ascii keyboards, has already sold some 1067's to Xerox.

Navigation Computer Corp., Valley Forge Industrial Park, Norristown, Pa. 19401 **[389]**



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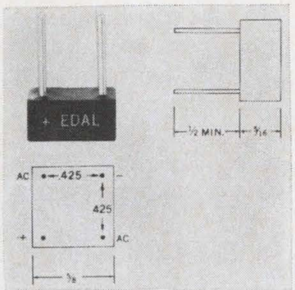
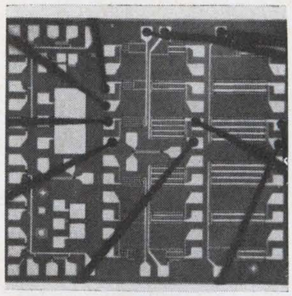
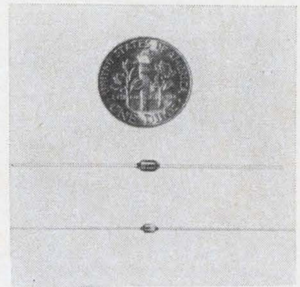
New Semiconductors Review



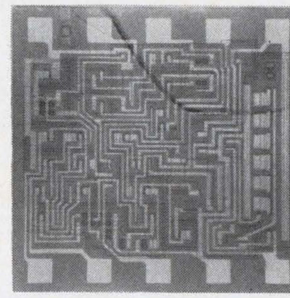
Single phase, silicon bridge rectifiers offer reduction in space requirements by handling max. power per unit size and withstanding high transient energy. High temperature capability, low leakage current and low forward voltage drop of these units with 6-amp current are offered in ratings of 50 to 1,200 v piv. Edal Industries Inc., 4 Short Beach Rd., East Haven, Conn. **[436]**



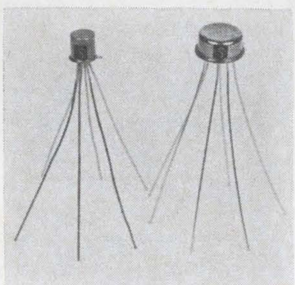
Monolithic active filter IC WML-5, a true linear MOS device, consists of 3 differential amplifiers in a 70 x 90 mil chip. It is a basic building block that can be used for more complex functions. For example, a 4-pole pair band pass filter could have relative bandwidth from less than 1% to over 100%. Western Microwave Laboratories, 1045 DiGiulio St., Santa Clara, Calif. **[437]**



Doubly hermetically sealed glass diodes meet MIL-S-19500 specs. The 5-w diode has a 0.085 in. max. body diameter and a 0.155 in. length. The 750-mw unit has a 0.065 in. body diameter and a 0.100 in. length. They range from 2 nsec, 2 pf switching devices to 1,000-v rectifiers, including zeners from 5.5 v up. Micro Semiconductor Corp., Playa Court, Culver City, Calif. **[438]**

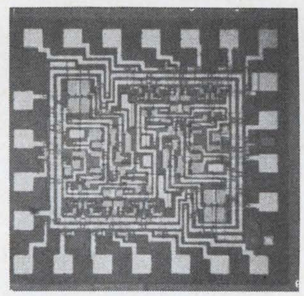


Differential preamplifier model μA727 is a monolithic linear circuit featuring input impedance of 300 megohms over a —55° to +125°C temperature range. Input offset voltage drift is 0.3μ v/°C; input offset current drift, 2 pa/°C; input offset current, 2 na; long term drift, 5 μv/wk. Fairchild Semiconductor, 313 Fairchild Drive, Mtn. View, Calif. 94041. **[439]**

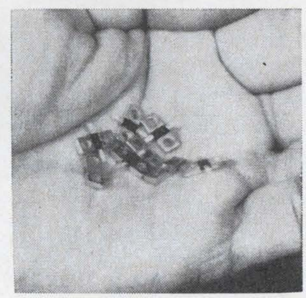


Small signal pnp and npn differential amplifier transistors will track over a wide temperature range with temperature coefficients as low as 3 μv/°C. They offer matched gains to within 3%, voltages up to 120 v, leakage less than 20 pa and low level gains typically 100. They come in TO-78 and TO-71 cases. Solitron Devices Inc., 1177 Blue Heron Blvd., Riviera Beach, Fla. **[440]**

Medium power n-channel junction FET's U221 and U222 are for power amplifiers to 30 Mhz and vhf oscillators to 100 Mhz. High 50-v breakdown permits operation from supply voltages up to 28 v with over 30 db power gain at 30 Mhz. Power output at 100 Mhz is 0.5 w. Units are mounted on high dissipation TO-5 headers. Siliconix Inc., 1140 W. Evelyn Ave., Sunnyvale, Calif. **[441]**



MOS FET JK flip-flop logic circuit element type HRM1306 features AND gates forming the J and K inputs, together with a clocked preset function and a direct reset function. It operates at frequencies ranging from d-c to 500 khz and at power dissipations of less than 30 mw. Price is $21.50 in lots of 1 to 99. Hughes Aircraft Co., 500 Superior Ave., Newport Beach, Calif. **[442]**



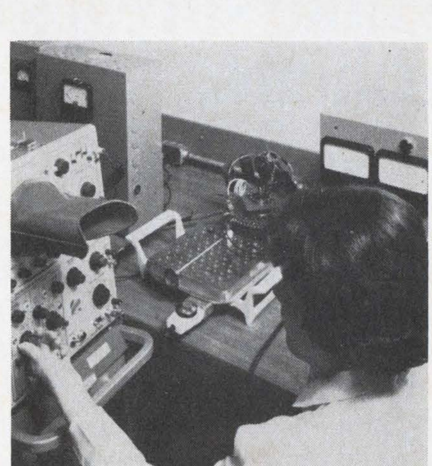
P-i-n diode 5082-3040 can be used as a modulator or switch over a wide range of microwave frequencies—from vhf up to Ku band. It behaves as a smooth section of 50-ohm transmission line when the diode is unbiased or reverse-biased. Insertion loss is typically 0.4 db at X-band; vswr, less than 1.6 up to 18 Ghz. Hewlett-Packard Co., 1501 Page Mill Rd., Palo Alto, Calif. **[443]**

New semiconductors

SCR withstands high currents

Inrush levels of 600 amps per microsecond are handled by a device that uses a regenerative process at its gate

For all the rapid advances made by silicon controlled rectifiers in recent years, there's still one condition they haven't been able to handle—high inrush currents. Present units will burn out if the rate of anode current change (di/dt) goes to more than about 60 amperes per microsecond. Of the various approaches engineers have taken to increase the SCR's capacity in this area, the only one that appears to work is a regenerative technique developed by National Electronics, a division of Varian Associates. The application of this technique



Checking. Operator checks SCR for turn-on characteristics to insure high di/dt.

. . . burnout is related to gate geometry . . .

has led to a device that can handle 600 amps per microsecond.

The burnout of an SCR is directly related to its gate geometry. If a high current is applied to the anode at a time when the gate isn't completely turned on, those portions that are on have to carry the whole load. And if the current is high enough, they are overwhelmed and the SCR goes. The problem can be circumvented by limiting the di/dt so that the gate has enough time to completely turn on, or by using a high drive to turn on the gate in a shorter time. Both of these methods are in common use but they don't really solve the problem; they only avoid it, and at an additional cost in complex and expensive circuitry. The logical solution lies in changing the gate geometry.

Good try. A center-fire gate has been tried but this configuration carries high currents at the initial spot—a high power density that can lead to local burnout. The center-fire gate SCR does, however, almost halve the time between turn-on and full area conduction, an important advantage when operation is limited to 30 to 100 amps per microsecond, particularly at high pulse repetition rates.

In the ring-gate arrangement, the gate area is increased with increased current rating. However, the ring gate turns on at one spot as does the conventional side-fire gate. And because of its large gate area, the device has a lower gate sensitivity than does the side-fire unit, and is thus limited to low-power circuits.

Multiple gates have been tried in an effort to handle inrush currents of more than 100 amps per microsecond. But even here, one gate will always get the first surge of current—and wilt. At a low di/dt level, however, the multiple-gate scheme reduces turn-on losses. And if the multiple gates are on opposite sides of the emitter, the full area turn-on time is nearly half that of the side-fire SCR.

Big boost. What National Electronics calls its Regenerative Gate SCR requires a more complex masking procedure and tighter diffusion control to achieve its capacity of

600 amps per microsecond in a circuit rated at 110 amps rms and 1,000 volts. But it isn't as easy as that, according to Herman Albertine Jr., president of National. "We not only wanted to build a device with a high di/dt, but also one that could use a simple unijunction transistor trigger circuit."

In a regular SCR, Albertine explains, "power is wasted in the form of heat as the gate signal propagates across the chip. We've found a way to channel this power, in the form of current, back to the gate." With this technique, all the triggering signal has to do is start conduction. The Regenerative Gate provides the principal gating function, turning on many additional points and eliminating burnout. And the gate drive is kept low—3 volts at 150 milliamps.

The new SCR's come in two models: the NL-F45, a 55-amp unit with a di/dt of 400 amps per microsecond, is available in eight versions from 200 to 900 volts; the NL-F150, a 110-amp unit with a di/dt of 600 amps per microsecond, has ratings from 200 to 1,000 volts.

The 110-amp units cost from $100 to $289, the 55-amp devices from $90 to $220.

National Electronics Inc., Geneva, Ill. 60134 **[444]**

New semiconductors

Op amp combines squelch and agc

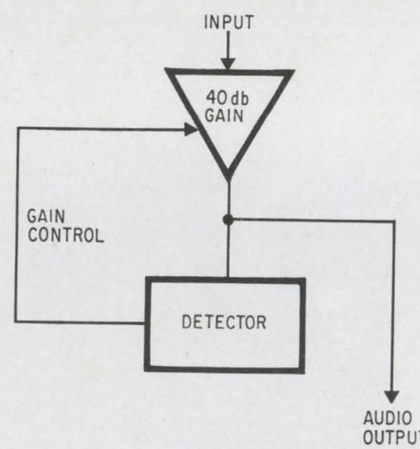
Low-gain device makes talk buttons unnecessary and can replace discretes

Conventional mobile voice-communications systems usually suffer from several disadvantages: the user has to push a button to talk; if he leaves the microphone open between sentences, the person at the other end hears all the buzz and crackle of background noise, and the system doesn't compensate for variations in his voice level.

. . . squelch and agc combined in one package . . .

Some designers attack these problems by squeezing the compensating performance out of available operational amplifiers. But op amps typically can't handle the functions of automatic gain control, which converts varying inputs to a steady output signal, or squelch, which eliminates background noise.

However, Robert A. Hirschfeld of the National Semiconductor Corp. appears to have solved these problems by designing a very low-gain op amp that's the first device on the market to combine squelch and agc functions in a monolithic integrated circuit.



AGC CIRCUIT

Level road. The automatic gain control section of the LM 170 can be used in both the transmitting and receiving modes. It reduces overload, cutting distortion.

The LM 170 audio squelch/agc amplifier is made in a conventional six-mask process, says Hirschfeld, an alumnus of the Amelco Semiconductor division of Teledyne Inc. [Electronics, Dec. 11, 1967, p. 10]. But, into a 39-by-42-mil chip he's crammed 21 resistors and 31 transistors for his agc and squelch circuits.

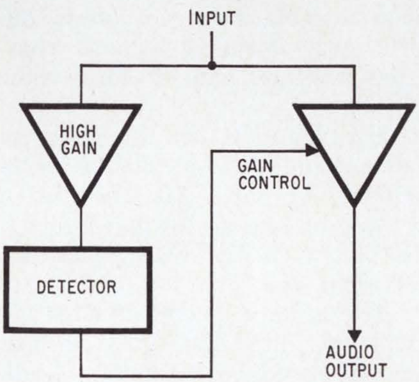
Borrowed circuit. Designed for airborne and mobile communications markets, the LM 170 goes "on" only when the user speaks, thus eliminating background noise and making the talk button unnecessary. Since the device can replace about 10 transistors and associated circuitry, it could fit into

. . . small size for telephones . . .

a headset, giving pilots and policemen greater flexibility.

Potentially, it could be the amplifier for telephone communications equipment when the cost comes down, says E. Floyd Kvamme, microcircuits product manager. He adds that this is the first of a series of National products in the communications area.

Among the LM 170 features are: large gain control range of 80 db; less than 1% distortion throughout the gain control range; 18 milliwatts power dissipation from a 4.5-volt supply, and a sensitive squelch threshold that can be set by a



SQUELCH DETECTOR

Quiet. The squelch detector shuts off the audio input when talking stops, in both the transmitting and receiving modes.

single external resistor. The device can be used with any power supply between 4.5 and plus 24 volts. Most mobile radio sets use plus 6 or 12.

Hirschfeld borrowed the input circuit from coworker Robert J. Widlar's LM 101 op amp to give his chip a wide range of inputs. "You can really abuse it without any damage because of the high-voltage lateral pnp transistors in the input circuit," he says. The maximum input without distortion is 50 millivolts.

With its internal agc circuit, the LM 170 is constantly compensating itself, he says. The circuit allows for automatic or remote gain control reducing the effects of attenuation and noise pick-up. The voltage gain of the direct-coupled device is controlled by an external d-c voltage so the user can set the

. . . op amp monitors sound . . .

circuit level he wants. Agc also improves a network because it doesn't overload the transmitter. The maximum gain of the amplifier with a 12-volt power supply is 40 db. The maximum undistorted output is 5 volts peak-to-peak.

Extra pins. To achieve his voice-activated squelch amplifier, Hirschfeld devised an on-off voice switch like a digital circuit. A high-gain, sensitive amp monitors all incoming sounds, including background crackle, for a detector. When the detector hears a voice frequency it turns on the squelch amplifier. The fast-attack/slow-release circuit turns on quickly for talking but waits a split second after the last syllable before it shuts off. This way it isn't constantly shutting itself on and off for a slow speaker.

The LM 170 can be used as either agc or squelch or both, Hirschfeld says. "It cost us a couple of pins to do it. We use a 10-pin [TO-5 can] package instead of eight pins."

The military-specification LM 170 will sell for $12.95 each in lots of 100. A reduced-temperature military unit, the LM 270, will sell for $4.95. Later, a consumer unit, the LM 370, will be available at $2.95.

National Semiconductor Corp., Santa Clara, Calif. 95051 **[445]**

New semiconductors

Frequency divider is low-cost MOS

Device designed primarily for musical instruments can also count events

Under the direction of Carroll Perkins, manager of MOS marketing applications, the Hughes Aircraft Co.'s Semiconductor division has developed a low-cost MOS frequency divider, the HRM F/2, for use in electronic organs and other musical instruments.

The device is an integrated FET circuit packaged in a four-leaded metal TO-72 can. Signals with greater than a 5-volt swing, in the frequency range from d-c to 500 kilohertz, are divided by two, producing half-tones at the output terminals.

Staying still. The MOS devices' negative temperature coefficients eliminate the problem of thermal runaway, Perkins says. He believes the component will be able to compete with bipolars on the commercial market.

The HRM F/2—when used as a low-frequency signal source—is linked to a master RC oscillator. The oscillator produces the highest fundamental frequency, and several dividers are used for building a "chain" to bring the frequency down in stages. Because the divider is a compact MOS binary element fabricated on a silicon chip .027 by .030 mils, Perkins thinks it should be attractive to makers of musical instruments.

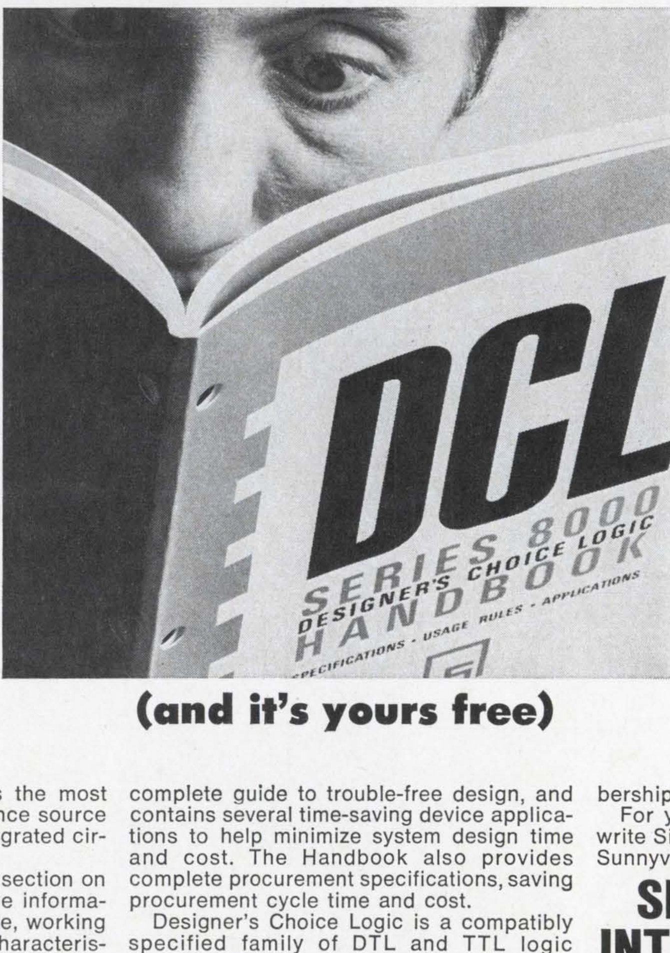
Other applications include doorbell buzzers—producing one tone at the front and a different tone at the rear—and multistage events counters. The primary market, however, will be in musical instruments, and Perkins foresees sales of 2 million devices annually.

