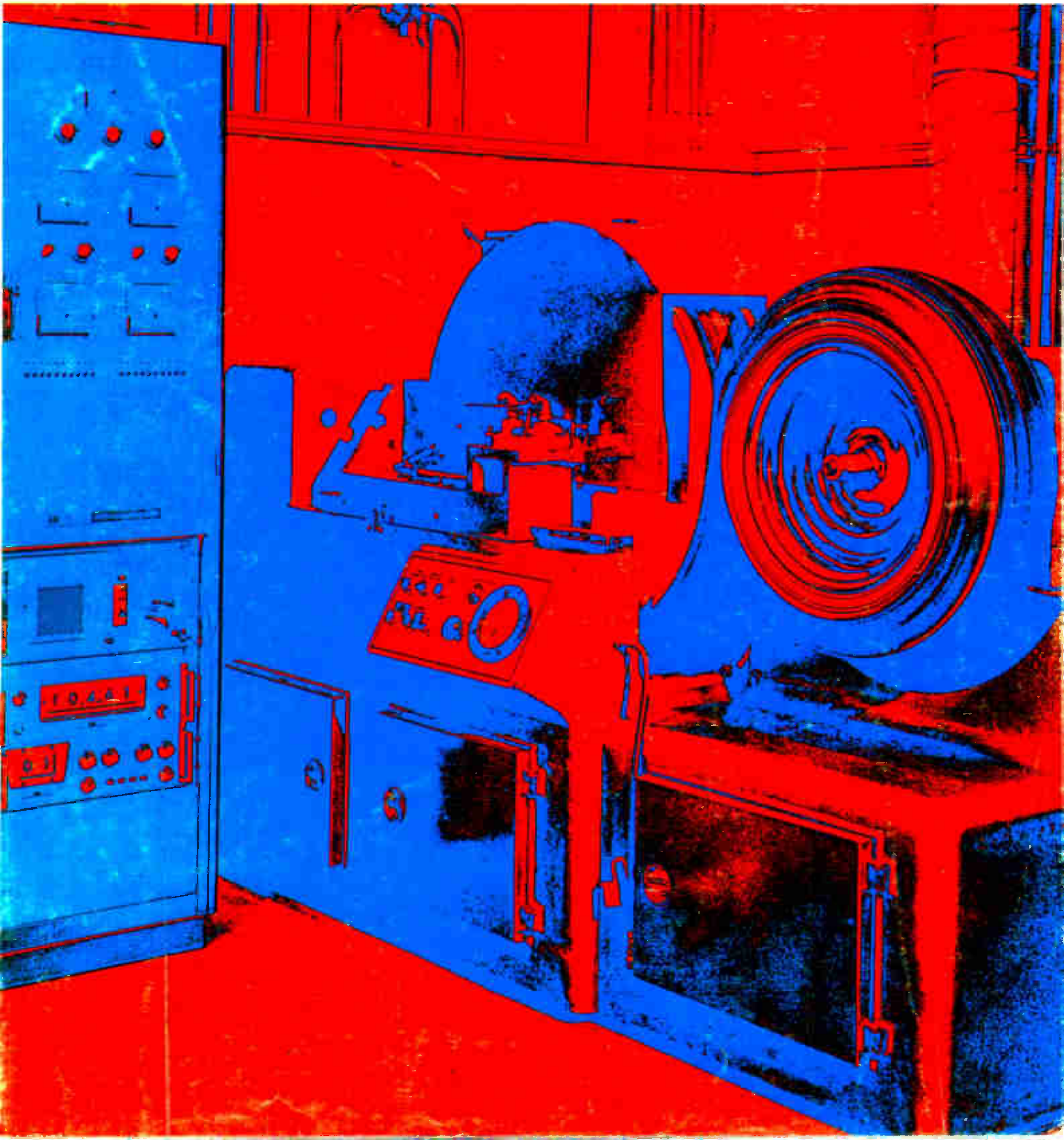
Electronics

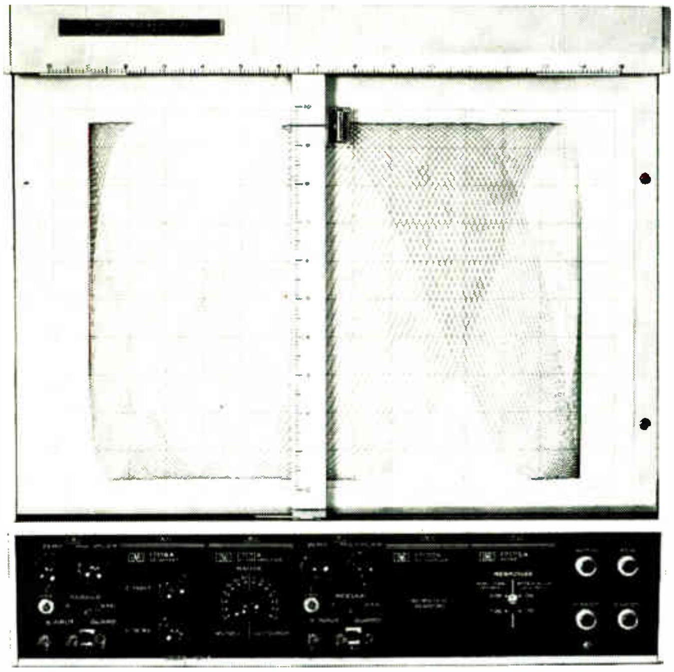
Progress in thin-film transistors: page 88
Using infrared for measuring: page 101
LSI cuts costs of small computers: page 119

March 18, 1968
$1.00
A McGraw-Hill Publication

Below: Analog computer checks new tire quality, page 125

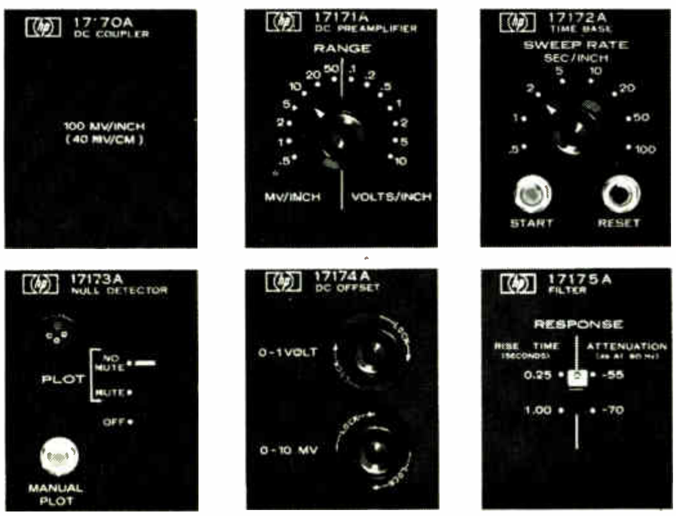


A new concept in x-y recording:



Something new has entered the X-Y recorder field. The new Hewlett-Packard 7004A X-Y Recorder, with dynamic performance of 1000"/sec^2 acceleration and slewing speed of 30"/sec—unparalleled in the recorder industry—offers plug-in convenience for unprecedented versatility in either analog *or* digital applications. SIX plug-ins let you convert this precision, solid-state 11" x 17" X-Y recorder into many different recorders—and either X-Y, Y-T or X-T operations—and the variations are nearly endless, because there are more to come.

Plug-in expandability with highest dynamic performance!



With plug-in units constantly being developed, the HP 7004A X-Y Recorder offers you guaranteed versatility combined with superior performance. Price: 7004A, $1295.

Here's what's available now:

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— Time base, 8 calibrated sweep speeds. $200.
— Null detector, up to 50 plots/second. $200.
— DC offset, continuously adjustable to 1 V. $100.
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For a complete brochure and data sheet call your local HP field engineer or write Hewlett-Packard, Palo Alto, California 94304; Europe: 54 Route des Acacias, Geneva.

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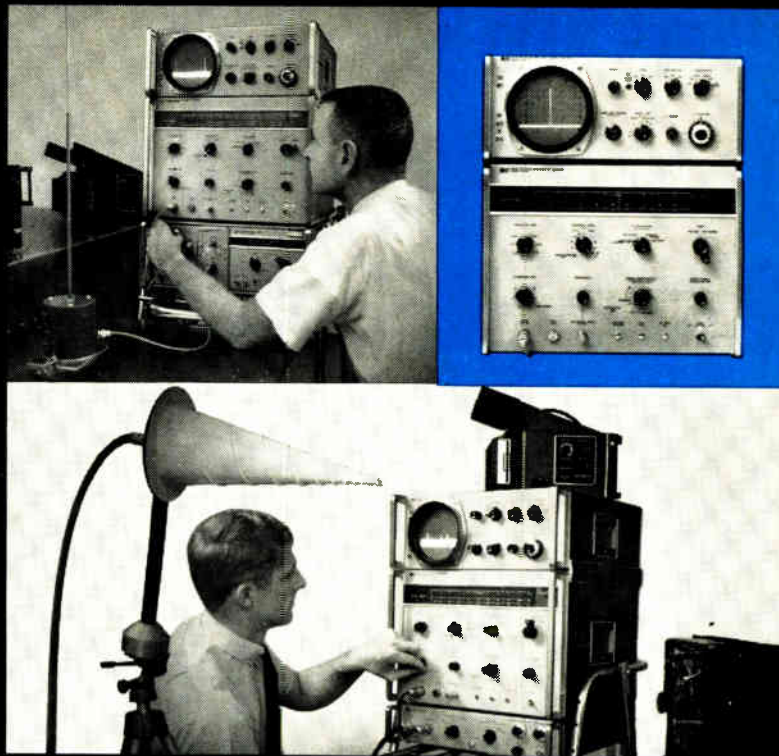
GRAPHIC RECORDERS

11706



Get quick relief from RFI measurement drudgery with this spectrum analyzer.

A wideband spectrum analyzer, by its nature, is well suited for analyzing electromagnetic interference (EMI). But Hewlett-Packard offers EMI/RFI specialists even more with the 8551B/851B Spectrum Analyzer. HP engineers have developed comprehensive, proven techniques by which the analyzer and associated equipment can make fast, accurate RFI tests whose results conform to modern EMC specs, such as MIL-STD-826A and 461/462/463.

In just a few hours, you can make measurements that used to take days. More extensive analyses that required weeks or months can be completed in days. The procedures cover 14 kHz to 10 GHz. They tell where and how to use the HP Up-Converter, YIG Preselector, and preamplification to comply fully with specified measurement conditions.