Lower voltages. Compared with MOS counters developed by the General Electric Co., Motorola Inc., and the Philco-Ford Corp., Perkins says, the HRM F/2 has an edge: Hughes' 2-volt threshold technology enables counters to be built for operation at lower voltages. "Our device is a single monolithic circuit chip packaged in a discrete-component header to keep the cost down," he explains. "With only four leads, it's easier to test them comparable 14-leaded devices, and less expensive to replace. If the divider fails, you're replacing a 35-cent item. If somebody else's seven-stage counter fails, you have to replace all the stages at maybe 10 times the cost."

Hughes expects to go to epoxy encapsulation within three months. Prices range from 35 cents apiece in quantities of a million or more to 85 cents in quantities up to 99.

Hughes Aircraft Co., Semiconductor Division, 500 Superior Ave., Newport Beach, Calif. **[446]**

Hard-nosed soft-ware



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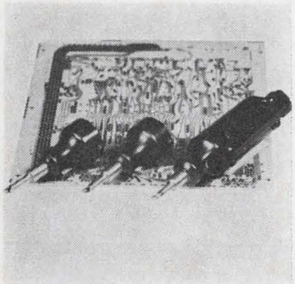
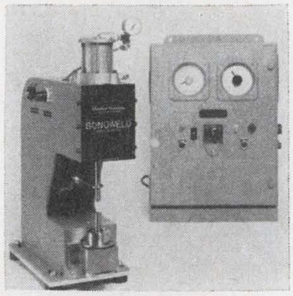
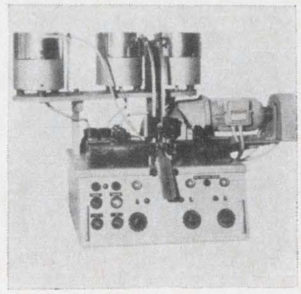


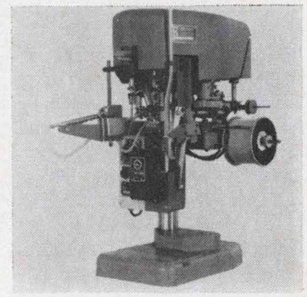
Air operated cut and bend tool BP-1 Bend Eze features interchangeable heads, which meet the circuit board at either 20, 30, or 45°. The quill has a max. o-d of 3/16 in. diameter. The tool will take an existing component wire, cut it off, and lay it flat to the circuit board to military specifications. Price is $99.50. Henry Mann Co., Box 37, Cornwells Heights, Pa. 19020. **[421]**



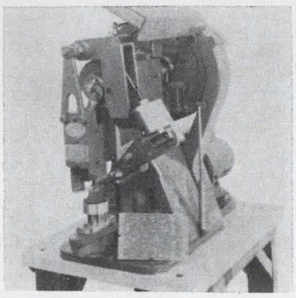
Intermediate-range ultrasonic welder W-150-AW is designed to meet thin metal joining requirements as found in the capacitor industry. Aluminum and tantalum foils are joined to respective tabs with bar-type welds quickly and easily. No external heat is introduced in the process, which eliminates oxide formation. Sonobond Corp., 310 E. Rosedale Ave., West Chester, Pa. **[422]**



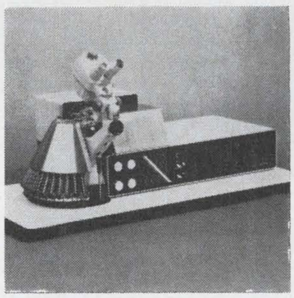
Automatic machine type 6.10, for the capping of cylindrical bodies used in the manufacture of resistors, will apply caps at both ends at speeds up to 5,500 units per hr. The caps and bodies are simultaneously fed from vibratory bowl feeders to a position where caps are applied. Capping pressure is easily adjustable. B. Freudenberg Inc., 50 Rockefeller Plaza, New York. **[423]**



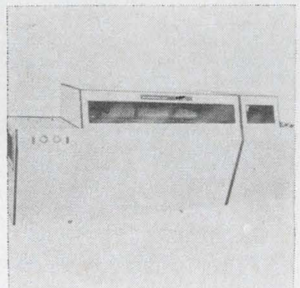
Coil-winding machine BV4-G is a carousel-type unit designed to wind electrical coils without forms at production rates from 160 to 1,920 coils per hr depending on coil design and size. Lead ends are automatically tinned. Low voltage electric heat is applied to the rotating tinning bath with electronic temperature control. Leesona Corp., 131 West St., Danbury, Conn. 06810. **[424]**



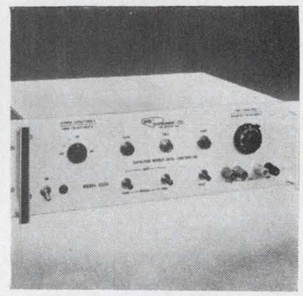
Automatic machine NRGM-CT inserts eyelets as small as 0.020 in. i-d in p-c boards. It features a carrier type raceway that eliminates eyelet feeding problems. It can feed and set all types of eyelets—funnel, flat and roll flange. Design of the machine provides for changing from one eyelet size to another within minutes. Edward Segal Inc., 132 Lafayette St., New York. **[425]**



Automatic die classifier 2907 tests devices ranging from 0.020 to 0.125 in., round or square, at the rate of 3600 per hr. It features a vacuum feed device which deposits the devices gently in the test position. Vacuum is generated internally and controlled by valves to prevent them from sticking or scattering. Hughes Aircraft Co., 500 Superior Ave., Newport Beach, Calif. **[426]**



Remote operated conveyorized chemical etching system, designated Dynamil 707, etches p-c boards and chem-milled parts ranging in size from 6 x 6 in. to 30 in. x indefinite length. A wall-mounting control unit contains a variable-speed controller for regulating conveyor speed from 0 to over 2,400 ft/hr. Western Technology Inc., 220 W. Central Ave., Santa Anna, Calif. **[427]**

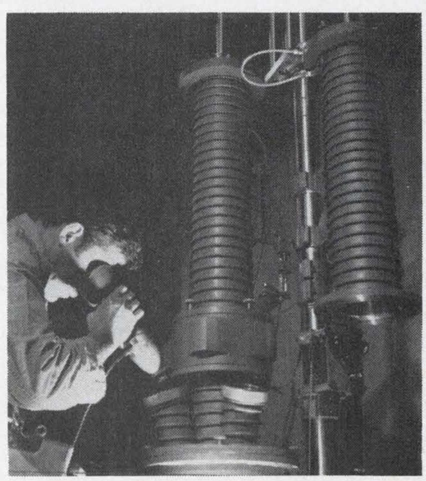


Capacitor winder auto-controller model 5332 provides continuous monitoring and control of final capacitor value during the manufacturing process. It is suited to high volume production of close tolerance metalized film or metal foil capacitors. Test frequency is 60 hz. Price is $1,680; delivery, stock to 4 weeks. Micro Instrument Co., 12901 Crenshaw Blvd., Hawthorne, Calif. **[428]**

New production equipment

System grows 50,000-chip crystals

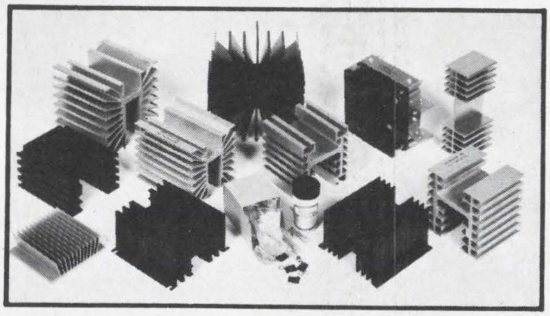
Double-chamber design allows more than one crystal to be grown from a single melt and cuts setup time



Eyeful. Crystal structure is checked in one of the two chambers.

Crystals don't grow on trees; they grow at the end of a rotating shaft in an oven. The Vacuum Equipment division of the Norton Co. has been making crystal-growing systems for the past few years. Its newest unit, the NRC 2808, makes a crystal that's twice the size of the one grown in the company's current model. And Norton says the double-chamber setup of the 2808, combined with the increased size of the crystal, could increase output about 80%.

Like older Norton machines, the 2808 uses the Czochralski method



... temperature of melt's surface held to ±0.5°C ...

to grow crystals. Material in a crucible is brought to the molten state in a resistance-heated furnace. A small crystal, called the seed and located at the end of a rotating shaft, is lowered through a sealed chamber and into the furnace until it touches the melt. Then the shaft is slowly withdrawn, and material from the crucible crystallizes on the seed's surface.

The diameter and length of the grown crystal depend on the rate of shaft rotation and withdrawal and the temperature of the melt. The 2808 can grow a 2800-gram semiconductor crystal with a 3-inch diameter that can be cut into 50,000 chips.

Hot surface. One problem faced by Norton engineers was controlling temperature in the 2808's furnace. To make the control systems more sensitive, they replaced the old power supply, a saturable core reactor, with a silicon-controlled rectifier unit. The new supply operates from a 480-volt, single-phase, 60-cycle supply line, and contains an SCR power pack and a 30 kilovolt-ampere transformer with a 50-volt secondary.

The desired temperature of the melt's surface is set by an operator and kept at this level by a feedback loop. An optical pyrometer measures the surface temperature and signals a Leeds and Northrup control system that adjusts the output of the power supply. This alters the current in the resistance heater. The temperature is held to within ±0.5°C.

With the two chambers, more than one crystal can be pulled from the same melt, and one chamber can be cleaned and set up for the next run while the other is being used. The company says the double chamber is unique.

Taking turns. When two crystals are to be pulled from the same melt, the first is grown, then an isolation valve between the furnace and the chamber with the grown crystal is closed, completely sealing the furnace. The used chamber is then swung away from the furnace, and the other chamber is moved into position. The valve is

. . . silicon or germanium crystals can be grown . . .

opened, connecting the second chamber to the furnace, and another crystal is grown. The melt is never exposed to the atmosphere.

Norton also says it's first with a built-in programmer that adjusts temperature during the growth process. It's important that surface temperature be constant at any given moment, but this optimal temperature changes during the growth process. If the system has the optional programmer, it's not necessary for an operator to be constantly watching the crystal and making adjustments.

In the 2808, crystals can be made from any material that responds to the Czochralski method at temperatures less than 1600°C and gauge pressures less than 9 pounds per square inch. Silicon, germanium, and many intermetallic compounds fall into this category.

The 2808 costs $26,000; delivery time is 16 weeks.

Specifications

Seed rotation	4.8 to 67 rpm
Seed drive	0.3 to 8.2 in/hr
Crucible rotation	1.7 to 22 rpm
Crucible drive	0.1 to 1.6 in/hr
Furnace diameter	11 in
Furnace length	17.5 in
Crucible diameter	5 in
Crucible length	5 in

Norton Co., Vacuum Equipment Division, Newton, Mass. 01355 **[429]**

New production equipment

Chip capacitors tested automatically

Anglo-German system measures capacitance of up to 5,000 chips an hour

The recent rise in demand for chip capacitors comes as good news to the Advanced Technology & Systems Corp. The firm doesn't make the chips itself, but it has acquired U.S. sales rights on the ACT/APT, a system that automatically tests

. . . chips are fed to bed from bowl or magazine . . .

and sorts them.

The electronic part of the system comes from British Physical Laboratories, Radlett, England, and the mechanical handling equipment from E.B.S. of Olching, West Germany. BPL calls the ACT/APT the first automatic system of this type to be made commercially available in the U.S., although some chip-capacitor makers have built automatic rigs for themselves.

New ballgame. Advanced Technology notes that automatic systems weren't needed until recently; when sales were small, chip-capacitor makers were satisfied with manual testing. But the increasing popularity of microcircuits has changed all that, according to the firm.

The ACT/APT contains two separate test instruments, one to measure capacitance—and, as an option, dissipation factor—the other to measure insulation resistance (IR) and to test for breakdown (hipotting).

Chips are either bowl- or magazine-fed to a perforated test bed, and are moved from station to station by a plastic comb-shaped device. The capacitors are held in place by a slight suction that's maintained during their movement from one station to another.

Squaresville. The rectangular chips are aligned when they come out of the magazine or bowl. There's no orientation problem unless they're square; if they are square, there are four possible orientations, two of which produce a short-circuit indication during the test. The first test made on the chips, therefore, is a short-circuit test, and improperly oriented chips are removed right away.

The copper contacts are plated with silver and over-plated with rhodium. Each pair is close enough to the next so there is always a test voltage across the chips. According to BPL, sudden voltage changes during tests affect the accuracy of the results.

Categorizing. At the first test instrument, the chips are sorted into six bins—one for opens and shorts, one each for the three preset tolerance classifications, and

. . . capacitance is measured away from high voltage . . .

one each for highs and lows. If the dissipation factor is measured, there's a seventh bin for the capacitors that fail.

At the second instrument, the chips pass through 12 stations. Initial hi-pot failures are binned at the second station and IR failures at the 10th; final hi-pot failures are culled at the 12th station.

Two separate test instruments are used because the chips may be sensitive to voltage gradients. Capacitance is therefore measured away from the area where high-voltage tests are performed.

So wide. The ACT/APT system handles chips of any width and depth, and of lengths between 2 and 10 millimeters. The measurement range is from 15 picofarads to 10 microfarads, and tests are made at either 1 or 100 kilohertz. The three tolerance ranges can be set anywhere from ±0.25% to ±50%, resolution is 200 parts per million, and drift over an eight-hour period is within ±2%.

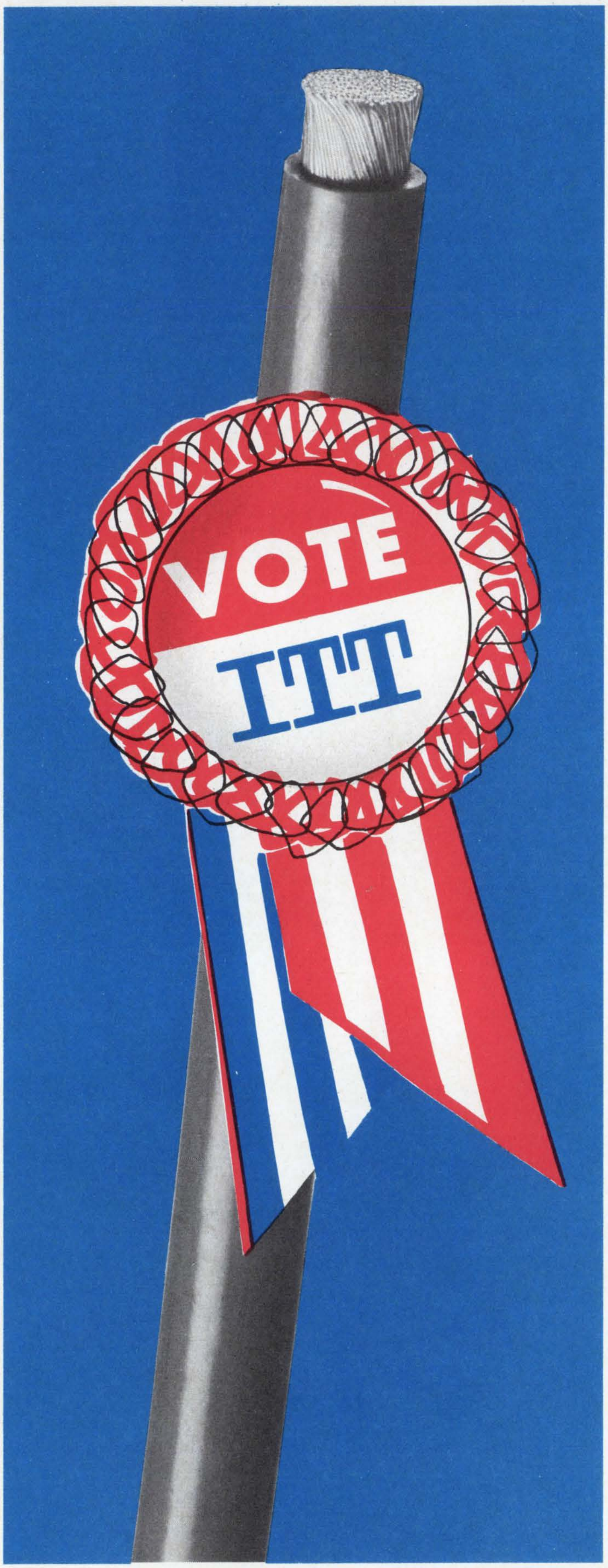
Insulation resistances from 1 to 50,000 megohms can be measured with ±5% accuracy, and the voltage for both this test and the hi-potting is continuously adjustable between 10 and 500 volts d-c.