Substantial time-savings are achieved in both phases of RFI testing: system calibration and actual measurements. Absolute amplitude calibration, for "broadband" and "narrowband" conditions, is simplified because the 8551B/851B Analyzer's flat response and stable IF bandwidths minimize the number of calibration points.

Measurements are faster because calibrated scans as wide as 2 GHz let you cover the whole range quickly. And data logging with an oscilloscope camera is quick and conclusive.

The price of the Spectrum Analyzer is $7550 for the 8551B RF Section, $2400 for the 851B Display Section.

Call your local HP field engineer for more information about the HP 8551B/851B Spectrum Analyzer and its use in RFI measurements. Have him reserve your copy of the forthcoming Application Note 63E discussing RFI and the spectrum analyzer. Or write to Hewlett-Packard, Palo Alto, California 94304; Europe: 54 Route des Acacias, Geneva.

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SPECTRUM ANALYZERS

04802

Electronics

Volume 41, Number 6 March 18, 1968

News Features

Probing the News

Electronics Review

Electronics Abroad

New Products

Technical Articles

Departments

Electronics: March 18, 1968, Vol. 41, No. 6

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Readers Comment

Wrong number?

To the Editor:

You appear to have been misinformed regarding certain developments in the field of Belgian telecommunications [Dec. 25, 1967, p. 88].

We, as important manufacturers of telecommunications equipment in Belgium, were very surprised to find that there was no mention of our company, or of the 1,000-line electronic installation at Hasselt, about 25 miles from Antwerp, which was manufactured by our company and installed in June 1967. This installation, officially ordered by the Belgian telephone authorities, has been in public service with 700 subscribers connected since Dec. 18, 1967, and is itself incorporated in the national network. We can therefore honestly claim that this is the first electronic exchange to be actually installed and put into service in Belgium.

On the other hand the electronic exchange installed in Antwerp was never ordered by the telephone authorities who only agreed to its installation as a field trial. As a result, this exchange has certainly not been "put into service" by the Belgian government telephone authorities, as stated in your article.

E. M. Flamme
Automatic Electric S.A.
Antwerp
Belgium

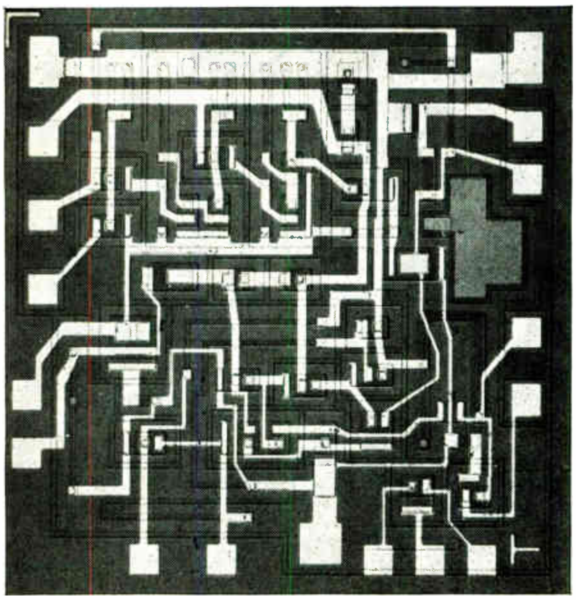
Low-cost dvm's

To the Editor:

I wish to correct the impression given in "Monitoring panels by the numbers" [Feb. 5, p. 172] that the panel meter replacement described will become the least expensive all-electronic digital panel meter.

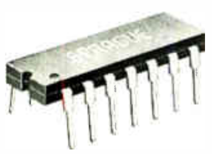
Gralex, a manufacturer of nanosecond/sub-nanosecond signal generation and measuring instruments, recently developed an all-electronic digital panel meter. The device, model 2103 digital voltmeter, also sells for $295 in small quantities, but a large quantity has recently been sold for considerably less. The device is aimed primarily at the OEM market where any param-

Here's a new linear IC from Sprague. The ULN-2111A.



It's a 3-stage 60 db broadband limiting amplifier and a balanced detector. A single-slug coil tunes it.

You can use it in TV sound channels and FM receivers, for SSB detection in mobile gear, in radar and TV AFC, and in telemetry receivers.



It comes in a 0-70 C DIP. And it's priced right...!

TYPE ULN-2111A SPECIFICATIONS

V_{CC}=12V, I_{CC}=16mA, P_D=200mW, bandwidth=5kHz—50MHz

Typical Characteristics for TV and FM Applications

	TV	FM	UNITS	CONDITIONS
F_O	4.5	10.7	MHz	
Dev.	±25	±75	kHz	
$V_{INJ.}$	60	60	mV rms	
Δf p-p	150	550	kHz	
V_{OUT}	0.60	0.50	V rms	R_L=2kΩ
V_{OUT}	0.35	0.30	V rms	R_L=200Ω*
Lim. Thr.	400	400	μV rms	—3db output
AM Suppr.	46	40	db	IHF-V_i—10mV
Cap. Ratio	—	1.4	db	IHF-30db-30%
THD	1.5	1.0	%	100% FM mod.
THD	0.6	0.4	%	30%FM mod.
Detuning	—	<±5	kHz	$0 < V_i < 0.5$ V rms

*Requires 1 kΩ, pin 1 to gnd.

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eter which can be converted to a d-c voltage must be measured accurately.

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As the price of integrated circuits decreases and LSI units become available it will probably be less than two years before the under-$100 dvm, predicted in your magazine, becomes a reality. We are actively pursuing that goal.

Paul Lenoble
Vice president
Gralex Industries Inc.
Copiague, N.Y.

Back issues

To the Editor:

The earliest solid state amplifications [Feb. 19, p. 82] may have been achieved early in 1920.

Two magazines, Radio News, and Science and Invention, reported in letters from readers some claims of getting amplification from crystal radio receivers. Two included circuit diagrams with descriptive details. One radio amateur experimenter included two "cat's whiskers" on a single crystal, battery and potentiometer. He was smart enough to know you could not get amplification with a rectifier, and thus attributed his highly superior results to the point of operation on the rectification curve. The other experimenter had a conventional crystal, but a circuit that included a battery voltage. He simply insisted he was getting amplification without a rational explanation for it (probably negative resistance).

The flurry of controversy over amplification with crystal detectors was suddenly put to an end by a more authoritative explanation of reradiation from vacuum tube regenerative receivers and a positive assertion that any exceptional crystal receiver operation was due to such a cause.

It would be interesting, if copies of these magazines still exist, to examine the circuit details to determine whether signal amplification was actually achieved.

Carl V. Erickson
Shawnee-Mission
Kansas

▪ The first description certainly sounds like the point-contact transistor; the second could well have been a negative resistance effect. Perhaps some reader can quote the "authoritative explanation" cited. It may have nipped the semiconductor industry of the 20's in the bud.

Not yet

To the Editor:

As sole agents in Japan of the English Electric Valve Co. of Chelmsford, England, we must inform you that our principals have not at present made a technical agreement with Shiba Denki K.K. for the manufacture of high power klystrons [Jan. 22, p. 192] and it will be appreciated if you will advise your readers of this fact.

R. S. Weem
Cornes & Co., Ltd.
Tokyo

▪ Shiba says it has a letter of intent from the British company and expects that an agreement will be signed soon.

People

The assigned tasks of IBM's Center for Exploratory Studies have been broad, ranging from a major effort in advanced laser development to smaller studies of new approaches to criminology. The effect has been to help get IBM's fingers into an increasing number of pies. Albert E. Babbitt, 40, the new director of the center plans to continue to broaden the scope and complexity of the center's activities.

Albert E. Babbitt

Without setting priorities or tipping the International Business Machines Corp.'s hand on its latest emphasis, Babbitt outlines some projects he will direct at the Rockville, Md., center. He says the center will continue to emphasize lasers and laser application, but that other work will get new attention. He says, "We are very interested in the development of new classes of sensors and the control of these sensors by computer." Development of digital sensors are particularly appropriate at the center, he adds.

More computers. Babbitt sees a major interest in the new roles for computers. "We will certainly be increasingly concerned with the use of computers in bigger systems, such as massive control and data communications systems."

Babbitt sees an increasing place for the computers as a tool in the design of new systems.

In the Mallard program—a four-nation tactical communications system now in early development at IBM and other firms—he says the system design is being simulated and evaluated by computer.

He moves from his job as manager of advanced development for the Federal Systems Center where, among other things, he headed the Mallard program for IBM. Now, four months into the 19-month Mallard research and development schedule, IBM is taking no chances and is moving the program to the center along with Babbitt.

People

C. Raymond Harmon, the new president of the acquisition-minded Electronic Specialty Co., predicts that the firm will add a new technology emphasis in 1968: automation. "Right now we're talking with five or six companies whose business is related to a broad-based field of automated labor-saving technology," he points out.

Raymond Harmon

"Examples of the possible specialties this will cover are bottling and packaging, material handling and transfer, inspection, and quality control," Harmon says. "I figure we'll be taking some action on acquisitions soon and may be creating a new group before the end of the year."

Another Harmon forecast: Electronic Specialty will deemphasize its military business, from 40% in 1966 to 15% to 20% by 1970.

When laser pioneer Theodore Maiman resigned as head of the Korad Corp. [Electronics, Dec. 11, 1967, p. 8]—apparently in a dispute over the Union Carbide Corp.'s move to absorb the operation—Clayton Zerby was named as his replacement.

The 43-year-old general manager of what is now a department of Union Carbide's Electronics division sees a shift in operational emphasis. Korad, he explains, has always sold most of its lasers to universities and scientific laboratories; only about 30% have gone to the military. But Zerby expects the defense sector to account for much more of Korad's future laser business. The company has already furnished laser artillery rangefinders to the Army.

Zerby asserts that absorption into the Electronics division has not and will not change Korad's makeup. The unit will remain an autonomous organization, he declares.

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Meetings

International Convention, Aerospace and Electronics Systems of IEEE; Warwick Hotel, New York, **March 19.**

Modulation Transfer Function, Society of Photo-Optical Instrumentation Engineers; Boston, **March 21-22.**

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

Flight Test Simulation and Support Conference, American Institute of Aeronautics and Astronautics; Los Angeles, **March 25-27.**

International Aerospace Instrumentation Symposium, College of Aeronautics and Instrument Society of America; Cranfield, England, **March 25-28.**

Quality Control Conference, American Society for Quality Control; University of Rochester, N.Y., **March 26.**

Railroad Conference, IEEE and American Society of Mechanical Engineers; Conrad Hilton Hotel, Chicago, **March 27-28.**

Electrical Engineers Exhibition, American Society of Electrical Engineers; London, **March 27-April 3.**

International Conference on Color Television, Electronic Industries Association of France; Paris, **April 1-5.**

International Components Show, Federation Nationale des Industries Electronique; Paris, **April 1-6.**

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

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

Meeting and Technical Conference of the Numerical Control Society; Marriott Motor Hotel, Philadelphia, **April 3-5.**

Symposium on Engineering Aspects of Magnetohydrodynamics, American Institute of Aeronautics and Astronautics, University of Tennessee, Tullahoma, **April 3-5.**

Conference on Thick Film Technology; Institution of Electronic and Radio Engineers; London, **April 8-9.**

Aerodynamic Testing Conference, American Institute of Aeronautics and Astronautics; Sir Frances Drake Hotel, San Francisco, **April 8-10.**

Frequency Control Symposium, U.S. Army Electronics Command; Shelburne Hotel, Atlantic City, N.J., **April 22-24.***

Short Courses

Electronic materials and devices, Fairleigh Dickinson University's College of Science and Engineering, Teaneck, N.J., **March 25-26;** $100.

Fundamentals of statistical quality control, University of Wisconsin's College of Engineering, Madison, **April 1-4;** $90.

Radiation effects in semiconductors and interaction processes, University of Michigan, Ann Arbor, Mich., **May 20-31; $325.**

Call for papers

International Antennas and Propagation Symposium, IEEE; Northeastern University, Boston, Sept. 9-11. **June 1** is deadline for submission of summaries to Leon J. Ricardi, Massachusetts Institute of Technology, Lincoln Laboratory, P.O. Box 73, Lexington, Mass. 02173.

Symposium of the American Vacuum Society, Pittsburgh Hilton Hotel, Pittsburgh, Oct. 30-Nov. 1. **June 15** is deadline for submission of abstracts to W.J. Lange, the Westinghouse Electric Corp., R&O Center, Churchill Boro, Pittsburgh, Pa. 15235.

Meeting of the Union Radio Scientific International, Union Radio Scientific International; Northeastern University, Boston, Sept. 10-12. **June 21** is deadline for submission of abstracts to Leon J. Ricardi, Massachusetts Institute of Technology, Lincoln Laboratory, P.O. Box 73, Lexington, Mass. 02173.

Engineering in Medicine and Biology Conference, IEEE; Shamrock-Hilton Hotel, Houston, Texas, Nov. 17-21. Upon receipt of title and identification of category of proposed paper, an author's kit will be forwarded. Completed papers must be submitted by **June 30.**

* Meeting preview on page 16.

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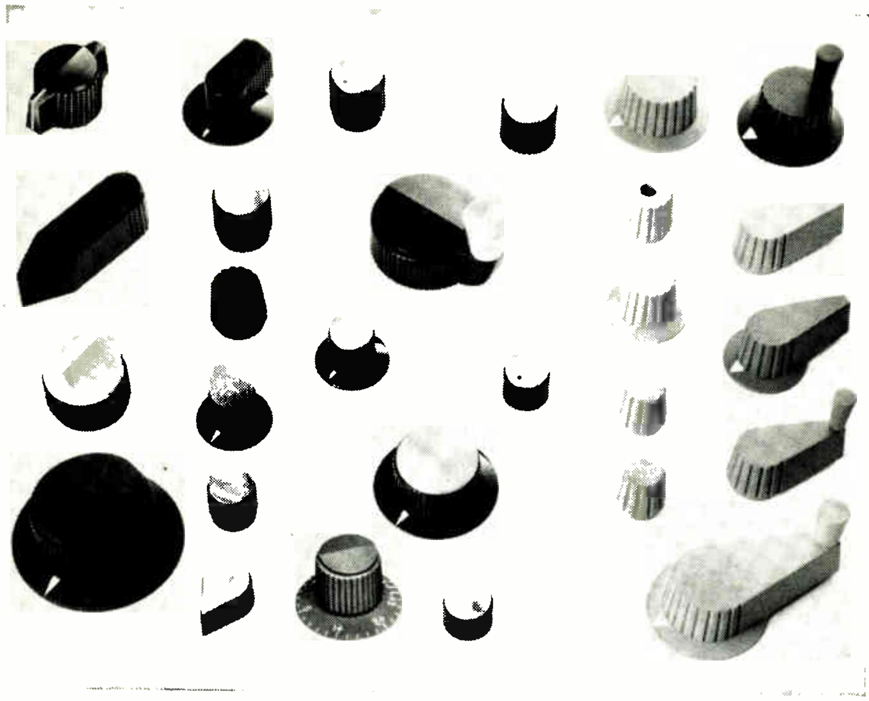

Meeting preview

Frequency control

The annual Frequency Control Symposium is not as narrow as its title might suggest.

Engineers attending this year's meeting in Atlantic City, N.J., April 22 to 24, should come away with a good grasp of the latest theoretical and practical advancements in areas ranging from quartz crystal research to the development of atomic frequency standards.

In a session on crystal measurement, papers by engineers from Hewlett-Packard's Frequency and Time division, Palo Alto, Calif., and Western Electric Co., North Andover, Mass., will describe new and more accurate techniques for measuring crystal resonance parameters. Both approaches involve a vector voltmeter and a computer to gather phase data, a departure from the IEEE standard, which is based on the amplitude of the voltage.

New devices. Also to be described will be two new instruments developed under contract to Army Electronics Command, Fort Monmouth, N.J. One, an active measurement system, is a new generation of crystal-impedance meters. The other, a servo bridge system, measures phase and uses the crystal being tested as the determining element in a passive system.

In a session on crystalline material properties, Raymond D. Mindlin, a professor at Columbia University's School of Engineering and Applied Sciences, will deliver a paper on electromagnetic interaction in nonpiezoelectric crystals.

The session on the use of filters and other resonators will discuss replacing a transformer with several acoustically coupled resonators implanted on a single crystal blank. Engineers from the Toyo Communication Equipment Co., Kawasaki, Japan, the Bell Telephone Laboratories, Allentown, Pa., and the Autonetics division of the North American Rockwell Corp., Anaheim, Calif., will contribute papers.

For more information contact A. D. Ballato, U.S. Army Electronics Components Laboratory, Fort Monmouth, N.J.

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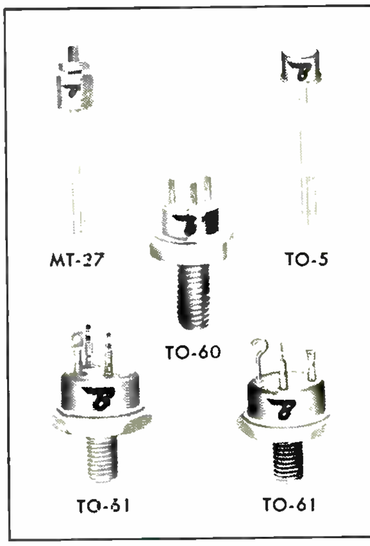
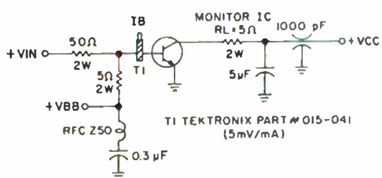
					SWITCHING TIME				
h_{FE}	V_{CEO}	I_C (max.)	V_{CE}(sat)	P_T	t on ns	t off ns	@ I_C A	@ $\pm I_B$ mA	TYPE
25 min. @ 2A, 10V	40V	3A	0.5V max. @ 1A, 0.1A		35	75	1.5	150	2N4225
80 min. @ 3A, 10V	40 to 80V	5A	0.75V max. @ 3A, 0.3A		40	300	3.0	300	B-143002, 5, 8 B-143017, 20, 23
20 min. @ 5A, 10V		10A	1V max. @ 5A, 0.5A	25W to 50W					B-144002, 5, 8 B-145002, 5, 8 B-146002, 5, 8
15 min. @ 10A, 5V	60 to 100V	15A	1.5V max. @ 15A, 3A	100W 60W	225	600	10	1,000	B-148002, 3, 5 B-155002, 3, 5
20 min. @ 10A, 5V		20A	1.5V max. @ 20A, 4A	100W 60W					B-148000, 1, 4 B-155000, 1, 4



(SATURATED SWITCHING TEST CIRCUIT DIAGRAM FOR B-148000 & B-155000)



Maximum Switching Times: td $\leq$ 25 ns; tr $<$ 200 ns; ts $\leq$ 300 ns; tf $<$ 300 ns. **Test Conditions:** $V_{in} = 70V$ when generator with 50Ω internal impedance is terminated in a 50Ω load. VBB = −5V; VCC = 55V; IC ≈ 10A; $IB_1 \approx 1A$; $IB_2 \approx 1A$; tp = 400 ns; f = 720 Hz.