Speeds. The instrument that measures the capacitance will test 5,000 chips an hour, and the hi-pot and IR tester can handle 2,000 an hour. Either instrument can be used by itself.

The mechanical part of the system is 2 by 1½ by 1½ feet, and the electronic equipment is 2 by 2 by 5 feet; the whole thing weighs 325 pounds.

The least-expensive model, a magazine-fed unit priced at $4,600, measures only capacitance and at just one frequency. A $10,000 machine measures capacitances at 1 or 100 Khz, depending on a switch setting. It performs both hi-potting and IR tests, and can be either bowl- or magazine-loaded. The dissipation-factor option costs $1,-750. Delivery time is up to three months.

Advanced Technology & Systems Corp., 199 Sound Beach Ave., Old Greenwich, Conn. 06870 **[430]**



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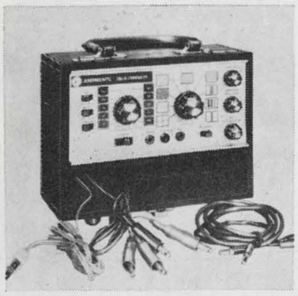
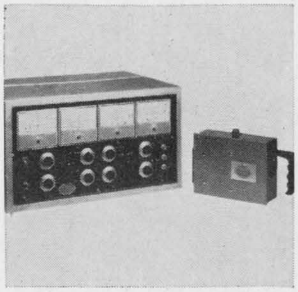
WIRE AND CABLE ITT

New Consumer Electronics Review

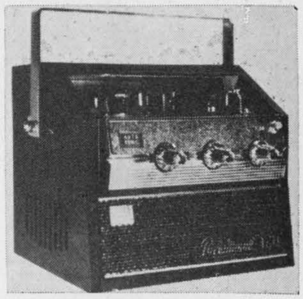


Tv alignment generator model 865 is capable of generating the familiar 10-bar gated rainbow, plus new single-bar and 3-bar test patterns. It provides a total of 9 patterns. The unit measures 4-7/8 x 9½ x 5¼ in., weighs under 4 lbs. Featuring all transistorized circuitry, it is priced at $189.95 less batteries. Amphenol Corp., 2875 S. 25th Ave., Broadview, Ill. 60153. [401]

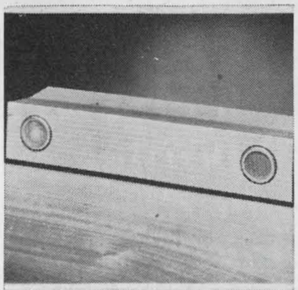
Lead-acid Eveready rechargeable batteries can be utilized with portable tv and radio sets, outdoor appliances, camp lighting and fluorescents, sailboat power packs and for emergency standby power. Current models include capacity ranges up to 8 ampere hours. They are priced between the nickel-cadmium and alkaline types. Union Carbide Corp., 270 Park Ave., N.Y. 10017. [402]



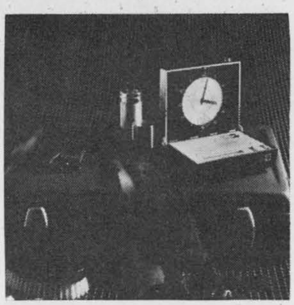
Mark II Colorgard meter will meet the requirements of color tv receiver manufacturers for quality control check on kinescopes and for setting color temperature and gray scale of color receivers on the production line. The instrument is not calibrated in color temperature values but in arbitrary R-G-B values. Television Zoomar Co., 870 High Ridge Rd., Stamford, Conn. 06905. [403]



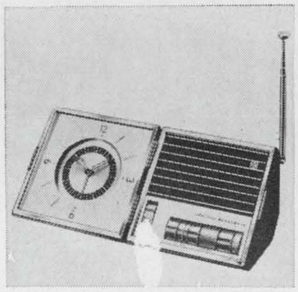
The Portamount ST-120G stereo tape player can be plugged into the cigarette lighter socket of a car or any 110 v wall outlet. With the rechargeable battery pack RB-123, it is ready for use anywhere else. The unit has self-contained stereo speakers and controls for tone, separation, loudness and program selection. SJB Inc., 2339 S. Cotner Ave., Los Angeles. [404]



Ultrasonic intrusion alarm model A-1 is for use in homes, apartments, offices and commercial establishments. The alarm responds to any moving object within its 20- to 30-ft range. Two sockets are provided at the rear, for connection of external lamps and bells. Suggested list price is $97.50. Euphonics Marketing, 202 Park St., Miami Springs, Fla. 33100. [405]



The Weekender model RZS43 is an f-m/a-m travel clock radio in a case scarcely larger than an electric shaver kit. The two-band radio, contained in the base of the case, operates on its own 9-v battery, while the coordinated clock, with a long-life mercury cell power supply is in the tilt-up lid. Suggested retail listing is $45. RCA, 30 Rockefeller Plaza, New York 10020. [406]



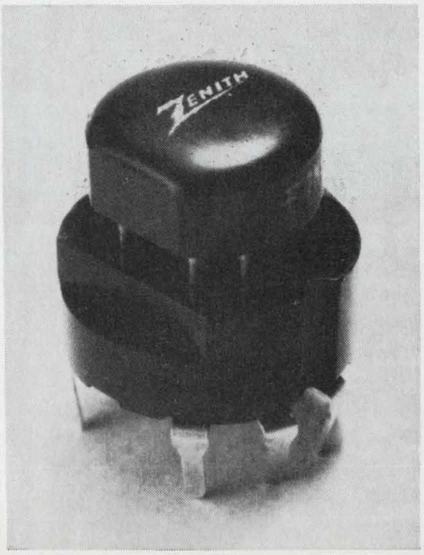
The Trafford RC-7878 is a portable clock radio with its own detachable clock. The clock is self powered by a long life mercury battery, and operates independently of the radio. When combined with the radio, it awakes by either a buzzer alarm, or preset radio station. The radio is powered by a 9-v battery. Matsushita Electric Corp. of America, 200 Park Ave., N.Y. 10017. [407]

A-c stereo cassette player deck model 2500 is for use with an existing hi-fi system. Prerecorded cassettes snap into place ready for playback. The transistorized deck has a frequency response of 60 to 10,000 hz, and may also be used in conjunction with a mono amplifier and speaker or a radio. Price is under $60. North American Philips Co., 100 E. 42nd St., N.Y. 10017. [408]

New consumer electronics

Color-tv demodulator goes IC

Circuit replaces center-tapped coils with double-balanced network



Across the country last year, one of every five owners of color television sets wrote a nasty letter to a manufacturer to complain about poor color registration and the difficulty and expense of correcting color deficiencies. Manufacturers, however, weren't entirely to blame; poor set performance could often be attributed to tv servicemen ignorant of the complexities of color sets [Electronics, Nov. 27, 1967, p. 127].

Naturally, manufacturers have hoped to build sets that would somehow resist the worst efforts of

. . . one package for less trouble . . .

unscrupulous or ill-trained repairmen.

One of the first nonsolid state sets to move toward this goal will come from the Zenith Radio Corp. Zenith sets available this fall will use a monolithic integrated circuit instead of a vacuum-tube circuit as the color signal demodulator. The new demodulator is built by the Semiconductor division of the Fairchild Camera & Instrument Corp.

IC's have often been advanced by set designers as a possible way to overcome some of the operational and adjustment difficulties of color sets. They feel that putting more components in one package means there is less for the serviceman to deal with. And closer matching can be achieved in critical circuits by eliminating individual component tolerances.

Joint effort. Last year, engineers from Zenith and from Fairchild Semiconductor were simultaneously working on an IC to improve color stability and registration; neither firm was aware of the other's work. An added advantage of the circuit, it was thought, would be the elimination of a multitude of electronics that overeager servicemen had tampered with.

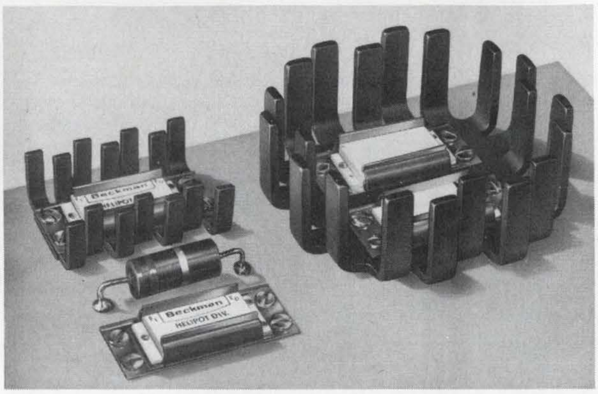
When the two companies discovered the similarity of their work, they decided to make the circuit a joint project. The result of their research is a new Fairchild IC color signal demodulator.

The μA737 chroma demodulator will be announced June 17 at Chicago IEEE Spring Conference on broadcast and television receivers; Fairchild will offer the circuit for sale to other manufacturers then.

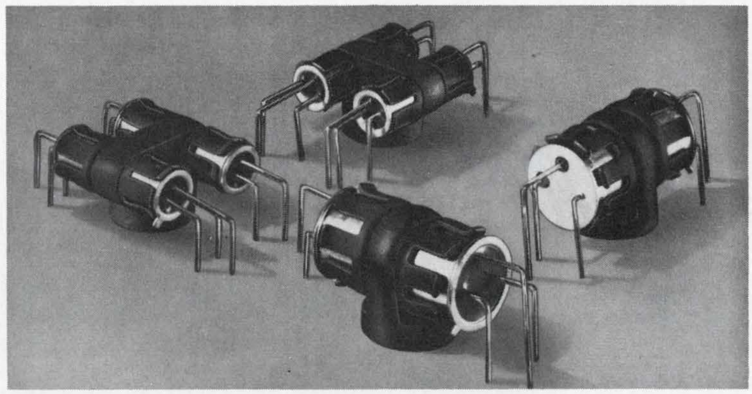
Engineers from both companies say that the use of double-balanced detectors in the new IC will substantially reduce long-term drift in color sets. These detectors, balanced both to reference and chroma signals, are extremely sensitive to both phase and amplitude of the chroma signal. (In the NTSC code, phase and amplitude of the chroma signal carry hue and saturation information, respectively.) The detectors feed a decoder matrix in which desired color-difference sig-

Tips on cooling off hot semiconductors and microcircuits

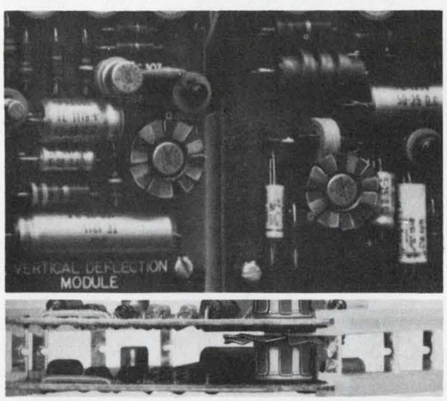
Read on. Find out how circuit designers use IERC heat dissipators to protect and improve circuit performance of semiconductors and microcircuits.



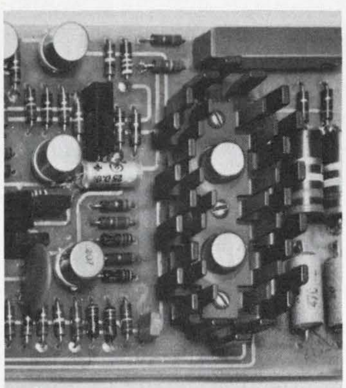
Cool off microcircuit devices with a choice of four new dissipator/retainers. Example: with natural convection, a typical microcircuit device dissipates 1.8 watts with case temperature rise of 103°C. Add IERC's model LBOC2-61B and retainer and you dissipate 5 watts with the same case temperature rise. Retainer-clip may also be used alone to mount package to conduction plane.



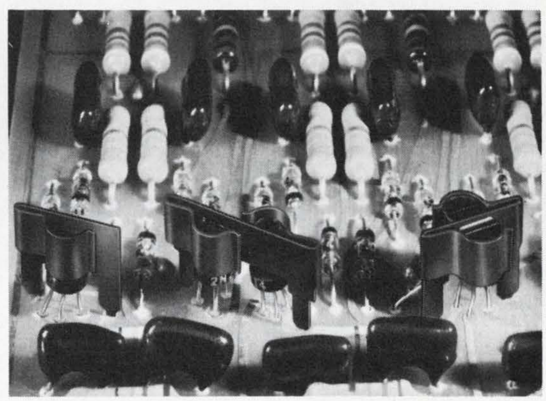
These special dual and quad Therma-Link dissipators permit thermal mating of matched transistors. Therma-Link retainers do exactly as their name says: They provide a thermal link between transistors and the chassis or heat sinks. They are also available with beryllium oxide washers which have the excellent thermal conductivity of aluminum, are electrically insulative and reduce normal mounting capacitance by ½ to ⅓. The washer is brazed to a brass slug or hex stud for mounting.



Fan Top Dissipators for TO-5 and TO-18 cases add almost nothing to board height. Don't need much room *on* the board either. Available for both metal and plastic cases. Spring fingers make installation simple. And Fan Tops cost just pennies.



Help low-to-medium power transistors keep their cool with IERC's stagger-fingered LP's. Available in single or dual mounting for thermal mating of matched transistors. They fit both TO-5 and TO-18 cases.



New "Universal" Spade Series for plastic transistors fits all D-case sizes. Spring clip allows for variation in case diameters. Excellent dissipation lets you boost operating power 33%. Both single and dual models as shown. IERC has heat dissipators for all popular epoxy and ceramic semiconductors.

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. . . temperature won't affect color . . .

nals are developed.

No degradation. Vacuum-tube demodulators haven't been effectively double-balanced, because of the difficulty of establishing a true balance in the passive elements (center-tapped coils, resistors and capacitors) in the critical parts of the circuit and the complexity introduced by the active devices.

"We have relied on the precision component matching achieved through IC technology," says Jack Gifford, Fairchild's linear circuit marketing manager. The result, he adds, will be that Zenith sets made with this circuit won't have color degradation, which stems from the changes in amplitude and phase relationships that characterize present color sets.

These changes, explains Gifford, have a variety of causes. A sudden temperature change, replacement of a tube, or the incorrect replacement of a resistor in the standard color matrix can alter phase and amplitude vectors. But with the new circuit, color integrity will be consistent from set to set and will be consistent over time.

If faults are found in the demodulator circuits of current sets, the serviceman usually removes components that could be to blame. After this time-consuming process, and if the culprit is found, a great deal of fiddling with the tuned coils to get the rest of the circuit back in order is almost always necessary. But now the serviceman need only replace the demodulator.

To simplify this task as much as possible, Fairchild and Zenith designed the μA737 to plug into a standard nine-pin minature tube socket; the leads, however, are plated to accept solder for mounting directly on a circuit board.

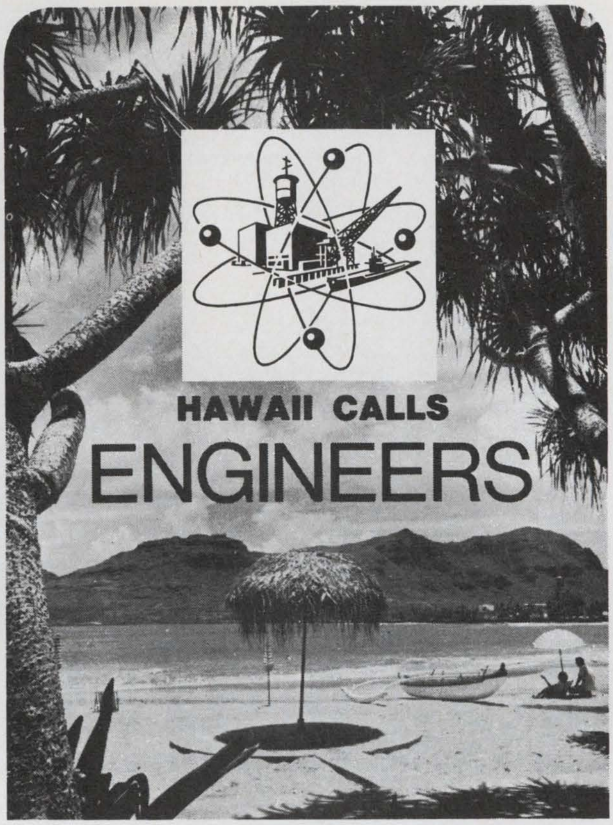
Specifications

Supply voltage	+28 v
Load resistance, min.	3 kohm
Reference input, p-p	+5 v
Chroma input, p-p	+5 v
Power dissipation	450 mw
Operating temperature range	0 to 70°C
Storage temperature range	−55 to +125°C
Lead temperature, 10 sec soldering	+260°C

Fairchild Camera & Instrument Corp., Semiconductor division, Mountain View, Calif. 94040 **[409]**

 Circle 224 on reader service card

Circle 285 on reader service card



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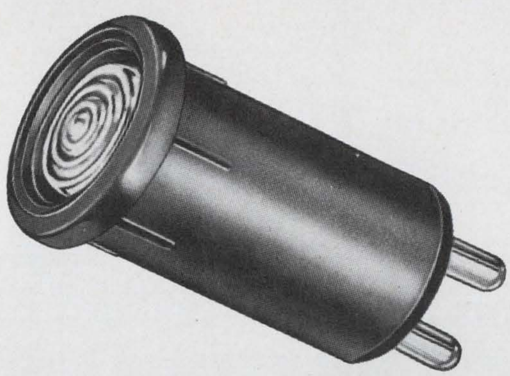
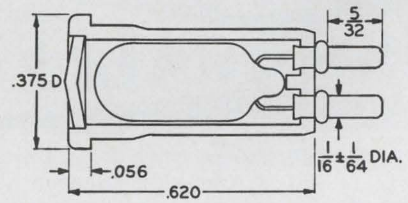
New, press-in indicator light





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Long-life incandescent T 1¾ bulb rated 750 to 20,000 hours or more, depending on bulb and applied voltage. Available for operating voltages of 4-6, 10-14, and 22-28 volts. Durable polycarbonate lens in clear, red, green, amber, blue or nontransparent opal. Housing is of tough molded polyamide, color black.