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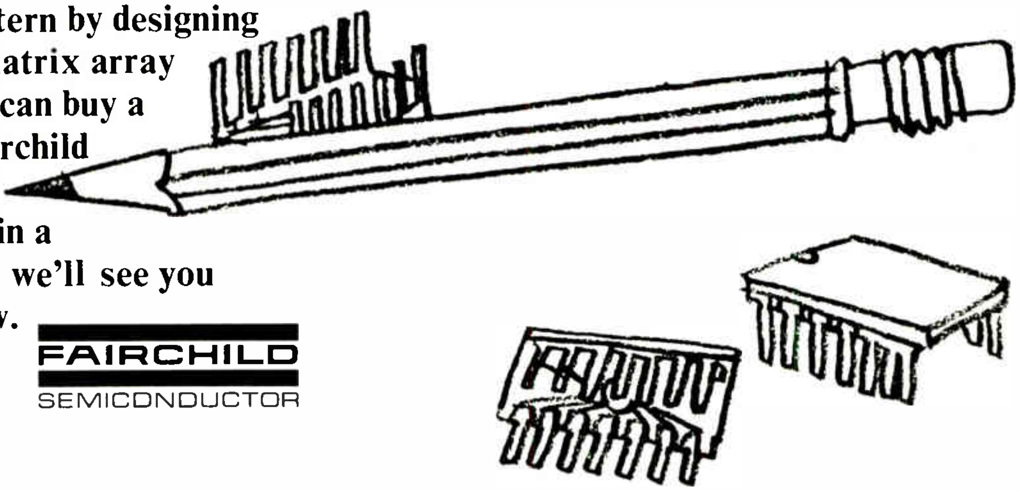

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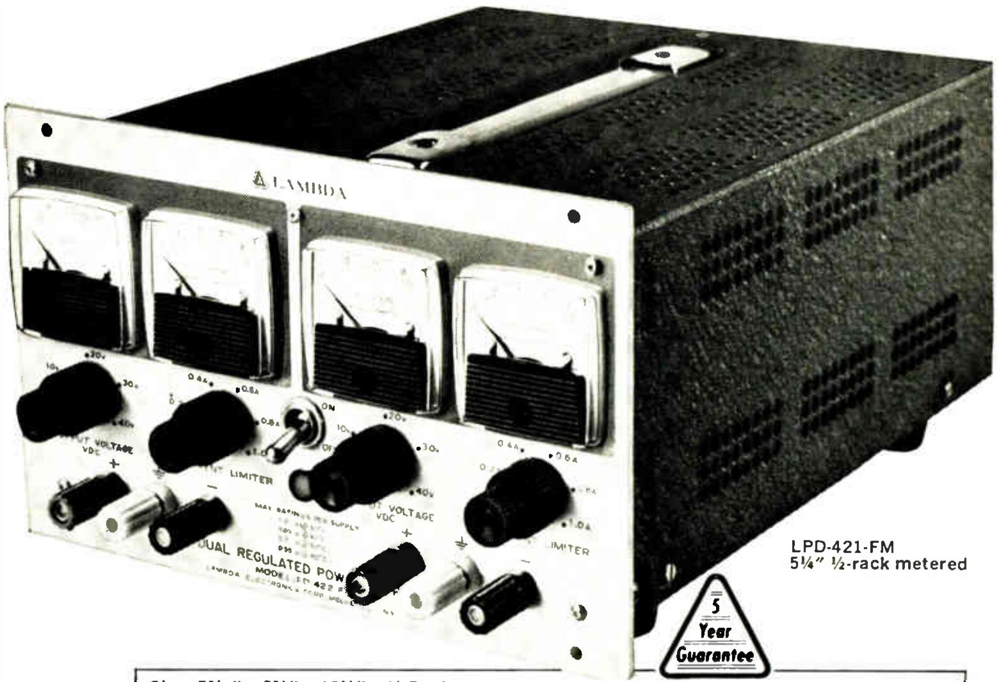
FAIRCHILD SEMICONDUCTOR A Division of Fairchild Camera and Instrument Corporation 313 Fairchild Drive, Mountain View, California 94040, (415) 962-5011 TWX: 910-379-6435

Circle 19 on reader service card

NEW Lambda dual output lab the power plus output ranges



LPD-421-FM
5¼″ ½-rack metered

plus–

5 Models with two independent DC outputs offer widest choice—Up to ±250 VDC, up to 1.7 amps. Either output may be + or —, or both outputs may be + or —.

Series/Parallel operation of both outputs yields two times the voltage or two times the current—up to 500 volts or up to 3.4 amps.

Auto Series/Auto Parallel (master slave) permits tracking to a common reference.

4 Meters provide simultaneous monitoring of both voltage and current.

Most power in a half-rack package.

Overvoltage Protection as an accessory.

Compatible with LP, LH and LK Series rack adapters and other accessories.

Multi-Current-Rated—Only dual power supplies on market with this advanced design feature.

Regulation: .01% + 1mV.

Ripple: 500μ VRMS (1.5mVp-p).

Size: 5³⁄₁₆″ x 8⅜″ x 10⅝″ ½ Rack • LPD Series

	Voltage Range Per output/ **Outputs in series**	I MAX AMPS AT AMBIENT OF: (1) Per output/**Outputs in parallel**				Price(2) US and Canada
Model(2)	VDC	30°C	40°C	50°C	60°C	
LPD-421-FM	0-±20/**0-40**	1.7A/**3.4A**	1.5A/**3.0A**	1.3A/**2.6A**	0.9A/**1.8A**	$325
LPD-422-FM	0-±40/**0-80**	1.0A/**2.0A**	0.85A/**1.7A**	0.7A/**1.4A**	0.55A/**1.1A**	260
LPD-423-FM	0-±60/**0-120**	0.7A/**1.4A**	0.6A/**1.2A**	0.5A/**1.0A**	0.4A/**0.8A**	325
LPD-424-FM	0-±120/**0-240**	0.38A/**0.76A**	0.32A/**0.64A**	0.26A/**0.52A**	0.20A/**0.40A**	325
LPD-425-FM	0-±250/**0-500**	0.13A/**0.26A**	0.12A/**0.24A**	0.11A/**0.22A**	0.10A/**0.20A**	350

(1) Current rating applies over entire voltage range. Ratings based on 57-63 Hz operation.
(2) Prices are for metered models. LPD Series models are not available without meters.

Overvoltage Protection
Available as bolt-on accessory for all LP and LPD models and LK-LH models with suffix (A). For LPD models, each output requires separate OV accessory.

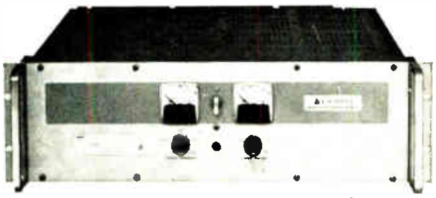
For use with	Model	Adj. Volt Range	Price
0-10, 0-20 V Models*	LH-OV-4	3-24V	$35
0-36, 0-40 V Models*	LH-OV-5	3-47V	35
0-60 V Models*	LH-OV-6	3-70V	35

*Except for Full-Rack LK models. Overvoltage protection for full-rack models to 70 VDC is available as a built-in option. To order add suffix (-OV) and add $90 to the price of models LK-350—352; add $120 for models LK-360-FM—362-FM.

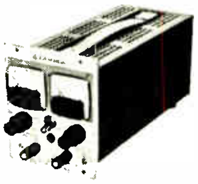
LAMBDA

supplies give you twice never before available...

LK-350-FM 5¼″ full-rack metered



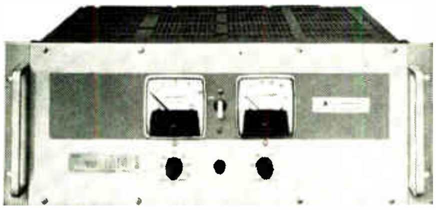
LP-410-FM
5¼″ ¼-rack metered



LH-118-A-FM
5¼″ ¼-rack metered

LK-340-A-FM
5¼″ ½-rack metered
(LH series ½-rack models same size)

LK-360-FM 7″ full-rack metered



or choose from these ¼, ½ and full-rack Lambda supplies

Size 5³⁄₁₆″ x 4³⁄₁₆″ x 10″ ¼ Rack • LP Series

Model[2]	Voltage Range	CURRENT RANGE AT AMBIENT OF:[1]				Price[2]
		30°C	40°C	50°C	60°C	
LP 410	0-10 VDC	0-2A	0-1.8A	0-1.6A	0-1.4A	$129
LP 411	0-20 VDC	0-1.2A	0-1.1A	0-1.0A	0-0.8A	119
LP 412	0-40 VDC	0-0.70A	0-0.65A	0-0.60A	0-0.50A	114
LP 413	0-60 VDC	0-0.45A	0-0.41A	0-0.37A	0-0.33A	129
LP 414	0-120 VDC	0-0.20A	0-0.18A	0-0.16A	0-0.12A	149
LP 415	0-250 VDC	0-80mA	0-72mA	0-65mA	0-60mA	164

Size 5³⁄₁₆″ x 4³⁄₁₆″ x 15½″ ¼ Rack • LH Series

Model[2]	Voltage Range	CURRENT RANGE AT AMBIENT OF:[1]				Price[2]
		30°C	50°C	60°C	71°C	
LH 118A	0–10VDC	0–4.0A	0–3.5A	0–2.9A	0–2.3A	$180
LH 121A	0–20VDC	0–2.4A	0–2.2A	0–1.8A	0–1.5A	170
LH 124A	0–40VDC	0–1.3A	0–1.1A	0–0.9A	0–0.7A	170
LH 127A	0–60VDC	0–0.9A	0–0.7A	0–0.6A	0–0.5A	185
LH 130A	0–120VDC	0–0.50A	0–0.40A	0–0.35A	0–0.25A	240

Size 5³⁄₁₆″ x 8⅜″ x 15⅝″ ½ Rack • LH Series

Model[2]	Voltage Range	CURRENT RANGE AT AMBIENT OF:[1]				Price[2]
		30°C	50°C	60°C	71°C	
LH 119A	0–10VDC	0– 9.0A	0– 8.0A	0– 6.9A	0–5.8A	$289
LH 122A	0–20VDC	0– 5.7A	0– 4.7A	0– 4.0A	0–3.3A	260
LH 125A	0–40VDC	0– 3.0A	0– 2.7A	0– 2.3A	0–1.9A	269
LH 128A	0–60VDC	0– 2.4A	0– 2.1A	0– 1.8A	0–1.5A	315
LH 131A	0–120VDC	0– 1.2A	0– 0.9A	0– 0.8A	0–0.6A	320

Size 5³⁄₁₆″ x 8⅜″ x 15⅝″ ½ Rack • LK Series

Model[2]	Voltage Range	CURRENT RANGE AT AMBIENT OF:[1]				Price[2]
		40°C	50°C	60°C	71°C	
LK 340A	0–20VDC	0– 8.0A	0– 7.0A	0– 6.1A	0–4.9A	$330
LK 341A	0–20VDC	0–13.5A	0–11.0A	0–10.0A	0–7.7A	385
LK 342A	0–36VDC	0– 5.2A	0– 5.0A	0– 4.5A	0–3.7A	335
LK 343A	0–36VDC	0– 9.0A	0– 8.5A	0– 7.6A	0–6.1A	395
LK 344A	0–60VDC	0– 4.0A	0– 3.5A	0– 3.0A	0–2.5A	340
LK 345A	0–60VDC	0– 6.0A	0– 5.2A	0– 4.5A	0–4.0A	395

Size 5¼″ x 19″ x 16½″ Full Rack • LK Series

Model[2]	Voltage Range	CURRENT RANGE AT AMBIENT OF:[1]				Price[2]
		40°C	50°C	60°C	71°C	
LK 350	0–20VDC	0–35A	0–31A	0–26A	0–20A	$675
LK 351	0–36VDC	0–25A	0–23A	0–20A	0–15A	640
LK 352	0–60VDC	0–15A	0–14A	0–12.5A	0–10A	650

Size 7″ x 19″ x 18½″ Full Rack • LK Series

Model[2]	Voltage Range	CURRENT RANGE AT AMBIENT OF:[1]				Price[2]
		40°C	50°C	60°C	71°C	
LK 360 FM	0–20VDC	0–66A	0–59A	0–50A	0–40A	$995
LK 361 FM	0–36VDC	0–48A	0–43A	0–36A	0–30A	950
LK 362 FM	0–60VDC	0–25A	0–24A	0–22A	0–19A	995

LP NOTES

1 Current rating applies over entire voltage range. Ratings based on 57-63 Hz operation.

2 Prices are for non-metered models. For metered models, add suffix (-FM) and add $10.00 to price.

LK-LH NOTES:

1 Current rating applies over entire voltage range.

2 Prices effective Feb. 1, 1968. Prices are for non-metered models (except for models LK360FM, LK361FM, and LK362FM which are metered models not available without meters). For metered models, add suffix (-FM) and add $30.00 to price.

3 Chassis slides for full-rack models: Add suffix (-CS) and add $60 to the price of LK-350–352; add $100 to the price of LK-360-FM–362-FM.

ACCESSORIES

Rack Adapter LRA-1 — 5¼″ Height x 16½″ Depth (For use with chassis slides)—Price $60.00

Rack Adapter LRA-2 — 5¼″ Height — Price $35.00

Blank Front Panels — Model LBP-10 (¼ rack size) — Price $5.00 — Model LBP-20 (½ rack size) — Price $10.00

Blank Chassis — with Blank Front Panels — Model LBC-10 (¼ rack size) — Price $25.00 — Model LBC-20 (½ rack size) — Price $35.00

CHASSIS SLIDES: To order LRA-1 with chassis slides order LRA-1-CS, and add $50.00 to price.

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Circle 251 on reader service card

Which IC Test System does all these things?

DIAGNOSTIC COMPUTER PROGRAMS automatically check out system operation.

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

TYPED SUMMARY SHEETS. Whenever desired. No interruption in testing. Give total units tested per test station, test yields and bin yields.

DIRECT ENGLISH data logging type-out, showing job name, serial number, test number, decimal point and units.

ABSOLUTE SOURCE CONTROL. Sources can be turned ON or OFF and changed in value in any sequence with variable delays from 100 µsec. to as long as you please.

DATALOG at any test station—without slowing down classification tests at any other station.

MULTIPLEXING. Several jobs simultaneously. Any assigned, at any time, to any test station.

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

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

GROWING LIBRARY of improved software packages to insure against obsolescence.

FAST TESTING. 1.5 msec per test. If crosspoint is changed, 5 msec. 10 msec on the lowest current scales.

TEN-YEAR GUARANTEE for all instrument plug-in circuitry (it's almost all plug-in).

NO ADJUSTMENT OR CALIBRATION POINTS. (Eternal vigilance is the price you pay for a single adjustment.)

OPEN AND SHORTED CONNECTIONS and **OSCILLATIONS** are automatically detected. System stops when a selected consecutive number of these occur.

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

MINIMIZED REPETITIVE INSTRUCTIONS for the operator through data libraries, variable word length programming, and autopinning.

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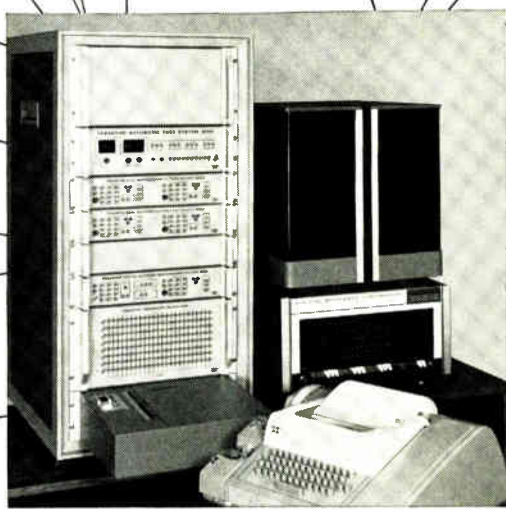

This one.

(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

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Commentary

Copying may not work

Europeans are not as awed by U.S. technology as they once were. Rather, they envy the entrepreneurship that successfully turns that technology into products.

Foreign businessmen are inclined to view the American tycoon as a student does his teacher—needing and respecting him, but wanting ultimately to surpass him.

European companies that seek to emulate their successful U.S. counterparts try to analyze what we are doing that they are not. They put our Government's support for new ideas and techniques high on the list. They are aware that it is the size of many U.S. corporations that permits them to risk significant portions of their profits to develop products that may not pay off. Finally, they cite the ready availability of hard cash from private sources in the U.S.

The Europeans see their own prospects dimmed by the absence of these factors and are constantly amazed at the U.S.'s ability to plow profits back into its domestic operations, build plants overseas and invest in European countries at the same time. Europeans watched U.S. direct private investments in their countries double three times over the 15 year period beginning in 1951. Adding to their consternation, sales of U.S. products abroad kept climbing; last year the electronics industry recorded foreign sales of $1.4 billion, up 25% from 1966.

While Europe's own products have languished in its laboratories, European companies have had to pay royalties on products they make under U.S. licenses.

Flattering as it would be to have Europe copy the U.S. techniques it covets, such an approach may not work. Europe's troubles may be symptomatic of a more basic problem—a prevailing attitude of caution and conservatism. John Diebold, writing in the January issue of Foreign Affairs, says: "Competition and the need to innovate generally are deprecated in Europe. Indeed, the role of European governments is often to protect against innovation, and private enterprises too generally prefer to let others do the hard work of breaking new ground, while hoping that future developments will not profoundly affect traditional ways of doing things."

Richard Nelson, of the Rand Corporation, argues that giant corporations and government funding in the U.S. are not necessarily the cause of Europe's lag; the lag existed long before either, he notes, and he warns that recent thinking in Europe would replace private competition with government control of research and development.

The inferior results achieved in Europe, set against the successes of the Americans, may be an incentive to European businessmen to change their ways. But American methods cannot be used as a cookbook; merely embracing proven management techniques will not suffice. Problems unique to Europe must be tackled. Among them is the morass of patent and corporation laws that vary so much from country to country that cross-licensing and marketing agreements are difficult to make. A consortium of European countries might tackle the problem of standardizing such laws. The real danger could be that such a union might go beyond its initial charter. It could wind up controlling the very firms it hopes to assist, and stifle beneficial competition among them.

Without the enthusiasm and enterprise of European businessmen, even a union of European states might not be enough to close the gap.

Unjamming the spectrum

Mushrooming use of land mobile radio-frequency bands in metropolitan areas has seriously overcrowded the spectrum. In New York City alone, an average of 47 licensees representing more than 400 mobile units squeeze into each channel of the business service band. Some relief came last month when the FCC doubled the number of assignable channels in the 450- to 470-Mhz band [Electronics, Feb. 19, p. 56].

The irony of the situation is that many frequencies go begging because they're set aside for future use for television and by the government. In Los Angeles, only 60% of the frequencies suitable for land mobile communications are actually used; the rest are reserved.

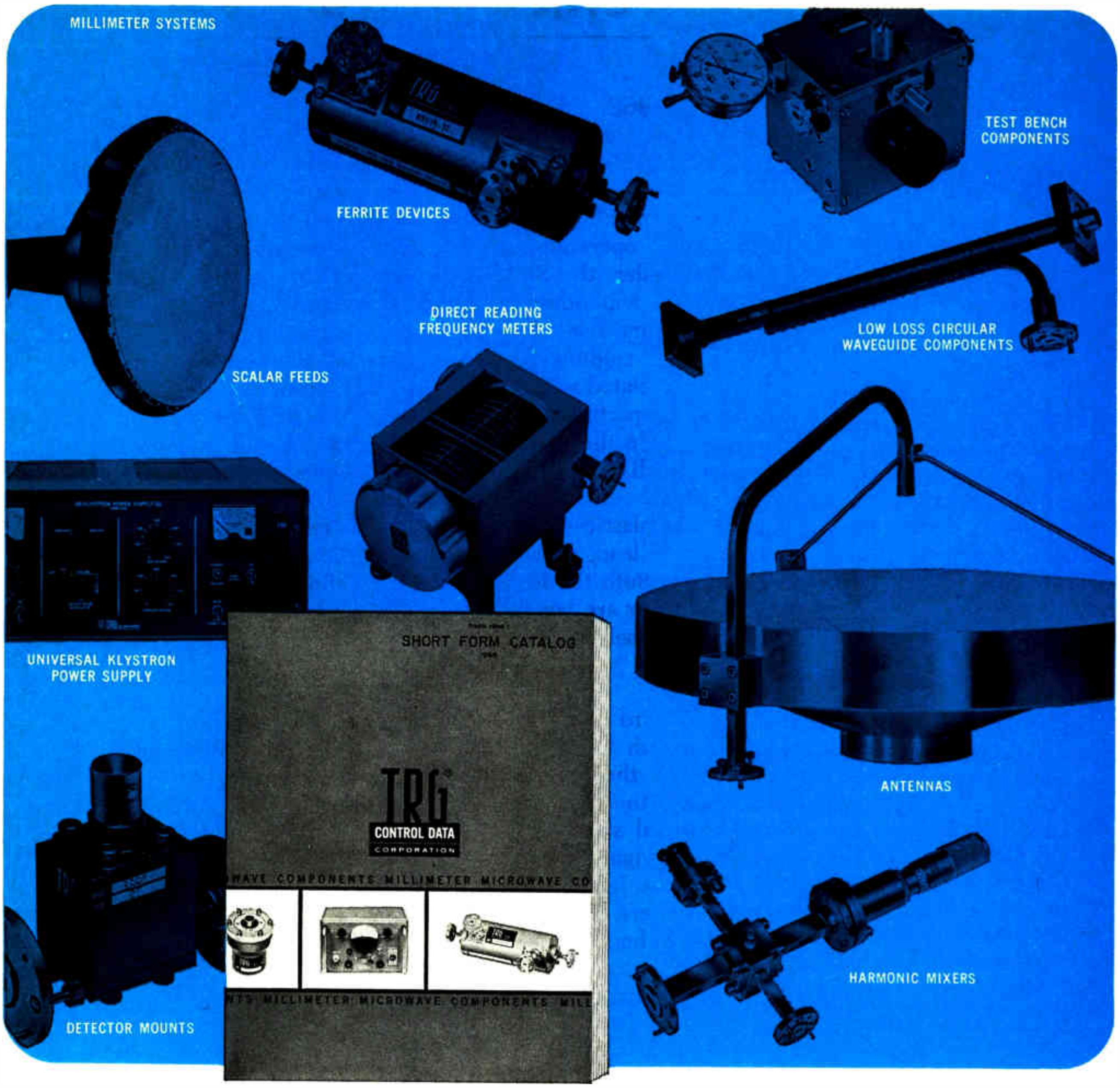
A few years ago, the FCC offered the reserve frequencies to secondary users on a temporary basis—until they were claimed by the primary licensees. There were few takers—secondary users weren't willing to risk buying gear that might become obsolete overnight.