Terminals are 1/16″ dia. intended for solder connection or to accept mating receptacles such as AMP #61064-1 or similar types. Insulated sleeving is recommended for receptacle ends.

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Circle 226 on reader service card

New Books

Where, not how

Sourcebook of Electronic Circuits
John Markus
McGraw-Hill Book Co.
888 pp., $18.50

For the engineer who needs to find a specific circuit or circuit type quickly, this collection of more than 3,000 diagrams should be a handy reference. But a word of warning: it won't tell him how the circuit works. To know that he has to go to the original source, referenced in each case by book or by magazine volume and page.

Arranged alphabetically by categories, the circuits are each accompanied by a brief description of design purpose and, in most cases, their advantages are pointed out. Although engineers won't be able to actually design the circuit by looking at the diagrams, they can pick up some general information about design configurations and typical component values.

Timely text

Display Systems Engineering
H.R. Lukenberg and Rudolph L. Kuehn
McGraw-Hill Book Co.
444 pp., $16.50

As time-shared computer services continue to increase, the number of peripheral units installed in many types of organizations around the country also continues to grow. In particular, there's been a boom in the display-unit market, and a new technology is rapidly developing to back it up. This timely book covers the physics and electronics of this technology, presenting the latest information clearly and comprehensively.

There are many things to recommend it—for example, its very frank discussion of lasers. For a change, the very formidable limitations of holography and other laser applications are detailed. This makes the reader feel that those laser applications covered might well be worth pursuing.

There's also a very helpful section on military-type displays. These accounted for the first significant chunk of the market, and—because they were developed for sophisticated needs requiring real-time color operation, for example—they were quite expensive. Today's mass market demands something far less expensive, but nonetheless this section of the book gives the reader a feel for the state of the art of all displays and contains valuable physiological and optical background information.

But there are also weaknesses. For instance, it's not pointed out that "tv lines" and "lines" can't be used interchangeably when there are few of them. As working engineers know, 525 tv lines doesn't mean a resolution of 525 lines, because 40 tv lines are lost in retracing. In addition, the Kell effect reduces the effective resolution to about 340 lines or 170 line pairs.

Unfortunately, the first chapter is often confusing and may discourage the reader. In a diagram of a typical communications system, terms aren't defined and arrow directions are inconsistent, leaving the reader to figure out whether feedback or direct flow is indicated at one point. Checking the reference to this diagram didn't help, either.

Later in the book, "light output" is used without any units, thereby encouraging the usual confusion between "brightness" and "luminance." The distinction is important because subjective brightness of a display screen—viewed from a distance—increases directly with power. Luminance goes up much faster, because as high voltage increases on a cathode-ray tube, spot size decreases and current increases, accounting for the heightened brightness per unit area. Thus, subjective brightness is important to viewers, while luminance is important in taking photographs of the screen.

Then, in discussing phosphor time constants, the book doesn't point out that most phosphors have more than one and don't decay exponentially. And in two otherwise excellent tables, phosphor life, a very important characteristic, isn't mentioned. Although many designers use long-persistence phosphors, and even operate tubes at relatively low beam power levels, they find that their tubes die earlier than those with P31, because of efficiency loss.

Perhaps the single greatest oversight in the book is the omission of the use of storage crt's for computer remote terminals. This is surprising, because there are now hundreds of direct-view bistable storage tubes in computer display service, and the literature references date back several years.

On the other hand, while there

New Books

probably aren't working displays anywhere that use Aiken tubes, the book devotes a half-page to these devices. It also mentions the three-color storage tube, another device that isn't useful for displays.

Nevertheless, the book is basically well done—the references are excellent, for example, and convenient tables are provided throughout —and its problems are common to texts covering new technologies that embrace several fields.

C. Norman Winningstad
Tektronix Inc.
Beaverton, Ore.

Nitty gritty

Modern Electronic Circuit Design
James D. Long
McGraw-Hill Book Co.
286 pp., $12.50

Circuit theory books are usually written for analysts. This one is unusual because it's aimed at the people who actually design circuits; the emphasis is on the special requirements of the working circuit designer. All concepts and equations are developed for the reader so he can apply them readily to familiar design problems. The author illustrates his points by solving 10 common design problems.

The problems at the end of each chapter can be solved without extensive algebraic manipulations. When a problem has more than one solution, several typical ones are given.

Recently published

Topics in the Theory of Random Noise: Volume II, R.L. Stratonovich, Gordon and Breach Science Publishers Inc., 329 pp., $17.50

Deals with noise in relays and oscillators, topics that involve nonlinear transformations of random functions and also covers relationship between the theories of correlation and Markov processes. Intended mainly for specialists in the field of statistical radio engineering.

Correlation Techniques, F.H. Lange D. Van Nostrand Co. Inc., 464 pp., $13.50

Comprehensive survey of theoretical foundations and practical applications of correlation analysis with emphasis on the latter. Shows how correlation analysis can be used to characterize signal sources, transmission systems, and receivers.

The shape of things

Digital control system accuracy improvement using nonuniform quantization
Rodney Edwards and John Durkin
University of Manchester Institute of Science and Technology
England

The use of a digital computer for process-control loop compensation entails the sampling of analog input signals and their subsequent conversion to digital form. That is, the digital system quantizes in time and amplitude. Both types of quantization reduce the control system's accuracy.

Amplitude quantization increases steady-state control error because the continuous input signal is changed to a staircase-like relationship between input and output. The difference between the true continuous signal and its staircase value at a given input is the quantization error. After the quantized analog signal is converted to its equivalent digital word, arithmetic manipulations in the computer result in an additional error because the words are rounded off.

Conventional quantization uses uniform increments of the independent variable. Accordingly, the conversion of large-amplitude signals uses most of the quantization levels and results in small relative errors. However, for small signals only the first few levels are used, so that errors are relatively large. Thus, uniform quantization isn't best for system control, because large transient errors can be corrected well with coarse quantization, while small errors need fine quantization.

One way around this problem is to use nonuniform quantization, which compresses the signal before uniform quantization and expands it afterward. Three methods of shaping, adapted from work in pulse-code modulation of speech, are hyperbolic, logarithmic, and log-linear quantization. The last consists of a true logarithmic shape smoothly joined to a linear segment at low levels.

Of the three methods, log-linear quantization has the lowest root-mean-square (RMS) error. Specifically, the log-linear quantization method reduces the steady-state RMS error, as compared with uniform quantization, by

$$\frac{A}{1 + \log A}$$

where A is the compression factor. When A equals 1, the formula represents uniform quantization. Generally, for nonuniform quantization the value may be several thousand.

For one loop, with dead time, controlled by a digital system using nonuniform quantization, the compression value was 1,380. This means the accuracy of the steady-state control system was improved 167 times by nonuniform quantization. This is equivalent to seven conversion bits over a wide range of converter bit capacity.

Presented at the Pulse Symposium of the International Federation of Automatic Control, Budapest, April 8-11.

Disappearing act

Laser trimming of thin film resistors
B.A. Unger and M.I. Cohen
Bell Telephone Laboratories
Murray Hill, N.J.

A laser beam, focused to a very fine and intense spot, can "machine" the metal from a thin-film circuit in a prescribed pattern. This noncontact process, used specifically to trim tantalum nitride thin-film resistors to precise values, applies to other types of resistive films as well. It can be used in almost any order of circuit fabrication.

A continuously pumped yttrium-aluminum-garnet (YAG) laser, the machining tool, can be operated continuously with nominal 1 watt power output. Or it can be switched to provide a continuous train of pulses with a nominal peak power of 1 kilowatt, average power of 100 milliwatts, and pulse duration of 200 nanoseconds—when the repetition rate is 400 hertz.

This is more than enough power to vaporize a 1-mil diameter spot of tantalum film that is 3,000-angstroms thick.

The YAG trims resistors by machining at the edges, by thermal oxidation, or by vaporizing small spots in the interior of the resistor. This last method changes the resistance with a minimum effect on capacitance and inductance and also maintains the full geometry for good heat dissipation. Spots from 0.1 mil to over 1 mil in diameter were vaporized in tantalum resistors with minimum damage to the substrate. A rectilinear array of spots provided changes in values of over 20% with trimming tolerances for some cases as good as ±0.01%. An aging characteristic—up to 2% change— has been observed immediately following laser trimming.

Resistor trimming by shaping the geometry with the laser beam—another method—can increase the resistance value by 3 to 10 times, and is suited for gross changes in resistance.

Oxidation of the tantalum film by laser heat—the third technique—may be used by itself as a trimming technique, or combined with the laser machining methods. An experiment that combined hole vaporization and laser heat treatment showed encouraging results with regard to the precision of value and to the stability of characteristics.

Presented at the IEEE-EIA 1968 Electronics Components Conference, May 8-10, Washington.

Opening the window

Ceramic piezoelectric wide-bandpass filter with elliptical shape
C.W.H. Barnett
Harry Diamond Laboratories
Department of the Army

Rejection filters are made with two cemented circular piezoelectric ceramic disks and a silver foil in between. The disks are series-connected in the high side of the signal, and the metal foil goes to ground. The result is a narrow-bandwidth filter whose resonant frequency is inversely proportional to the diameter of the disks—provided the diameter is at least four times the thickness of one disk.

When a wider passband is desired, more circular disks are stacked together, with each differing in resonant frequency from the preceding one by a few kilohertz. Such a combination is called a ladder filter. Thus, the wider the desired bandwidth, the greater the volume of the ladder filter.

In an effort to reduce the volume of wide-passband ceramic filters to make them suitable for microcircuits, the use of elliptical instead of circular disks was investigated.

The resonant frequency of an elliptical pair depends on the dimensions of the minor axis, d, and the major axis, D. The insertion loss of the filter is a function of the D/d ratio.

For one experimental elliptical filter, the D/d ratio was 1.24. The filter, 1/16-inch thick with a 1/4-inch minor diameter and 5/16-inch major diameter, had a 194-khz center frequency and a bandwidth of 31 khz at 3 decibels down, or a bandwidth 16% of the center frequency. But when the bandwidth is more than about 10%, insertion losses become excessive.

The rejection ratio of the elliptical filter is about 20 db, compared with the 30 to 85 db available in commercial ladder filters. There isn't any obvious way to improve this ratio in the elliptical filter, but the filter's smallness is still an advantage.

Presented at the IEEE-EIA 1968 Electronics Components Conference, May 8-10, Washington.

Stronger varactor chain

The generation of high microwave power using arrays of varactor diodes
D. Parker
Massachusetts Institute of Technology, Lexington, Mass.
A.I. Grayzel
NASA Electronic Research Center, Cambridge, Mass.

High microwave power in communication satellites is usually achieved by using varactor diodes to multiply lower frequencies generated by transistors. An experimental varactor frequency doubler eliminates the need for hybrid power dividers and combiners, which add circuit complexity and weight. A four-diode series array and an eight-diode series-parallel array, converting 0.9 gigahertz to 1.8 Ghz, have both handled more than 60 watts of input power at higher efficiencies than a single diode.

A phase-shift network of appropriate characteristic impedance separates each varactor in the array, allowing each to share an equal amount of power and ensuring that the outputs of all add in-phase at the load.

Networks consist of half-wave transmission lines with load and source at the same end of the array. Since both the input and doubled output frequencies flow on the same line, a diplexer at one end of the array separates the two. The array can be easily expanded and tuned at the input and output terminals.

Because parametric oscillation occurred during the tuning of arrays containing several diodes, a series stub that looks like a short circuit at input and output frequencies was built into the network. Below the input frequency, the stub acts like a high-capacitive reactance, thereby filtering low frequencies.

Presented at the AIAA 2nd Communications Satellite Systems Conference, San Francisco, April 8-10.

Watch out!

The associative processor in aircraft conflict detection
W.C. Meilander
Goodyear Aerospace Corp.
Akron, Ohio

In the nine years through December 1967, there were 187 aircraft collisions in the U.S. and they resulted in 454 fatalities. In 1967 alone, 150 people were killed in 27 collisions.

And if airspace was crowded before, it will be mobbed within a few years. The Federal Aviation Administration is counting on 200,000 planes in the U.S. by 1977, compared with today's 92,000. Airport operations totaled 41 million in 1967, but the figure is expected to reach 139 million in 1975.

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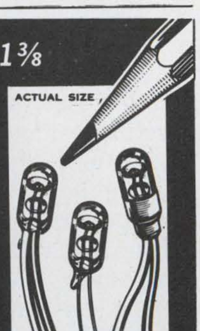

An unusual ring-electrode construction glows on the entire surface for maximum brightness. The unobstructed glass allows the illuminated elements to be placed close to the top where it may be viewed to advantage. 3 styles: with short bare leads; with 10" insulated leads; with 10" insulated leads and metal base.

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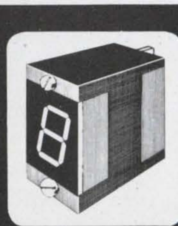

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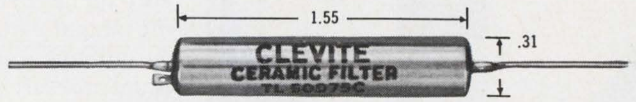
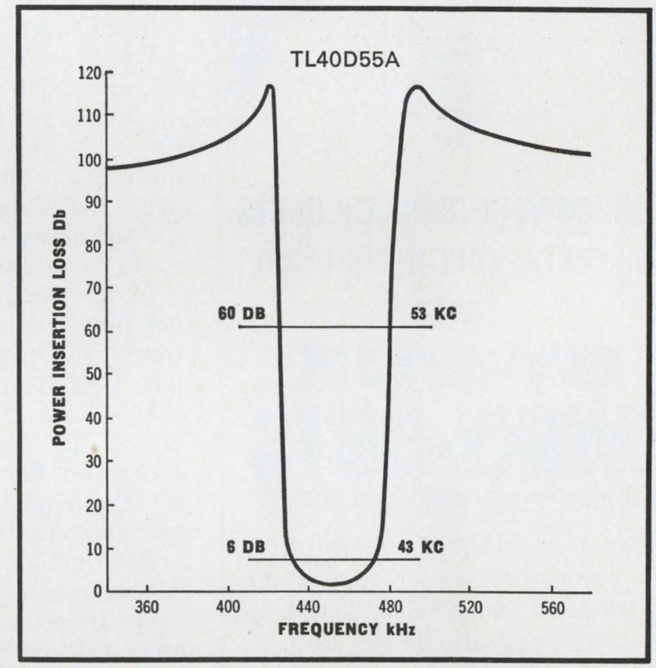


Clevite's ceramic ladder filters deliver 80 db rejection in 0.1 cu.in.!



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TL-4D8 (A)	4 kHz	8 kHz	TL-30D45 (A)	30 kHz	45 kHz
TL-6D11 (A)	6 kHz	11 kHz	TL-40D55 (A)	40 kHz	55 kHz
TL-8D14 (A)	8 kHz	14 kHz	TL-45D65 (A)	45 kHz	65 kHz
TL-10D16 (A)	10 kHz	16 kHz	TL-50D75 (C)	50 kHz	75 kHz
TL-16D25 (A)	16 kHz	25 kHz			

PRICES: 1 — $52.50; 25 — $42.00 ea; 100 — $36.75 ea; 500 — $31.50 ea; 2000 — $26.00 ea.

(Prices subject to change without notice.)

Send order or request for Bulletin 94017 to: Clevite Corporation, Piezoelectric Div., 232 Forbes Rd., Bedford, Ohio 44014, U.S.A. Or: Brush Clevite Company, Limited, Southampton, England.

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Technical Abstracts

ground-based, conflict detection system under consideration depends on a discretely addressable beacon-transponder on each plane and an associative processor. Using signals from transponders, the associative processor will rapidly order aircraft positions—from nearest to farthest—and extrapolate the velocity vector for each of up to 2,000 aircraft to determine if there are impending collisions. The pilots would have sufficient lookahead time—perhaps 1 minute—to maneuver their craft.