Alan S. Boyd, Secretary of Transportation, now proposes a plan that could void the risk. A secondary user would not be licensed for a specific frequency, but rather for a service. A leasing agency could keep track of the unused frequencies and assign them to subscribers, delivering and installing equipment tuned to the proper frequencies. When a principal user claimed his right to a frequency, the agency would reassign the secondary user to another, still unused, frequency and would modify or exchange his gear.

Whether Secretary Boyd's plan can work hinges on the answers to these questions:

- Will the use of dormant tv channels by mobile units cause interference with adjacent tv channels?
- Can cooperative arrangements be worked out among leasing companies so that equipment no longer usable in one geographical area can be traded off to another area?
- Will manufacturers be willing and able to design gear with the required flexibility ?
- Will it be possible to work out an efficient (perhaps computerized) record-keeping system for frequency assignments?
- Can frequency-assignments be juggled rapidly enough to avoid disruption of service to subscribers and still meet FCC requirements?

The answers to these questions are not immediately clear. Should they be affirmative, the payoff could be handsome. In Los Angeles, for example, 750 wasted channels might be put on the air in just a year.



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This 20-page, short-form catalog contains all the important specifications on products available for Ku and K bands, as well as A, B, V, E, W, F, D, and G bands. To get your copy, contact your TRG representative or write TRG, 404 Border Street, East Boston, Massachusetts 02128. Tel. (617) 569-2110.

TRG DIVISION CONTROL DATA CORPORATION

Electronics Newsletter

March 18, 1968

Fairchild takes the plastic plunge

At least one group in the Fairchild Semiconductor division doesn't share the firm's general skepticism about plastic packages. **The division's hybrid-circuit operation will introduce a plastic-packaged version of its biggest seller, the SH2002 high-power driver,** as its first move in a campaign to win industrial customers and so reduce its present dependence on military sales. Fairchild feels the plastic package—believed to be silicone—is suitable for some industrial uses because **the moisture problems associated with plastic aren't significant at lower temperatures.** The hybrid department has also developed a new silicone resin to coat the chips inside the package. The price in 100-unit lots will be $3.95, a couple of dollars less than the price of the industrial version in a TO-5 can.

Inside the plastic encapsulation of the "mini-dip"—so called because it has only 10 leads on a tiny dual in-line package—is another surprise: no substrate. **Both the logic chip, a Fairchild 932 DTL circuit, and the power transistor are bonded directly to the lead frame,** which is etched so the frame itself forms the conductive path.

Nortronics tying up Omega market

The Navy award of a $1 million contract to Northrop's Nortronics division this month to develop airborne Omega navigation receivers **just about sews up the Omega receiver market for this company.** Nortronics already holds the contract for the shipboard models and is cranking up for commercial sales [Electronics, July 19, 1967, p. 48]. Omega is a worldwide navigation aid that operates on low-frequency beacons.

The firm also holds an option to build two service models of airborne Omega receivers, a contract that could mean an additional $290,000. **The company hopes for a production contract in about a year.** The airborne receiver market is estimated at $300 million to $500 million, and the shipboard market will probably be even more lucrative.

Fairchild's loss: an inside look

The Draconian measures taken by Richard Hodgson when he took over as chief executive officer of Fairchild Camera & Instrument last fall resulted in a loss for fiscal 1967 staggering even to the most optimistic stock analyst. **Although the company had an operating profit, inventory writeoffs and losses from the sale of the Davidson and Du Mont divisions and the memory products group of the Semiconductor division resulted in a net loss of $7,699,000.**

But at the Semiconductor division, long relied on to make up deficits from the unprofitable divisions, there was something like a sigh of relief. "**The strain on us to make ridiculously high profits was fantastic,**" said one Semiconductor hand. "Now we're back to a normal 6% to 7% after taxes."

Firms study NASA microcircuit specs

Four semiconductor manufacturers and two electronics systems firms are now examining **a rough draft of NASA's proposed procurement specifications for microelectronics.** Late this month, the companies' representatives will submit their opinions to the space agency's subcommittee on microelectronics. The specifications, which a NASA official describes as "a total program for reliable microcircuits," were prepared over several years by the subcommittee, sometimes in conjunction with the Defense Department. **The draft covers such topics as test methods, visual test procedures, and packaging.**

H-P desk calculator makes its debut

After two and a half years of development, Hewlett-Packard has finally introduced its desk-top calculator [Electronics, Dec. 12, 1966, p. 26]. The machine, priced at $4,900, is designed for engineering and scientific applications.

Called the 9100A, it has three distinct memories:

- A random-access read-only unit with 32,000 bits.
- A core memory with 23 registers that stores special programs.
- A 2,000-bit read-only memory that's part of the calculator's control logic.

The calculator can handle inputs ranging from 10^{-98} to 10^{99} **—nearly double the range of some general-purpose computers**—and displays 10 digits.

The 9100A is built without integrated circuits. Discrete components are used because, among other reasons, some functions aren't available with IC logic.

The machine does not need a special computer language; and it can be programed through either the keyboard or special magnetic cards.

Readout currently is by cathode-ray tube. **Options will soon include a digital printer and an x-y plotter.**

Low-cost inertial system is proposed

Engineers at American Airlines have proposed to Arinc a new characteristic for **inertial navigation systems that could lead to units costing $30,000 or less.** Arinc characteristic 561, which covers such systems as Litton Industries' LTN-51 and the AC Electronics Carousel, specifies hardware suited to long (10 hours) flights over water. Because of their complexity, these units cost about $100,000—a price that frightens airline executives shopping for stable attitude reference systems for shorter overland flights. **The proposal, which could open the airbus and retrofit markets to inertial systems, will be considered early next month at an Arinc meeting in New York.**

Addenda

Moses Shapiro, president of General Instrument, has been named chief executive officer and vice chairman. Replacing him as president will be William C. Hittinger, who has been president of Bellcomm, a subsidiary of AT&T. . . . Admiral will offer a three-year warranty on its color picture tubes; the standard warranty is one year. . . . Ohio State University researchers have developed **a sonic riveter that can drive titanium rivets into titanium sheets without splitting or cracking the metal.** Using commercially available lead-zirconate-titanate piezoelectric crystals, driven by a 2,600-volt power supply, **the Ohio State device is able to generate a static force of 200 pounds in 1½ seconds. . . . An ultrasonic holography instrument for early discovery of tumors will undergo tests about April 1.** The instrument, developed and built by the Holotron Corp. of Wilmington, Del., is to be tried on breast cancer cases at Roswell Park Memorial Institute in Buffalo, N.Y. The tests will last a year. The equipment was developed by Byron Brendar, a researcher at the Battelle Memorial Institute. Holotron is a subsidiary of Battelle and the Du Pont Co.

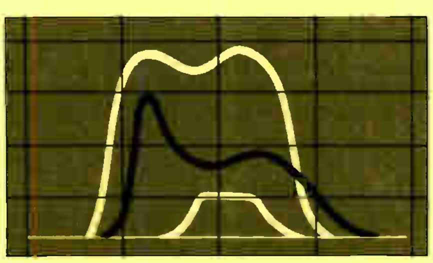
Component and Circuit Design IDEAS

FROM SYLVANIA

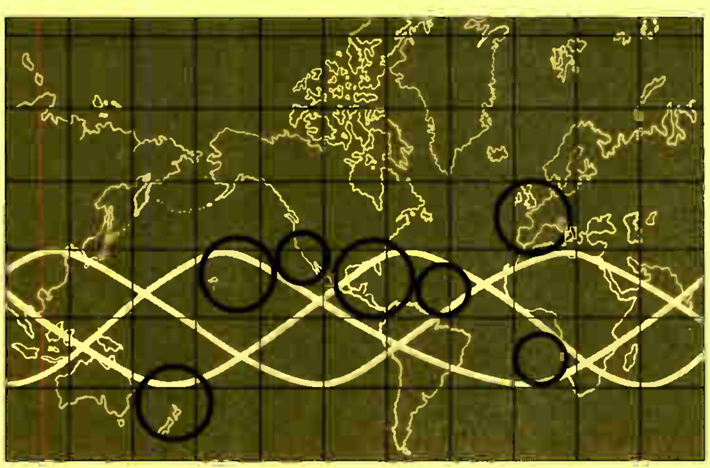
IDEAS / *CRTs*

Now, multicolor displays on 19" or 21" CRT... from a single electron gun.

New Sylvania 19" SC-4852 (Left) and 21" SC-4876 industrial and military cathode ray tubes, each capable of displaying alphanumeric or analog information in up to *4 colors simultaneously* from a *single electron gun*.



19" screen displaying 3 separate waveform patterns, each in a different color.



Typical satellite tracking pattern on 21" screen. Coastline in *yellow*, orbital paths in *orange*, tracking station locations in *green*, satellite position in *red*.

A new, large-size Sylvania CRT . . . using 2 phosphor coatings on the faceplate . . . displays up to 4 separate colors simultaneously from a single electron gun, and with no shadow mask.

A sine wave trace. A square wave trace. A pulse-code modulated trace. An alphanumeric line.

All on one 21" CRT screen. All displayed simultaneously. In four different colors. With *no shadow mask* to reduce brightness.

It's not done with mirrors. It's done by switching anode voltages.

The tube employs two basic faceplate phosphors: red and green, for example. Red is actuated by the low (6 kV) electron-beam voltage; green is actuated by the high (12 kV). Intermediate voltages produce red-green color mixtures. For example, 10 kV produces a basic green with a small red admixture: yellow; 8 kV produces a basic red

Continued on next page.

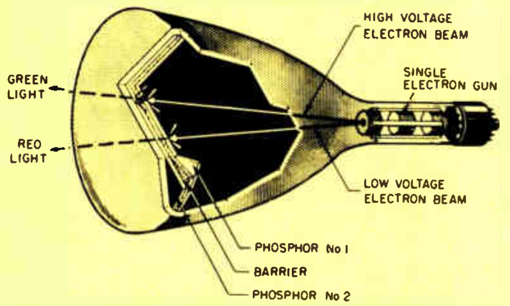
This Issue in capsule

Continued.

Applications

We recommend them for:

- ☐ Air traffic control systems
- ☐ Military identification systems
- ☐ Stock market quotation units
- ☐ Teaching machines
- ☐ Electronic test equipment
- ☐ Computer displays
- ☐ Airline and other transportation-status boards
- ☐ Any application requiring discrete-color information display.



CRT employs two phosphor layers—red and green or other combination—and one electron gun. Rapid switching from high to low voltage actuates one phosphor or the other; midrange voltages mix the basic phosphor light output to produce different colors.

with a slight green admixture: orange.

By rapid voltage switching, all four colors can be displayed sequentially, but fast enough that they can be viewed visually simultaneously.

And the tube can be supplied with other basic phosphor-color combinations: red and blue, for example.

Because the tube has no shadow mask, brightness and resolution are extremely high.

We offer commercially a 19″ round 35° deflection angle type (SC-4852), with electrostatic focusing and magnetic deflection, and a 21″, 72° deflection angle rectangular type (SC-4876) with electrostatic focusing and magnetic deflection. In addition we have previously announced a 10″ tube (SC-4827, electrostatic focusing and magnetic deflection) and a 5″ tube (SC-4689, electrostatic focusing and deflection). On special order we can make color tubes in any screen diameter.

In air-traffic control displays, for example, these CRTs could be used to provide quick and positive information on different altitudes 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 particularly significant data or newly changed, added or deleted data. For alphanumeric stock quotation displays, red could be used to indicate a stock which has declined since the last quotation, and green to indicate a stock which has gone up.

Come see them demonstrated at IEEE. We're sure you'll think of many other IDEAS for using them.

CIRCLE NUMBER 300

Specify your own EL readout brightness levels up to 50 fL.

Hermetically sealed all-glass or metal-glass electroluminescent readout panels provide initial brightness of up to 50 footlamberts—readily visible even at high ambient light levels.

Brighter phosphors in Sylvania "P-Series" hermetically sealed all-glass and metal-glass EL panels provide intrinsic brightness levels of 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 25 fL with 50% transmission glass for higher contrast, and about 15 fL with 30% transmission glass for extremely high contrast.

These bright, high-contrast panels are available in two basic types of construction: all glass or metal glass (see Fig. 1).

The ideal visual display

From the point of view of design, operational and human engineering considerations, EL panels offer distinct advantages over conventional display devices. When required, they display information faster than the human eye can respond, yet can retain it for as long as necessary. They are highly immune to catastrophic failure. They have the widest viewing angle of any display device: almost 180°, and all in the same viewing plane.

They readily display any type of information de-

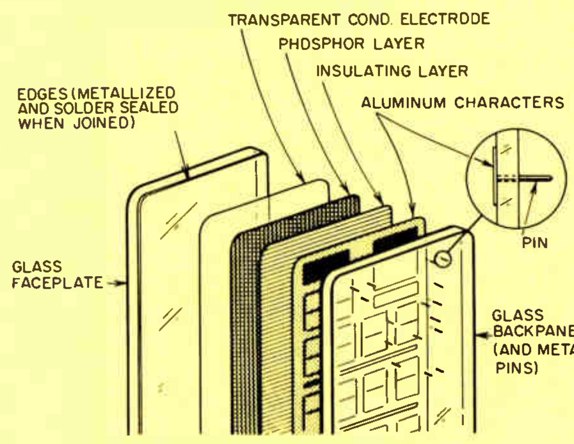
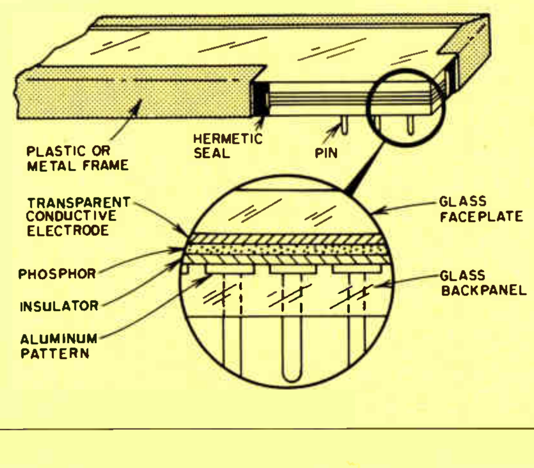


Fig. 1. Top, exploded view, all-glass EL readout panel. Below, sectional view of metal-glass construction.



sired: letters, numbers, pictorial or analog data, quantitative comparisons—and can be custom designed to the user's requirements. Their solid-state nature and construction assures stable performance under extremes of temperature, pressure, humidity and—when properly mounted—under severe shock and vibration. Their soft blue-green light output is very easy on the eyes; spectral emission (Fig. 4) approximates that of the human eye to permit prolonged viewing without fatigue.

Our new "P-Series" panels represent the finest EL display devices Sylvania has ever made—and Sylvania is the acknowledged pioneer and leader in EL technology. These rugged, hermetically sealed devices—although developed originally to meet the stringent environmental and operational demands of critical aerospace and military applications, are also ideal for many industrial uses.

Complete display flexibility

For visual displays, EL readout devices offer almost unlimited flexibility in customized presentation. The conducting electrodes forming the display are made by graphic art techniques so that almost any desired display pattern can be fabricated: numerals, letters, bars, squares, map segments, large solid areas, and special symbols in various arrangements, designs and configurations. Different colors may even be provided on a single panel. Legends and special symbols (i.e., plus and minus signs, decimal points, etc.) may be designed as an integral part of a panel or may be applied in the form of an overlay—whichever best suits the user's requirements. With EL, complex information display problems can be simplified and fully customized.

Typical configurations and applications

EL units are currently being produced in the following configurations. (Other configurations are of course possible; Sylvania engineers will be glad to work with you to develop what you need.)

Numerics—solid areas—alphanumerics. These displays represent the major types of EL readout currently in use by space agencies, the military and industry. When two or more digits are required to display the desired information, all characters are usually fabricated on a one-piece substrate. This design provides optimum spacing between digits, attractive digit-to-digit balance, permits extra compactness where space is at a premium.

Bar graphs. EL bar graphs are ideal for many aircraft, spacecraft and shipboard instrumentation applications—wherever quantitatively variable input data must be monitored and compared. Parallel EL bars give positive, easy-to-read data display and comparison with high resolution for precise measurement. Legends and/or limit markers can be incorporated either into the illuminated portion of the bar graph itself or onto the panel faceplate.

Random-access panels illustrate the true versatility and superiority of a solid-state EL visual display system. They can display alphanumeric, graphic or symbolic information *in any combination* to visually represent any situation. They are ideal for displays involving: air traffic control, automotive routing and flow, harbor surveillance, troop and equipment movement, local or remote classroom displays, machine programming, warehouse stock control displays, control and monitoring applications, communication of pictorial information—virtually any situation that requires a highly readable and graphic dynamic visual presentation.

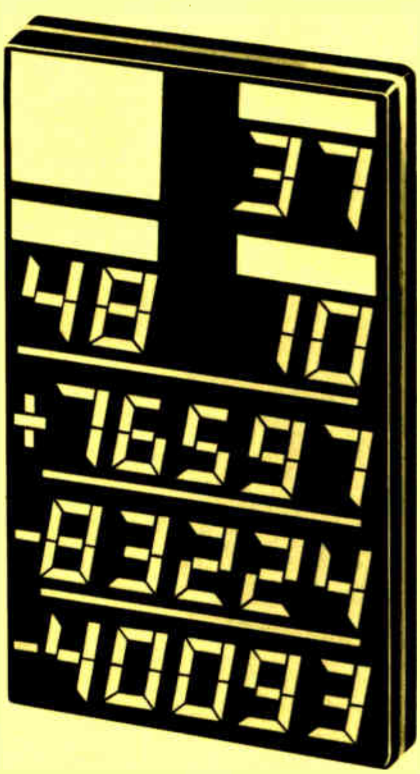


Fig. 2. Typical EL panel, all-glass construction. Intrinsic brightness of phosphor is approximately 50 fL at 250 V, 400 Hz. Brightness varies inversely with contrast depending on transmission characteristics of glass faceplate.

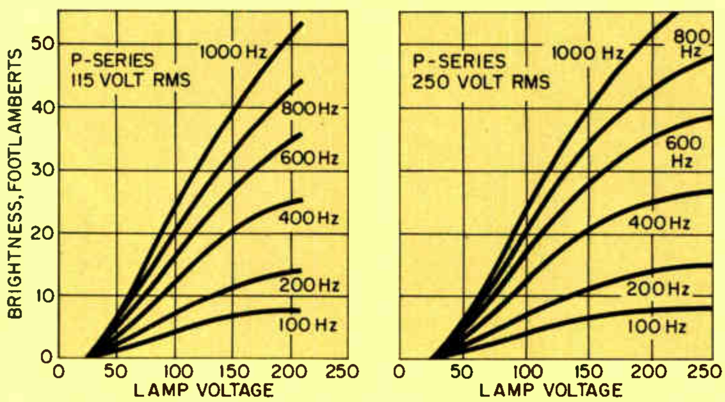


Fig. 3. Brightness vs. voltage, with 60% transmission glass, for both metal-glass and all-glass EL readout panels at 115 and 250 V. rms respectively.