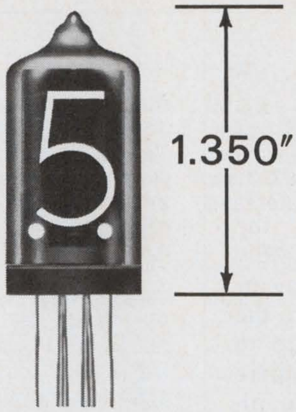
The discretely addressable transponder in each aircraft would be interrogated in two 1-second modes. In the first, a specific code for each plane would be transmitted from the ground, and each plane would respond with its identity and altitude. Up to 2,000 aicraft could be interrogated in a second.

In the next second, all aircraft not responding in the first second would be interrogated to detect new aircraft arriving in the traffic control area. Three receivers would detect an aircraft's transmitted code, and the time difference of signal arrivals would be used in triangulating the aircraft's position.

Determining triangulations for 2,000 planes, extrapolating their velocity trajectories, and performing other calculations—all in real time—is a formidable assignment, but the associative processor can handle the job. Consisting of a program storage unit, a control unit, and a content-addressable processing store unit, it can do many computations simultaneously. Each word of the processing store unit is a simple computer, and each can handle a different task.

Locating an aircraft and storing its three triangulated times would take less than 3 microseconds. Calculating positions from raw data would take less than 1 μsec. And the processor would need only 10 μsec to order each plane by its range from the terminal point. Over-all, the system could plot the present and future positions of up to 2,000 aircraft in less than 3 seconds.

Presented at National Aerospace Electronics Conference, Dayton, Ohio, May 6-8.



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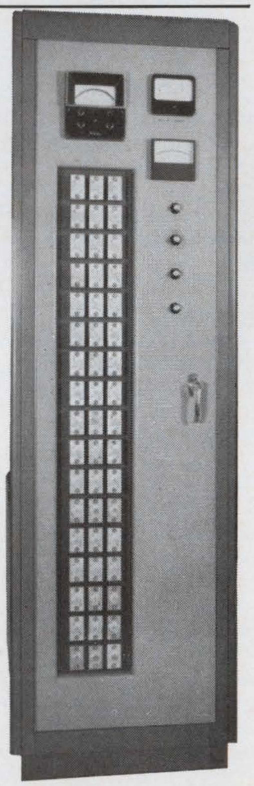

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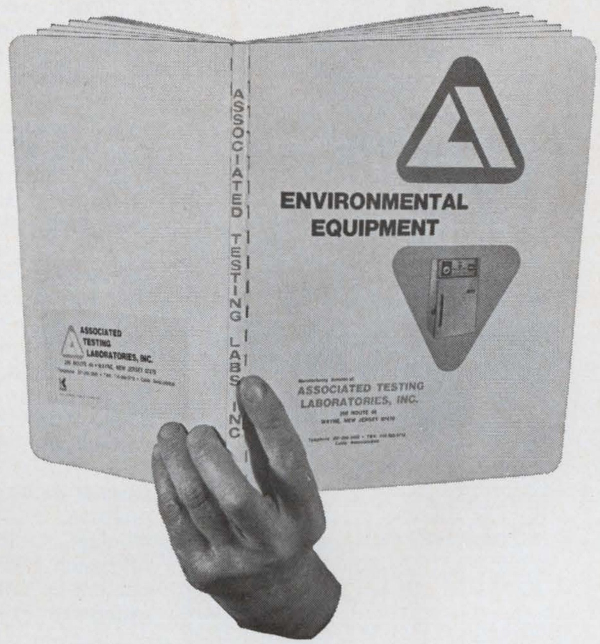

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New Literature

Pulse generator. Datapulse Inc., 10150 W. Jefferson Blvd., Culver City, Calif. 90230. Technical bulletin 113 describes a pulse generator that offers 0.5-hertz to 250 megahertz repetition rates and built-in pulse-burst capability.
Circle **446** on reader service card

Pulse modulator packages. Raytheon Co., 190 Willow St., Waltham, Mass. 02154, has issued a four-page brochure on pulse modulator packages for radar transmitters. **[447]**

D-c power supplies. Hewlett-Packard Co., 100 Locust Ave., Berkeley Heights, N.J. 07922, has published a pocket-sized folding selection guide that classifies all its d-c power supplies according to regulation and lists them within each classification according to output voltage and current ratings. **[448]**

Coaxial cable connectors. Reynolds Industries, 2105 Colorado Ave., Santa Monica, Calif. 90404. A short-form reference sheet lists coaxial cable connectors in four series with high altitude ratings to 20 kilovolts. **[449]**

Universal recorders. Houston Instrument Division of Bausch & Lomb, 4950 Terminal Ave., Bellaire, Texas 77401. Bulletin 2686520 offers a complete description of and specifications for the Omnigraphic 6520 and 6540 universal recorders. **[450]**

Operational amplifiers. Analog Devices Inc., 221 Fifth St., Cambridge, Mass. 02142. A four-page foldout data sheet gives circuits, specifications, and application guidance for models 210 and 211 low-cost, chopper-stabilized operational amplifiers. **[451]**

High-temperature materials. Aremco Products Inc., P.O. Box 145, Briarcliff Manor, N.Y. 10510. Selection chart No. 523 lists 10 ceramic and plastic adhesives, coatings, and potting compounds for use at high temperatures. **[452]**

Solid state choppers. Solid State Electronics Corp., 15321 Rayen St., Sepulveda, Calif. 91343, has available a 62-page catalog describing 30 types of solid state choppers. **[453]**

Germanium transistors. KSC Semiconductor Corp., KSC Way, Chelmsford, Mass. 01824. Engineering data sheets describe four new series of high-power germanium transistors in reduced size TO-8 and TO-66 cases. **[454]**

Core memory components. Ampex Corp., 401 Broadway, Redwood City, Calif. 94063. Operating specifications of 11 magnetic core types and description of various core memory stacks are offered in core memory components folder CO41. **[455]**

Coaxial cable. Andrew Corp., 10500 W. 153rd St., Orland Park, Ill. 60462. Technical bulletin 270 covers a low vswr coaxial cable that can minimize antenna feeder echo distortion in high-capacity 2-gigahertz microwave systems. **[456]**

Temperature controllers. Pak-Tronics Inc., 4044 N. Rockwell St., Chicago 60618, has available eight-page catalog F-6350 covering a line of solid state temperature controllers. **[457]**

Thermistor probes. Yellow Springs Instrument Co., P.O. Box 279, Yellow Springs, Ohio 45387. Temperature sensing thermistor probes series 400 and 500 are described in a six-page folder. **[458]**

Graphic level recorder. B&K Instruments Inc., 5111 W. 164th St., Cleveland 44142. Model 2305 graphic level recorder and its uses, features, and accessories are presented in an eight-page bulletin. **[459]**

Electro-optical construction modules. Ardel Instrument Co., P.O. Box 992, Jamaica, N.Y. 11431. A four-page illustrated brochure describes more than 60 modules of the Kinamatic electro-optical construction system. **[460]**

Digilogger. EnTex Inc., P.O. Box 770, Friendswood, Texas 77546. A four-page brochure describes the Digilogger, a versatile scanner, analog-to-digital converter, and printer, all in one low-cost instrument. **[461]**

Hybrid circuit design. Bendix Corp., South St., Holmdel, N.J. 07733, offers a six-page engineering report entitled "Standard Thick Film Package Design for Hybrid Microelectronic Devices." **[462]**

Electromagnetic readout device. Vernitron Corp., 59 Central Ave., Farmingdale, N.Y. 11736. Vernidex, a digital input-electromechanical readout device that enables engineers to solve many problems in electronic systems design, is described in a current bulletin. **[463]**

Drafting aids. Bishop Industries Corp., 11728 Vose St., North Hollywood, Calif. 91605, has issued an up-to-date 28-page catalog of drafting symbols for the electronic and aerospace industries. **[464]**

Telemetering modules. Solid State Electronics Corp., 15321 Rayen St., Sepulveda, Calif. 91343, offers a 40-page catalog describing its line of f-m/f-m telemetering modules. **[465]**

Test equipment. Beckman Instruments Inc., 2500 Harbor Blvd., Fullerton, Calif. 92634. Insulation test equip-

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New Literature

ment, electronic test and measuring instruments, high-voltage power supplies, and automatic component testers are comprehensively covered in a 40-page catalog. **[466]**

Digitized light table. Data Tech Inc., 65 Grove St., Watertown, Mass. 02172. Bulletin 3-100 presents a low-cost digitized light table tailored for the printed-circuit manufacturer using numerical-control drilling equipment. **[467]**

Microwave switching diodes. Unitrode Corp., 580 Pleasant St., Watertown, Mass. 02154. Bulletin M-138 introduces a new line of p-i-n high-power microwave switching diodes designed for operation in megawatt peak-power and kilowatt average-power applications. **[468]**

IC test system. Fairchild Instrumentation, 974 E. Arques Ave., Sunnyvale, Calif. 94086. A 12-page descriptive brochure details features of the series 5000 integrated-circuit test system. **[469]**

Instrumentation tape. Memorex Corp., 1180 Shulman Ave., Santa Clara, Calif. 95050, has issued a technically complete and colorful brochure on its new series 63 broadband instrumentation tape. **[470]**

Linear amplifier. Hamner Electronics Co., 1945 E. 97th St., Cleveland 44106. A technical bulletin describes the NA-16 variable shaping linear amplifier. **[471]**

Thumbwheel switches. Chicago Dynamic Industries Inc., 1725 Diversey Blvd., Chicago 60614. Ten-position bar indicator thumbwheel switches are illustrated and technically described in a two-page catalog. **[472]**

Digital data acquisition. Howell Instruments Inc., 3479 W. Vickery Blvd., Fort Worth, Texas 76107, offers a brochure describing in detail its new systems for digital data acquisition. **[473]**

Service computer. Bissett-Berman Corp., P.O. Box 655, Santa Monica, Calif. 90406, has published a 12-page brochure describing the functions and applications of its Sentry/100 heavy-equipment service computer. **[474]**

R-f connectors. Microdot Inc., 220 Pasadena Ave., South Pasadena, Calif. 91030, announces a brochure on the MARC 151 line of high-reliability, very-low-vswr r-f connectors. **[475]**

Rotary switches. Digitran Co., 855 S. Arroyo Parkway, Pasadena, Calif. 91105. A line of miniature pushbutton rotary switches for use in military applications and severe industrial environments is described in a product bulletin. **[476]**

Instrumentation tape recorder. Ampex Corp., 401 Broadway, Redwood City, Calif. 94063. Data sheet D082 contains description and performance specifications of the model FB-400 bin-loop instrumentation tape recorder for use in recording rapid-burst telemetry or radar signals. **[477]**

Video detector. Sage Laboratories Inc., 3 Huron Drive, Natick, Mass. 01760, has published a 24-page technical discussion entitled "The Video Detector." **[478]**

Semiconductors. Motorola Semiconductor Products Inc., Box 13408, Phoenix 85002, has released its 1968 condensed catalog describing major electrical specifications for more than 3,500 individual semiconductor types. Ordering information on some 12,000 devices is included. **[479]**

Neon glow lamps. Signalite Inc., 1933 Heck Ave., Neptune, N.J. 07753, offers a revised eight-page illustrated brochure describing neon glow lamps for indicator applications, voltage regulators, and circuit components. **[480]**

Precision waveguide tubing. Engelhard Minerals & Chemicals Corp., 113 Astor St., Newark, N.J. 07114. A brochure on precision waveguide tubing presents a complete listing of data and includes special sizes, materials, and parameters. **[481]**

Pressure transducers. Kistler Instrument Corp., 8989 Sheridan Drive, Clarence, N.Y. 14031, has issued three bulletins containing specifications and descriptions of quartz piezoelectric transducers for the measurement of high-level explosive pressures. **[482]**

Data acquisition and control. Foxboro Co., Foxboro, Mass. 02035, has released a 16-page publication describing a computer-based data acquisition and control system designed for power plant operations. **[483]**

Indicator lights. Marco-Oak, division of Oak Electro/Netics Corp., 207 S. Helena St., Anaheim, Calif. 92803. A 32-page catalog on indicator lights, compiled in the form of an engineering handbook, features photographs, line drawings, and detailed specifications. **[484]**

Infrared analytical accessories. Barnes Engineering Co., 30 Commerce Rd., Stamford, Conn. 06904. Featured in bulletin 68-2A is a sampling of the company's wide range of infrared spectrophotometer accessories and cells. **[485]**

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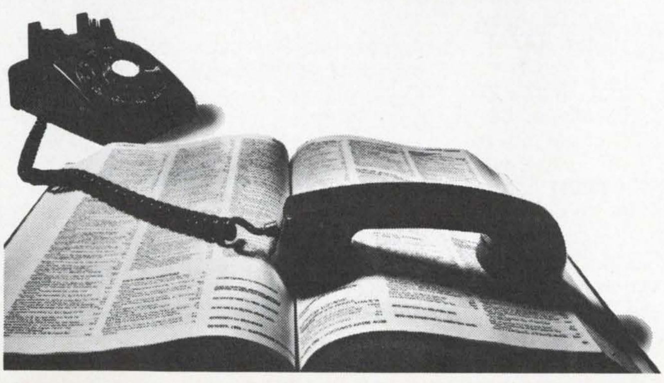

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Meetings

(Continued from p. 16)

Short Courses

Contemporary filter design seminar, University of Missouri, Columbia, Mo., **June 17-19;** $200 fee.

Computer-aided circuit design, George Washington University's School of Engineering and Applied Science, Washington, **June 17-21;** $300 fee.

Communications systems, George Washington University's School of Engineering and Applied Science, Washington, **June 17-21;** $250 fee.

System effectiveness, George Washington University's School of Engineering and Applied Science, Washington, **June 17-21;** $250 fee.

Radiometry-measurement and calibration, University of Michigan, Ann Arbor, **June 17-21;** $200 fee.

Optimization techniques and engineering applications, Cornell University, Ithaca, N.Y., **June 17-21;** $200 fee.

Technical communications, Cornell University, Ithaca, N.Y., **June 17-21;** $200 fee.

Foundations of information systems engineering, University of Michigan, Ann Arbor, **June 17-28;** $200 fee.

Computer graphics for designers, University of Michigan, Ann Arbor, **June 17-28;** $400 fee.

Fabrication and design, University of Arizona, Tucson, **June 17-28;** $450 fee.

Electromagnetic propagation, University of Colorado's Department of Electrical Engineering, Boulder, **June 17-July 13;** $300 fee.

Surges in transformers and rotating machines, University of Colorado's College of Engineering, Boulder, **June 24-28;** $200 fee.

Computer-oriented techniques for engineering analysis and design, Northwestern University's Department of Electrical Engineering, Evanston, Ill., **June 24-July 3;** $300 fee.

Principles of color technology, Rensselaer Polytechnic Institute, Troy, N.Y., **July 8-12;** $225 fee.

Probability and random processes for engineers and scientists, University of Michigan, Ann Arbor, **July 8-19;** $325 fee.

Fundamentals of semiconductors, University of Colorado's College of Engineering, Boulder, **July 15-19;** $200 fee.

Magnetic thin films, University of California, Los Angeles, **July 15-20;** $275 fee.

Communications systems, University of California, Los Angeles, **July 15-26;** $375 fee.

Engineering and physiologically aspects of man-machine systems, University of California, Los Angeles, **July 15-26;** $375 fee.

Logical design of electronic switching systems, Cornell University, Ithaca, N.Y., **July 16-26;** $350 fee.

Applied topics in computer technology, Ohio State University, Columbus, **July 17-26;** $275 fee.

Built-in test equipment for the maintenance of complex electronics systems, New York University's School of Engineering and Science, New York, **July 22-26;** $245 fee.

Basic communications theory, University of Colorado's College of Engineering, Boulder, **July 22-26;** $200 fee.

Logic systems, University of Colorado's College of Engineering, Boulder, **July 22-26;** $200 fee.

Topics in military operations research, University of Michigan, Ann Arbor, **July 22-Aug. 2;** $325 fee.

Introduction to optical data processing, University of Michigan, Ann Arbor, **July 22-Aug. 2;** $325 fee.

Principles of imaging radars, University of Michigan, Ann Arbor, **July 22-Aug. 2;** $325 fee.

Computer methods of network analysis, University of California, Los Angeles, **July 22-Aug. 2;** $375 fee.

Engineering and space applications of magnetohydrodynamics, University of California, Los Angeles, **July 22-Aug. 2;** $375 fee.

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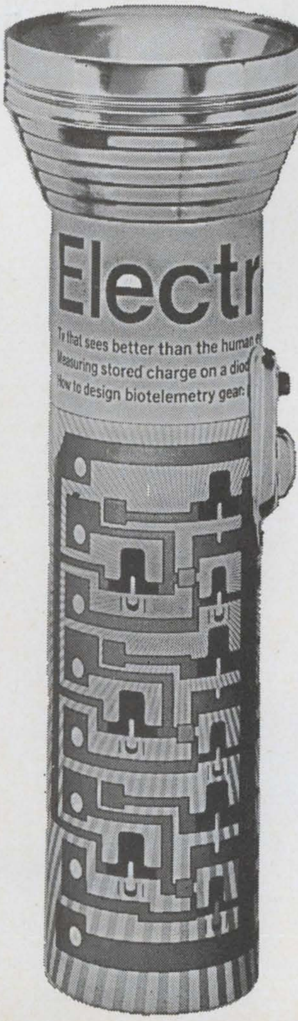

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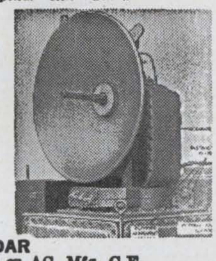

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Newsletter from Abroad

June 10, 1968

Fairchild may quit Italian venture

Fairchild Camera & Instrument Corp., long at odds with its two European partners in SGS-Fairchild, may pull out of the Italian concern.

The partners—Roberto Olivetti of the office-machine family and Virgilio Floriani, chief owner of the communications-equipment company Telettra—have **decided to double capitalization despite Fairchild's objections.** This move, following a series of squabbles over integrated-circuit product lines for European markets, could cause Fairchild to sell its one-third holding in SGS-Fairchild. **Fairchild officials won't discuss the matter, but it's known that they're currently tightening up—rather than expanding—their operations.**

Britain to build small satellites

British aerospace companies, deflated last month by the Wilson government's decision to pull out of two key international space programs, now see some chance of staying in the satellite business.

Their hopes are pegged on a government order to the British Aircraft Corp. for a quartet of 160-pound experimental satellites intended to "maintain Britain's capability in satellite technology." Aerospace industry men think the order makes sense only if the government expects to eventually build operational satellites.

The four satellites, called X-3's, will be used to check out a solar cell under development at Ferranti Ltd., an experimental pulse-code-modulation telemetry system, a power control system, and thermally sensitive paint finishes. The program calls for a 1971 launch of at least one of the experimental spacecraft, using a British Black Arrow rocket. **Later, the government may underwrite a larger satellite to test an ion propulsion engine under development at the Royal Aircraft Establishment.**

Czechs may shift to PAL color tv

Czech officials apparently plan to take their country out of the French-Soviet Secam (sequential and memory) color-television camp.

Signs that a shift is in the works have started to pop up in the government-controlled press. The official wire service has carried stories telling how **engineers at the Prague broadcasting institute unanimously prefer the West German PAL (phase-alternation-line) system.** A Prague daily recently called Secam uneconomical and promised to keep readers posted on the "revision" of the earlier decision to follow the lead of the Soviet Union and adopt the French system.

East Europe watchers in Vienna say the move stems only partly from the new Czech government's effort to loosen its ties with the Soviet Union. **As PAL broadcasters, the Czechs would bolster their chances of becoming the leaders in conversion of programs transmitted between East and West Europe.** Prague and Vienna are now vying for this role.

NATO may be stuck with concerted bid on ground stations

It looks as if the North Atlantic Treaty Organization could get only one bid on a contract to build the 13 ground stations planned for its communications satellite network. **Practically all the companies that can be tapped for the job have formed a consortium and have offered to build the stations for $30 million.**

The consortium—called Eurocan—is made up of Siemens AG and AEG-Telefunken of West Germany, Philips' Gloeilampenfabrieken of the Netherlands, the Marconi Co. of Britain, RCA Victor Ltd. of Canada, and a Rome-based group of electronics companies called Sistemi di Telecomunicazioni via Satelliti S.p.A.

This lineup leaves NATO with few options. **Britain's General Electric Co., which now controls Associated Electrical Industries, is about the only other possibility.** But the firm would be hard put to find Continental partners on a level with the Eurocan group. Under the financing arrangements worked out for the network, contracts must be awarded on the basis of NATO members' contributions to the program's costs.

U. S. companies are effectively out of the running for the ground-station work. **Philco-Ford already has the contract for the satellite itself, and that takes care of the U. S. share.**

Japan mulls national closed-circuit tv net

The Nippon Telegraph & Telephone Public Corp., Japan's government-affiliated communications carrier, is considering setting up a national closed-circuit television system.

NTT has successfully used a combination of 18-gigahertz microwave links and telephone lines for test transmissions; it has also turned up some interesting prospective customers. Among them: racetrack operators who want to transmit post parades to off-track betting outlets.

NTT will have to do more experimental work before it can fix the characteristics of the system and the rates it will charge. **But the company apparently expects to hold fees for closed-circuit service to a fraction of the regular rates for broadcast-quality tv lines.**

NTT will report on the equipment at the International Communications Conference in Philadelphia later this week.

U.K. computer firm plans sales push in East Europe

Look for a strong sales drive in Soviet-bloc countries by International Computers Ltd., the British giant formed by the merger of International Computers & Tabulators and the computer operations of English Electric and Plessey.

International will have the East European operations of English Electric and ICT stitched together by next month, with full-time sales squads operating in Moscow, Prague, Belgrade, Warsaw, and Sofia. **Their goal: capture half or more of the estimated $35 million market for computers among the Soviet satellites.** This figure, which doesn't include sales to Russia, would run much higher if the East Europeans had more foreign exchange, say British marketing men.

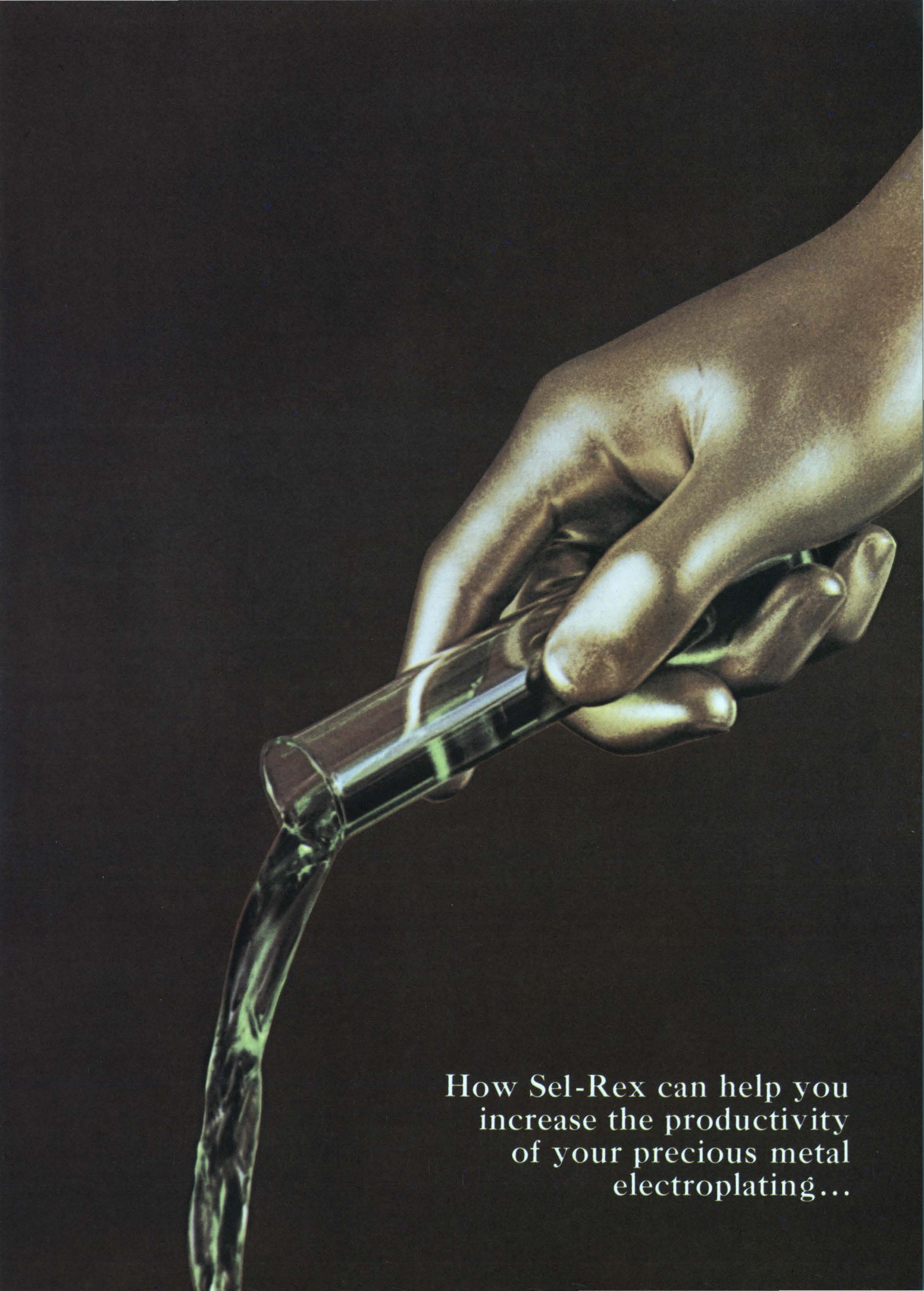
The sales drive should put the firm well ahead of U.S. computer companies in East European markets. International delivered a third-generation computer—the first integrated-circuit machine to reach East Europe—to Czechoslovakia late last month. Because of the stiff U.S. embargo on strategic exports to the area, U.S. companies so far can offer only slow second-generation equipment to Soviet-bloc countries.

Plessey cracks IC market in U.S.

The Plessey Co. has broken into the U.S. integrated-circuit market with the sale of $25,000 worth of logarithmic amplifiers to the Hazeltine Corp.

The British concern has even more ambitious plans to sell IC's in the U.S., but it won't have its marketing tactics fully worked out until the fall. Meanwhile, the company will try to flush out more U.S. customers for custom-made circuits originally developed for the British market. On these, Plessey can usually undersell U.S. producers.

Circle 247 on reader service card→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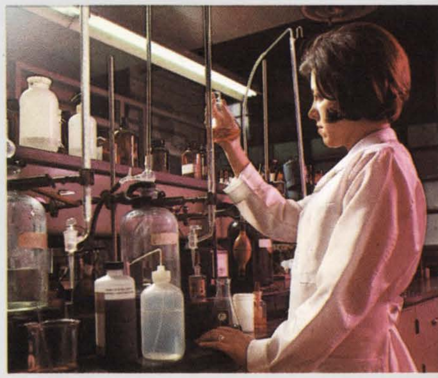

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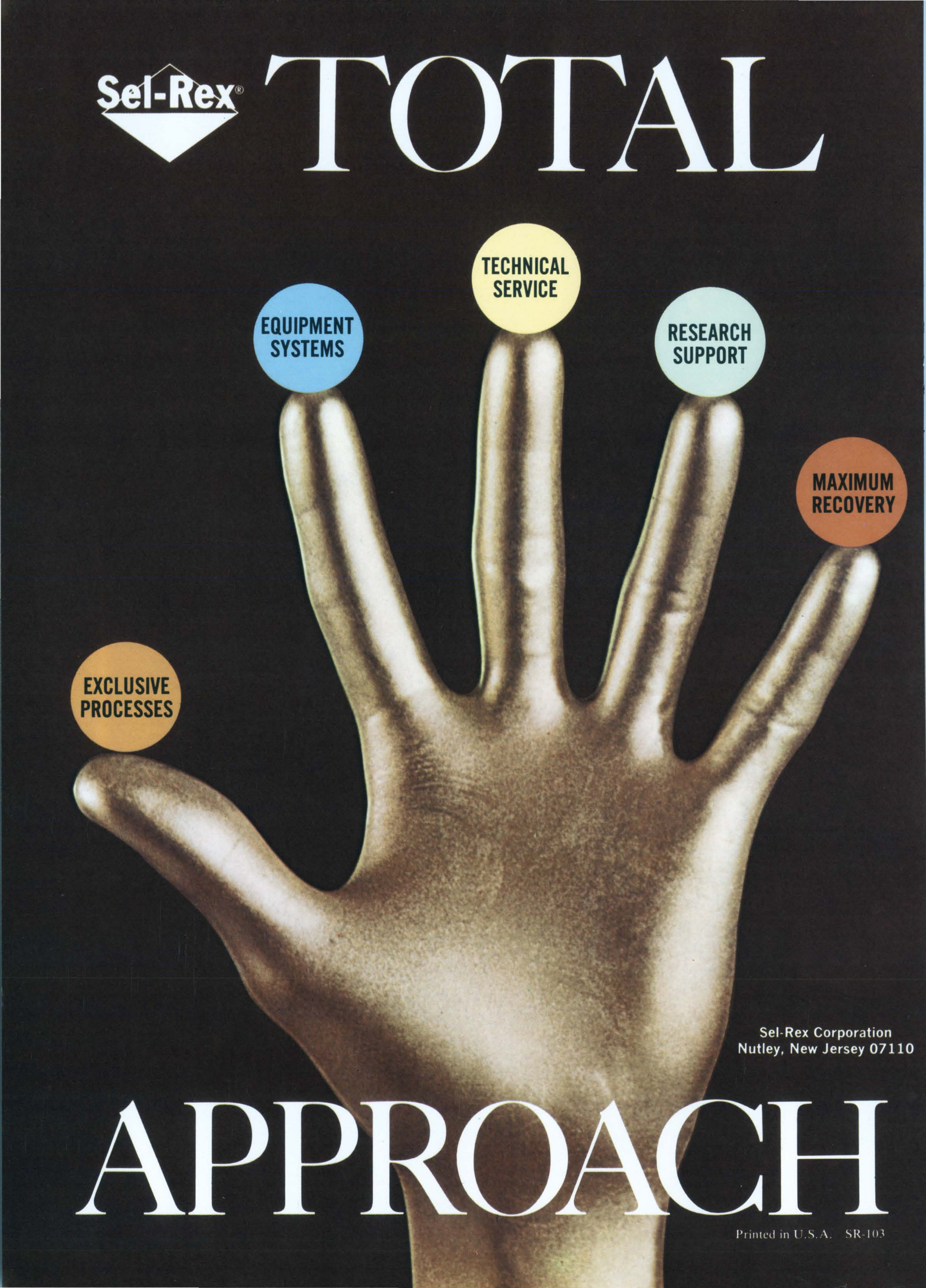
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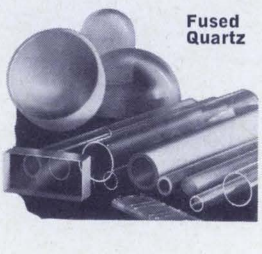

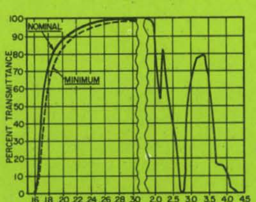

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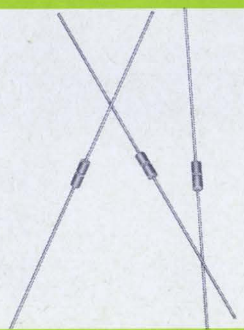

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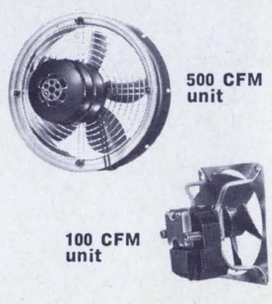

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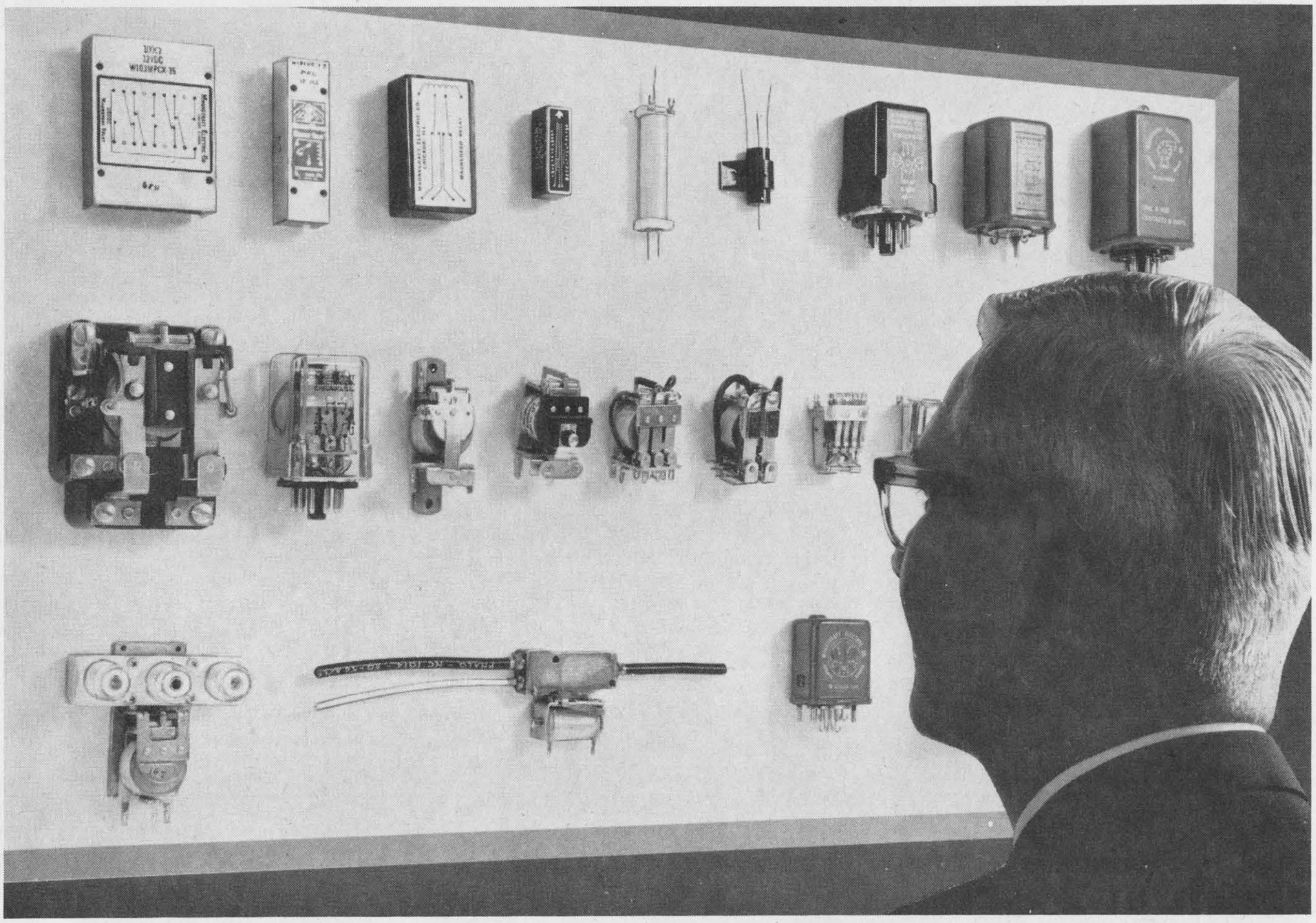

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June 10, 1968

Electronics Abroad

Volume 41
Number 12

Great Britain

Clearing the dishes

For all its merits, the Cassegrain antenna is plagued by an Achilles heel—its subreflector. Spotted on the axis of the main dish, the subreflector and its supports block part of the antenna's aperture and thus impair antenna efficiency. At the same time, radiation scattered from the subreflector into the main beam path adds to the noise that masks signals.

For large antennas, these drawbacks are merely a nuisance. But they're close to intolerable with dishes less than 30 feet or so in diameter. One obvious solution is to somehow get the subreflector and its supports off the axis. Antenna designers have been talking about "offset" Cassegrain layouts for some time, but the first attempt to build one is just about to start in England at Birmingham University.

Experimental. The Birmingham antenna, which should be operational in about a year, pairs a 20-foot dish with an offset subreflector. The university's electronics department will use it for research in space radio communications and for propagation experiments down to millimeter wavelengths. The first experiments will involve bouncing X-band (5.2 to 10.9 gigahertz) signals off the moon. Later, the Birmingham researchers will check out feed performance and polarization problems with the offset subreflector.

Husband & Co., the engineering firm that designed the famed radio telescopes at Jodrell Bank, will build the Birmingham antenna. Husband's designers say the offset layout will make the antenna suitable for frequencies up to 40 Ghz. Because there is no blocking by the subreflector and its supports, only surface error losses cut down the gain theoretically available from the main dish. With winds gusting to 40 miles an hour, the surface losses will run about 2% at 40 Ghz and 0.1% at 10 Ghz. In still air, of course, the losses will be somewhat lower.

Strong arm. Husband will build the main dish of 10-gauge mild steel panels bolted to a steel support. The design calls for a steel spine 6 feet wide extending across the underside of the dish. A pillar at one end of the spine will carry the subreflector support arm.

The subreflector, a full 5½ feet in diameter, shares the arm with a swan-neck feed. The swan neck can be positioned over the main dish—and the subreflector swung clear—whenever a front feed is desired.

The dish and subreflector support are mounted at an angle on a shaft inclined 47.5° from the vertical. As the support shaft revolves, the elevation angle of the dish varies from 5° below the horizon to zenith. The subreflector support is spotted on the circumference of the main dish so that the subreflector itself is on the low side of the dish when the dish points up and on the high side when it points down. Since the subreflector always points downward, its spillover at transmission is always directed away from the ground. For the same reason, the only energy that can get to the feed horn during reception is radiation coming from the sky. It adds up to a double bonus in noise improvement.

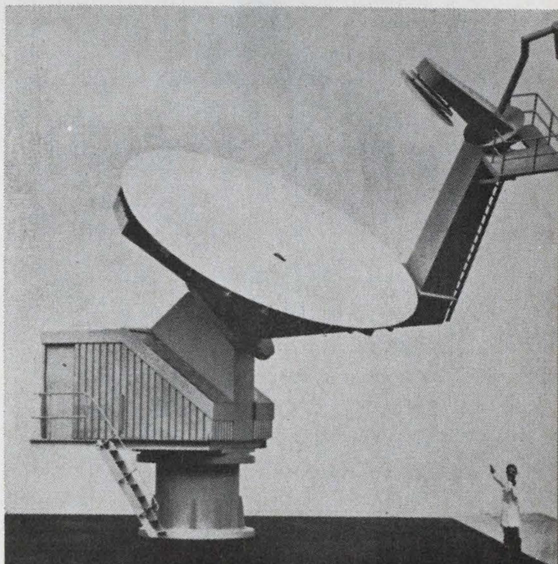
Round and round. To track in azimuth, the dish structure, plus a cabin housing the transmitter and receiver, rotate around a pedestal. Because of the tilted support shaft for the dish, azimuth and elevation movements affect one another, and a computer will be used to figure out tracking instructions.

Along with azimuth-elevation compensation, the computer will handle automatic tracking of satellites and the like. Position inputs will be derived by comparing signal strengths along the boresight axis and to one side of it.

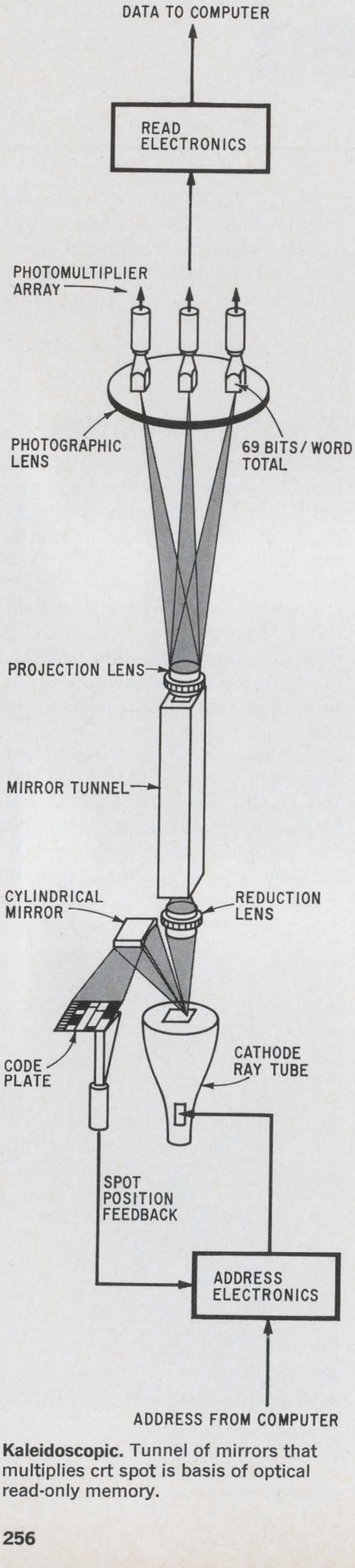
Through the looking glasses

Designers of large computers long have been irked by the high proportion of main memory they have to set aside for internal organization and checking. And the fact that some of the supervisory information has to be kept in the internal ferrite-core store adds to their discontent since they're forced to waste read-write memory on information that needs only to be read.

This state of affairs won't plague engineers at International Computers Ltd. when they get around to designing the super computer the company very likely will be making in a few years. International Computers & Tabulators Ltd., the company around which



It swings. Off-center layout for subreflector betters noise characteristics and gain of small Cassegrain antenna.



Kaleidoscopic. Tunnel of mirrors that multiplies crt spot is basis of optical read-only memory.

International Computers is being formed [Electronics, April 1, p. 146], is well on the way to developing an optical read-only memory that can store vast quantities of information and feed it quickly into the computer with random access. International Computers expects to have an experimental model ready in a few months. It will be relatively small—some 65,000 words of 68 bits each.

On the spot. The scheme is based on a tunnel of mirrors that, much like a kaleidoscope, turns a single light spot from a cathode-ray tube at one end of the tunnel into 69 spots at the other end. At that point there's a photographic plate divided into 69 1-inch squares—one for each spot. The spots each hit the same location on their respective squares—and there are 256 x 256 of these positions, or more than 65,000.

In this way, ICT gets its 68 data bits and one check bit per word. The words themselves are determined by the 65,000-plus positions that the master spot can take on the cathode-ray tube—positions corresponding to the locations on the squares upon which the reflected spots are thrown. The binary 0 or 1 at each spot position on the plate is set by leaving it clear or opaque. A photomultiplier array behind the plate reads out the information.

Checked. For readout, then, the computer sends a word address that drives the master spot to one of its locations. To make sure the spot goes where it should and stays there, a digital servosystem checks its position by two scales—one for the x axis and one for the y axis, each of which has 256 discrete positions. Any difference between actual and commanded positions gives rise to an error signal.

ICT engineers concede that their optical read-only memory will be highly sensitive to changes in alignment. But they've designed a tetrahedral mount that takes care of shocks and temperature effects.

As for the memory plate, the engineers foresee little difficulty. Although the spots are small, the resolution required can be obtained with present photographic techniques, they say.

France

Hard times

No matter how President de Gaulle's moves to save his regime turn out, France's electronics industry figures to take a beating for months to come.

May has already been wiped off the production calendar by the wave of strikes that have followed the student uprisings. Electronics companies' profit margins were slim even before the country was carried to the brink of revolution, and the firms see these margins disappearing as they prepare to meet wage increases that can go as high as 35%. What's more, shorter work weeks, earlier retirements, and other benefits will further boost production costs.

With output at a standstill but costs continuing, it will be a rare electronics company that shows anything like a normal profit for the year. Even more ominous for the long term is the outlook for companies that have had their order books kept plump by de Gaulle's spending for planes, missiles, satellites, and arms. These projects will be slowed now that de Gaulle is forced to deflate "prestige" programs in order to bolster domestic ones.

An allergy. Companies with stakes in such nonmilitary programs as the Concorde supersonic transport, the Plan-Calcul computer effort—and even the Symphonie communications satellite—are worried more about delays than outright cutbacks in programs. "Public opinion is allergic to luxury spending," says the sales manager of a small but profitable avionics and instrument manufacturer. "The public may consider the Force de Frappe sheer luxury, but not the computer program or the satellites." Few want France to drop programs that have been touted as buttressing the country's economy in the future.

Even the strongest electronics firms expect 1968 to be one of their roughest years. The leader, Compagnie Française Thomson Houston-Hotchkiss Brandt, expected to double or triple its profit this year from the scant $1.6 million on sales of $616.3 million in 1967. Like nearly all electronics companies, Thomson-Brandt had started the year off swimmingly. Sales in February rose 9% from February 1967. Now the company has fallen behind its year-earlier total because of the lost May. "With vacations coming," says a company spokesman, "there's no way of catching up this summer."

Rising prices. Most French electronics firms are convinced they'll have to pass the rise in production costs along to their customers. "We can't do anything else," says an official of the Fédération Nationale des Industries Electroniques.

What's worse, the price rises are coming at an unfortunate time—just before the Common Market's internal tariffs are to end. Consumer electronics companies, particularly, will lose a competitive edge in their domestic market when they will need it most.

For French electronics firms, there's little comfort in sight. Some observers think that the new pressures on profit margins will force managements to modernize their often-antiquated management techniques and corporate structures. But that's scant consolation for companies trying to recoup the losses of the near-revolution in May.

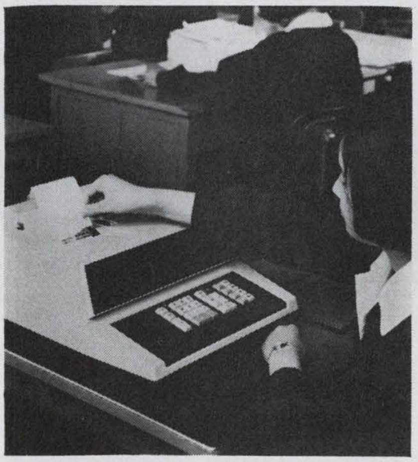
Japan

Fast count

To no one's surprise, the late-May Business Show at Tokyo's Harumi fairground attracted throngs of people and a flock of electronic desk calculators. Fourteen Japanese companies had 34 models of calculators up for sale. And there'll be more at the next show.

The desk-calculator industry is snowballing. At the show, Brother Industries Ltd.—a sewing-machine maker—the Canon Camera Co., and two watchmaking firms were lined up with the 10 electronics companies that manufacture desk-top calculators. Three more electronics concerns are planning to market their first machines soon, and some other precision-mechanics firms may further swell the industry's ranks.

The reason for the widespread itch to manufacture electronic calculators isn't hard to find. Some 2.6 million small calculators—mostly mechanical—are sold each year throughout the world, and the Japanese intend to capture this growing market with their electronic machines. They expect to



Taped. The first two Japanese IC desk calculators with line printers were marketed last month. Hayakawa unveiled its Compet CS-50A (above) and Hattori introduced the other machine.

turn out some 200,000 electronic calculators this year, more than three times last year's output. By 1970, the figure should climb to 500,000 machines—nearly half of them for export, principally to the U.S.

Pioneer. The Hayakawa Electric Co. in July 1964 became the first firm to market a solid-state calculator in Japan. Hayakawa also pioneered the integrated-circuit calculator, which, because of its potential low cost, poses the biggest threat to mechanical calculators. The firm's first experimental IC machine was built in late 1966. Hayakawa now produces two kinds of IC calculators, one with bipolar circuits and the other with metal oxide semiconductor circuits. And on its way to a monthly production capacity of 8,000 machines, the company has maintained its top spot in the industry.

All the Japanese producers have followed Hayakawa's technological lead. Only one of the 14 desk-calculator producers at the show had only discrete-component machines to offer. This was the Tokyo Shibaura Electric Co.; it, too, will start marketing an IC model in September.

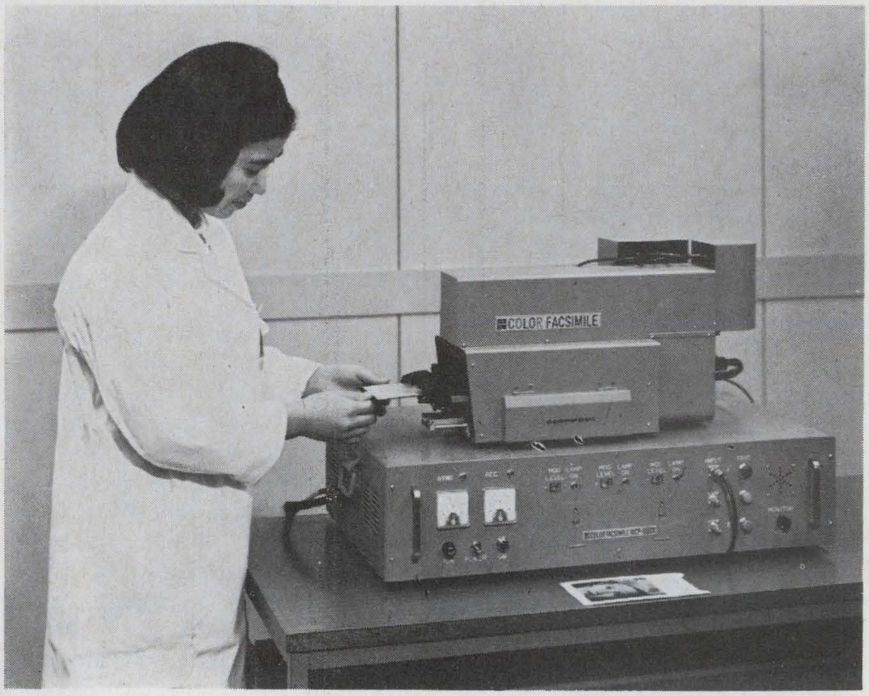
Onward. Nearly all the calculators at the show had lamp-indicator readouts, mostly cold-cathode glow tubes. Hayakawa and K. Hattori & Co.—one of the watchmakers—broke new ground with IC machines—their latest—paired with line printers. And the Sanyo Electric Co. made a splash with two models built around Motorola large-scale-integration packages. Sanyo intends to switch to domestic LSI packages as soon as Japanese semiconductor producers offer them.

Facsimile palette

Television newscasters of the government-owned network Nippon Hoso Kyokai will start getting still color photos by facsimile from all over Japan this month. But NHK's brand new equipment—it turns out—won't be the latest thing in color facsimile for long.

NHK developed its hardware, which transmits primary colors sequentially over a standard telephone circuit, jointly with the Toho Denki Co. [Electronics, Jan. 22, p. 193]. Toho's parent company, the Matsushita Electric Industrial Co., unveiled in May the prototype of a system that transmits all three colors simultaneously and exposes a Polaroid film after a 3.6-minute scan. The one-color-at-a-time equipment NHK is currently installing at 30 strategic stations around Japan takes 7.2 minutes a photo.

More impressive still, Matsushita says, is the improvement in color quality. The prototype has a masking circuit for each primary color. These circuits compensate for very small deficiencies in both the transmitter's optical filters and the film itself. Traces of blue and green light that pass through the red filter, for example, are masked out electronically. Spurious responses in the color-sensitive layers of the



Fast and faithful. Primary colors transmitted simultaneously—and corrected individually—expose Polaroid film with high fidelity during 3.6-minute scan.

film are also taken care of.

Added carriers. Because all three primary-color signals are transmitted simultaneously—the only practical way to get the comparison needed for corrections of individual colors—the new system needs considerably more bandwidth than the 3,000-hertz telephone channel that will do for the line-sequential system NHK developed. With masking, each color signal modulates both a 2,000-khz subcarrier and the main carrier. The three signals, stacked on the main carrier, add up to a bandwidth of slightly more than 12 khz.

The modulated subcarrier for the masking information is Matsushita's way of avoiding d-c coupling around the color-correction feedback loop. In the system, the scan rate is five lines a second (the Polaroid film pack is advanced 0.532 millimeter a second); without the 2,000-khz subcarrier, then, the low-frequency response would have been critical.

Bright light. Toho Denki as yet has no firm plans to go into production on the three-at-a-time hardware. But the facsimile receivers NHK has ordered for its newscasting operations will have a new xenon lamp that Matsushita developed along with the masking circuits.

The xenon lamps develop a light output of 9,000 candles per square centimeter. That makes them about 500 times brighter than the glow tubes generally used in facsimile receivers.

West Germany

Fading color line

Ever since broadcasting officials failed to agree on a single color-television system two years ago, much ado has been made over the split among European countries into two video camps.

Broadcasters and viewers lamented the limitations on program exchanges between countries committed to the West German phase-alternation-line (PAL) system and those using the French séquential-à-mémoire (Secam) system. Receiver makers saw their potential market fragmented. Some European federalists even saw in the split a sign that the Continent—despite the Common Market—was still far from political togetherness.

But while the pundits were talking about the split, electronickers were doing something about it. Production-line equipment for making Secam programs suitable for rebroadcasting in PAL territory—and vice-versa—is just about here.

Ahead. The West German networks, almost certainly will be the first to get transcoders into regular service. Researchers at the Darmstadt telecommunications laboratories of the Federal Post Office have built the prototype of a transcoder, and the first production models are in the works at Fernseh GmbH, a Darmstadt-based firm.

The transcoder—a 6-foot stack of 19-inch racks—is currently priced at $35,000 and includes test instruments to monitor incoming and outgoing signals. Once production picks up, the price could drop to about $25,000. The initial market for Secam-PAL transcoders is pegged at 25 to 30 units by Fritz Jaeschke, who headed the research team that developed the prototype.

Separated. Fortunately, both Secam and PAL use the same 625-line/50-frame transmission standard, so tricky format-conversion circuits aren't needed. The transcoding, in fact, boils down to two steps. First the luminance signal is separated out of the composite signal. Then the chrominance information is coded onto the PAL carrier.

For the separation, the incoming composite signal is fed to a diplexer-like stage that sorts the luminance—or Y—signal at the low-frequency end of the band from the chrominance components at the high end. The luminance signal then goes through a pulse-shaping amplifier that steepens its leading and trailing edges. Then the signal is made to coincide with the chrominance signal and applied to the PAL modulator.

The treatment. Meanwhile, the chrominance signal is operated upon in the transcoder's demodulator section. First, a carrier de-emphasis circuit eliminates any residual luminance components. Then an array of diodes in an electronic switch paired with a 64-μsec delay line sorts out the R-Y and B-Y signals that alternate with each

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line in the Secam system. These frequency-modulated signals are fed to two identical channels, and, after being amplitude-limited, are applied to discriminators followed by 2-megahertz low-pass filters that eliminate any remaining carrier-frequency components. A blanking circuit clears the horizontal blanking interval of hum and noise. De-emphasis circuits suppress pre-emphasis signals that are part of the incoming Secam video.

In addition to the Y, B-Y, and R-Y signals, the 4.43-Mhz PAL color subcarrier must be applied to the modulator along with the sync pulses.

Double coverage

The air traffic snarl over Western Europe, as elsewhere, is worsening. This potentially dangerous situation is made more acute by the fact that the surveillance radars at major airports often fail to detect aircraft—especially those coming in at low altitudes.

Some relief's on the way, though. There'll be no blind spots in the system AEG-Telefunken has designed for the West German government. A prototype of this radar, which will be able to spot planes anywhere between the horizon and an altitude of 70,000 feet at distances of 150 nautical miles, is scheduled for installation at the airport at Bremen in 1970. After that, four production versions will be sited in Dusseldorf, Hamburg, Stuttgart, and a forest between Frankfurt and the French border.

Revived. To get the improved coverage, Telefunken engineers opted for an arrangement in which a pencil beam and a cosecant-squared beam above it are sent from the same reflector—a design first used by the U.S. Air Force in post-World War II surveillance radars. The staggered-beam scheme has only recently come in for serious consideration in the air traffic control field. The Federal Aviation Administration is expected to let a development contract next month aimed at converting existing U.S. air traffic control radars to twin-beam propagation.

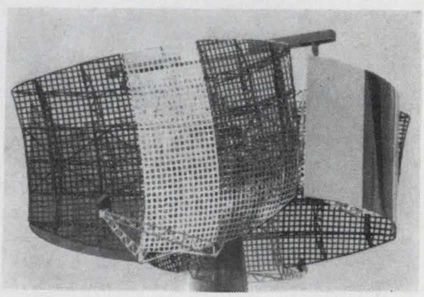
Besides going with twin beams, Telefunken's engineers have put a pair of reflectors back to back, thus creating four radiation patterns. The antenna rate is 7.5 revolutions per minute, slow enough to provide good moving-target indications and yet fast enough—because of the two reflectors—for information renewal to keep the display well illuminated.

High and low. The pencil beams are 1.2° wide horizontally and 3° high at the half-power point. The cosecant-squared pattern extends up to about 40° above the ground. Gain is 35 decibels in the upper beams, 38 db in the lower.

Three transmitters power the back-to-back antennas. Each upper beam has its own transmitter, while the pencil beams are handled by a single transmitter whose output is split by a 3-db coupler. The transmitters operate over a frequency range of 1,250 to 1,350 megahertz, and there's always a 50-Mhz difference between the upper and lower beams to prevent energy crossover in the receivers. Transmitter peak power is between 4 and 5 megawatts. Pulse width is 4.5 microseconds and the repetition rate is 400 hertz.

Telefunken has kept the antenna-transmitter combinations flexible. A single transmitter, for example, can be used for the cosecant-squared patterns. Operating this way, though, the range is reduced. There's also a fourth transmitter, a standby.

As for receivers, there are five—one for each beam and one standby. Each produces both a normal video signal and a moving-target-indicator video signal.



Back to back. Telefunken's upcoming air traffic control radar uses a pair of reflectors, each 29½ by 48½ feet. Waveguides aren't mounted on this unit, a model for wind-tunnel tests.

Around the world

Australia. Amalgamated Wireless Australasia Ltd., Australia's sole domestically owned electronics producer of major rank, has been tapped by the government to build an integrated-circuit production facility. AWA will develop and produce IC's under an initial contract that provides $670 million over a three-year period. According to supply minister Ken Anderson, the government support could last until well into the 1970's.

Japan. Takeji Kobayashi, minister of posts and telecommunications, has ordered the head of the Nippon Telegraph & Telephone Public Corp. to punish the engineers who designed the repeater stations for NTT's 500-mile microwave link between Tokyo and Sapporo.

The directive comes in the wake of a mid-May earthquake during which standby power generators at one station broke loose from their supports and put the link out of service for an hour and a half. The emergency generators in the 130 repeater stations in Japan's microwave network are all of the same design, and NTT will now have to spend some $280,000 to make them quakeproof.

The Netherlands. Philips' Gloeilampenfabrieken, a latecomer in the computer business, has landed its first important computer order. Philips will deliver a $1.3 million P-1000 system to the Dutch post office next February. Philips will get a follow-on order for four more systems if the first one performs well. The company has so far disclosed little about the P-1000; but it will release details in mid-June.

Great Britain. Marconi Co. engineers have used an asbestos-like plastic to design a new pivot assembly that eliminates any chance of long outages from the breakdown of antenna support bearings at satellite communications ground terminals. Instead of conventional metal bearings that can take weeks to replace under a heavy disk, Marconi uses plastic pads that can be repaired in less than a day.

The design will be used in two stations that Marconi is building for Cable & Wireless Ltd.

The Philippines. A permanent satellite communications ground station with a 97-foot antenna has gone into service about 25 miles east of Manila. The facility was designed to work with Intelsat 2 satellites and replaces a transportable station—distinguished by a 42-foot horn antenna—that had been operating since April, 1967.

Japan. The Nippon Television Network Corp. will start construction this year in Tokyo of what will be the world's highest tv tower. The $42 million Tokyo tower will, at 1,804 feet, top the present record-holder in Moscow by 65 feet. In addition to the broadcast equipment at its top, the tower will have a 20-story office-apartment complex as its base.

Canada. Lenkurt Electric of Canada Ltd., a subsidiary of the General Telephone & Electronics Corp., has a $10 million contract to build a 770-mile microwave system for Ontario Hydro, an electric utility. The system will be the longest in North America, Ontario Hydro claims.

The Netherlands. A self-service gasoline station that accepts bills as well as coins was opened last month near the Hague. A small computer figures out how many liters of gasoline are due a motorist for the money he deposits in a "cashbox" and meters out that amount from special pumps. Koppens Automatie designed the station equipment in cooperation with the Ministry of Transport.

Czechoslovakia. Twenty-six medium and 239 small computers are now operating in Czechoslovakia. Officials released the figures last month as a National Cash Register NCR 315 machine went into operation at the headquarters of the Czech footwear industry in Moravia.

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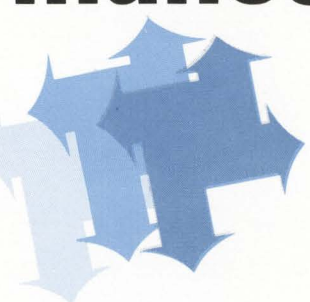

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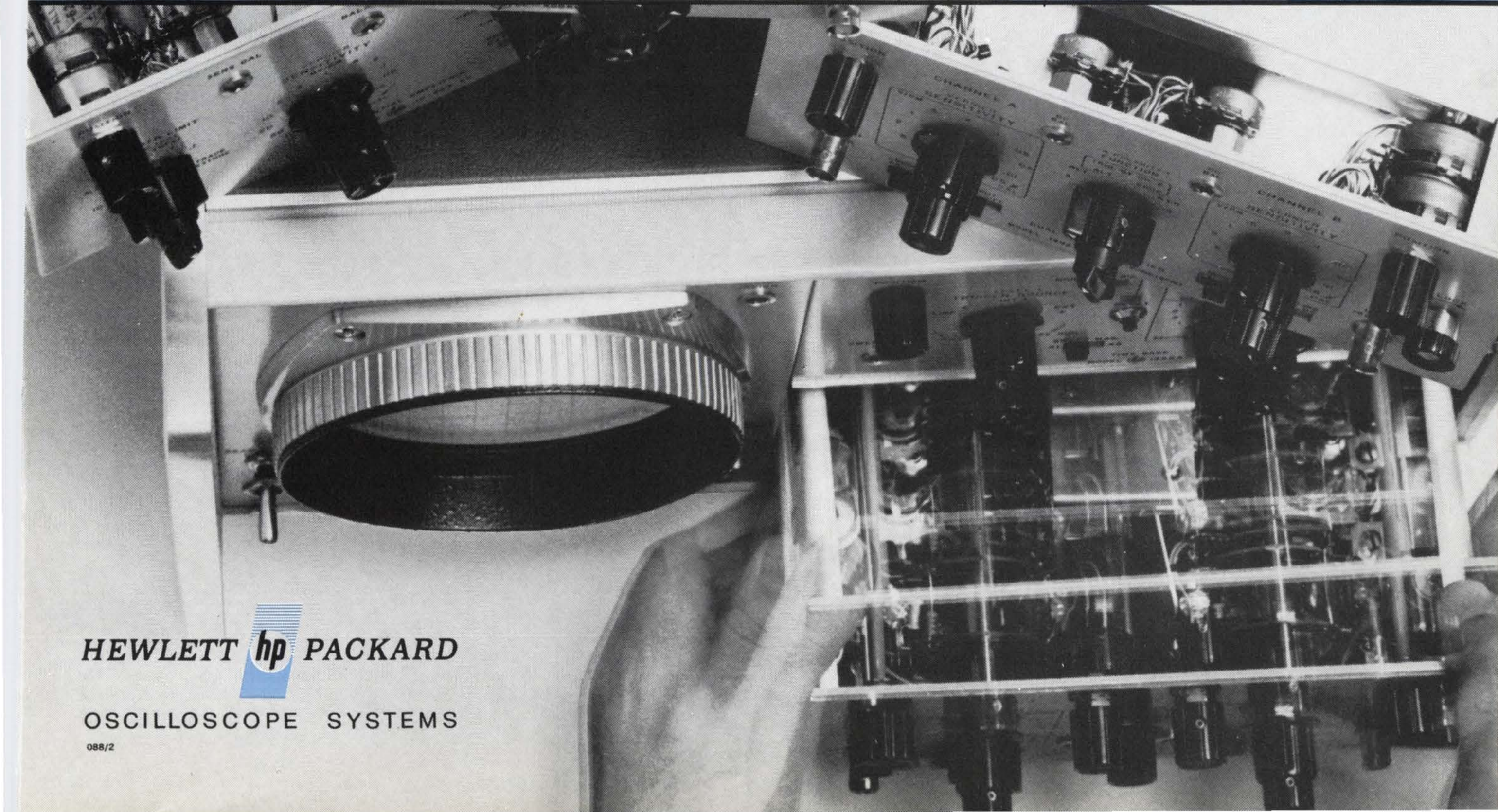
The hp 140 Scope System covers the entire oscilloscope spectrum from dc to 12.4 GHz with the extraordinary versatility you need to get step-ahead measurements—now and in the future!

Count these exclusive capabilities: hp's 140 Scope System is the only scope system to give you sampling bandwidth to 12.4 GHz . . . delayed sweep time base for sampling . . . 50 μV/cm sensitivity dc coupled *with no drift* . . . plus plug-ins for direct readout of TDR and swept frequency. In addition, it offers full plug-in compatibility with standard CRT persistence in the 140A mainframe—or optional variable persistence and storage in the 141A mainframe. Select from these unique capabilities for your special measurement requirements. For your all-around, day-to-day use, pick the 20 MHz, 5 mV/cm dual trace plug-in.

With 17 high-performance vertical and horizontal plug-ins and three remote sampling heads to choose from, you match your oscilloscope system to your measurement requirements. The selection chart shows how.

For the complete story on the scope system that gives you better performance in any direction—hp's 140 system—contact your nearest field engineer. Or, write to Hewlett-Packard, Palo Alto, California 94304. Europe: 54 Route des Acacias, Geneva. Price: 140A Mainframe, $595; 141A Variable Persistence and Storage Mainframe, $1395; plug-ins, $250 to $1600; samplers, $1000 to $3000. Circle 901 on reader service card

	VERTICAL PLUG-INS												COMPATIBLE TIME BASES						DBL. SIZE PLUG-INS	
hp 140 Scope System PLUG-IN CAPABILITIES	1400A	1401A	1402A	1403A	1405A	1406A	1407A	1410A	1411A	1430A	1431A	1432A	1420A	1421A	1422A	1423A	1424A	1425A	1415A	1416A
1. Wide Band			•		•								•	•		•				
2. Sampling								•	•	•	•	•					•	•		
3. High Gain Differential	•			•		•	•						•	•	•	•				
4. Dual Trace		•	•		•			•	•				•	•	•	•	•	•		
5. X-Y	•	•	•	•	•	•	•	•	•				•	•	•	•	•	•		
6. Delayed Sweep														•				•		
7. No Drift						•	•						•	•	•	•				
8. High Common Mode Rejection				•		•	•						•	•	•	•				
9. Algebraic Addition		•	•		•			•	•				•	•	•	•	•	•		
10. Time Domain Reflectometry																			•	
11. Wide Band TDR									•	•							•	•		
12. Swept Frequency																				•



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088/2