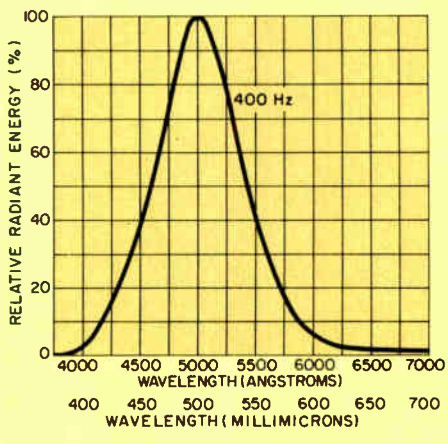


Fig. 4. Spectral emission characteristics, metal-glass and all-glass EL readout panels. Light output very closely matches the response of the human eye, permitting easy prolonged viewing.

Now you can get high sensitivity, low 1/F noise and microphonics in a video detector.

Schottky barrier diodes, when used in video dectector circuits in electronic countermeasures systems, provide broadband detection capability to 40 GHz, yet assure high sensitivity with low microphonics in such applications.

Manufacturing technology for low-noise Schottky barrier diodes has progressed so rapidly over the past few years that it is now possible to fabricate, on a production basis, true metal-to-semiconductor junctions having the extremely small areas necessary to achieve maximum tangential signal sensitivity (TSS).

TSS is a measure of small signal sensitivity in a diode, and high TSS levels are essential to proper performance of electronic countermeasures systems (detection of hostile aircraft and radars), doppler radars, military aircraft beacons and electronic surveillance systems.

Sylvania now offers a new line of Schottkys with TSS levels of better than -50 dBm at X-band and better than -40 dBm at 40 GHz—virtually a flat response over the entire frequency range as illustrated in Fig. 1.

Diode bias is required if maximum sensitivity is to be attained. Both bias and video bandwidth must be specified if the TSS measurement is to have any significance. Fig. 1 indicates the relative TSS with a 50 μA bias. Reducing the bias to about 30 μA will improve the TSS, but will also increase the video impedance to a level that may not be desirable in certain applications. Fifty microamps was chosen to provide a more reasonable impedance match with the video amplifier.

Video impedance variation (R_v) vs dc bias is shown in Fig. 2. Under normal conditions, R_v is specified at about 6000-8000 ohms at 50 μA.

A low noise level—particularly at low 1/F envelope frequencies—is another vital characteristic which is also affected by bias level. Fig. 3 compares noise output of a point-contact diode and a Schottky diode from 1 to 1000 KHz—typical doppler-radar envelope frequency ranges. Each is measured at 20 and 50 μA bias current. As the figure indicates, at 1 KHz the Schottky diode exhibits about ¼ the noise output of the point-contact device.

In addition to the advantages of high sensitivity (TSS) and low 1/F noise (flicker noise), Schottky barrier diodes offer low microphonic noise output (see Fig. 4), high burnout resistance and uniform performance characteristics.

CIRCLE NUMBER 302

		D5754	D5754A	D5691	D5691A	D5733	Unit
Test Frequencies		5 and 12	5 and 12	5 and 12	5 and 12	35	GHz
Minimum TSS with a 10 MHz bandwidth at 50 μamp bias	TSS	47	50	47	50	45	−dbm
Video Impedance at 50 μamp bias	Rv	6.5	6.5	6.5	6.5	7.3	kohms
BreakdownVoltage at 10 μamp	V_B	7	7	7	7	7	volts
Package		013	013	075	075	013	

Fig. 1. Tangential signal sensitivity vs frequency for three types of Sylvania Schottky barrier detector diodes. Note virtually flat response from 1.0 to 40.0 GHz carrier frequencies.

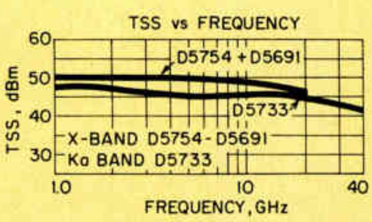
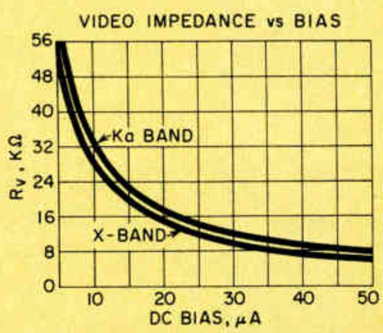


Fig. 2. Video impedance variation (R_v) vs dc bias, for X-band and Ka-band Schottky diodes.



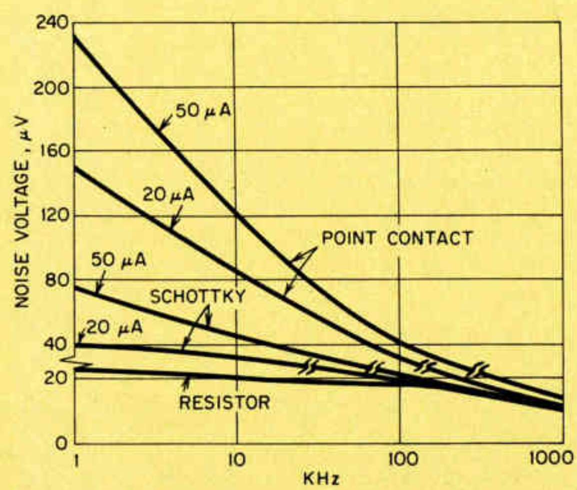


Fig. 3. Noise ratio vs bias current. Sylvania Schottky barrier diodes exhibit much lower noise voltage levels at low 1/F frequencies when used in video detector applications than point-contact diodes.

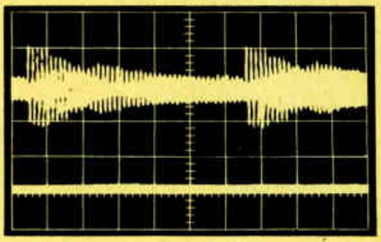


Fig. 4. Sylvania Schottky diodes exhibit much lower microphonics than point-contact diodes. Upper trace is microphonic response of a point-contact diode when subjected to a mild shock; lower trace shows the lack of microphonic response of a Sylvania Schottky D5754 when subjected to the same shock.

Hybrid microcircuits: frequency capability to 300 MHz, now available in production quantities.

Sylvania's advances in resistive and dielectric material, plus our proven high-frequency solid-state design capability, enable us to reduce size and increase reliability at low cost.

Today Sylvania's film hybrid microcircuits operate well up into the UHF band, are produced in quantity, and at lower cost than equivalent discrete component circuits.

An example is the recently developed Sylvania AN/PRC-63 hand-held transceiver/beacon. It operates on the military distress frequency of 243 MHz; transmission range of the rescue beacon at 325 mw power output is approximately 75 nautical miles; voice transmission range is 30 nautical miles. Utilizing Sylvania's microcircuit design, the complete unit (less antenna), measures only 4 1/2″x 3 5/16″x 1 5/16″ and weighs less than 18 oz. including batteries. The mean time between failure (MTBF) is over 5,000 hours, based on more than 17,000 hours of life testing. Until recently this size/performance capability would have been considered beyond production capabilities—yet today the unit is in volume production.

Another microcircuit we recently developed is a digital circuit capable of operating in a computer system with a 50 MHz clock rate. Propagation time through the circuit is less than 14 nsec, and this includes going through two levels of diode logic and three transistor levels. We also developed microcircuits for a frequency synthesizer operating at 8 MHz.

Techniques we have developed to produce such circuits are adaptable to other custom requirements in a frequency range of from dc to 300 MHz. And they permit *component-for-component miniaturization* of most circuit functions.

What makes it possible?

Passive components such as conductors, resistors and capacitors are produced by depositing ceramic-metal materials onto an alumina substrate. Firing at an elevated temperature in a controlled atmosphere establishes film characteristics such as excellent stability and component tracking. Stray capacitance is minimized because of the proximity of components. And circuit-to-circuit uniformity is inherent.

For capacitors, dielectric materials have been developed which provide up to 0.5 μF per square inch. Resistive materials range from 50 ohms/sq. to 400 kohms/sq.

Active components, as either discrete packaged devices or semiconductor dice, are attached to the substrate and interconnected to form the hybrid circuit.

The wide range of passive component characteristics available in thick-film form, plus the ability to add a wide variety of diodes, transistors and ICs, permits ready fabrication of many digital, pulse and linear circuits which can be direct, miniaturized translations of the designer's discrete-component breadboard.

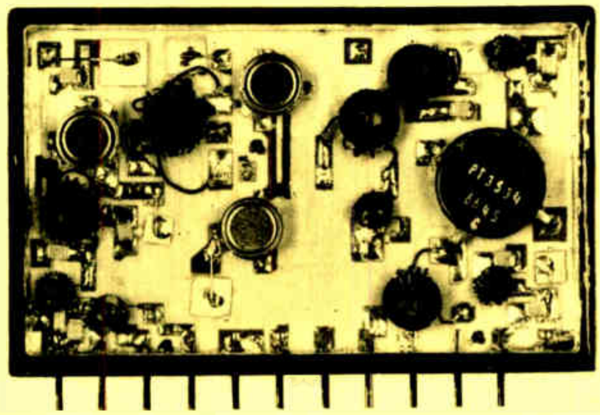
Sylvania can assist you with your hybrid microelectronic design problems because we have:

1. Over seven years of experience in film microelectronics.
2. Semiconductor capability and the facility to handle semiconductor material.
3. Documented reliability.
4. Volume production capability in complex microelectronics.

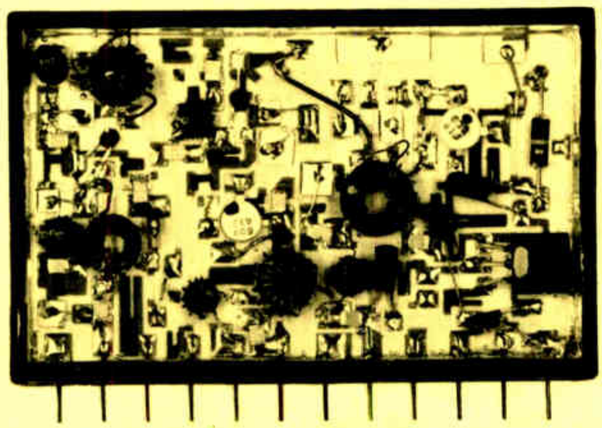
If microelectronics is in your future, Sylvania can help you.

For more information, send for Sylvania's Microelectronics Design Guide. It's yours with our compliments.

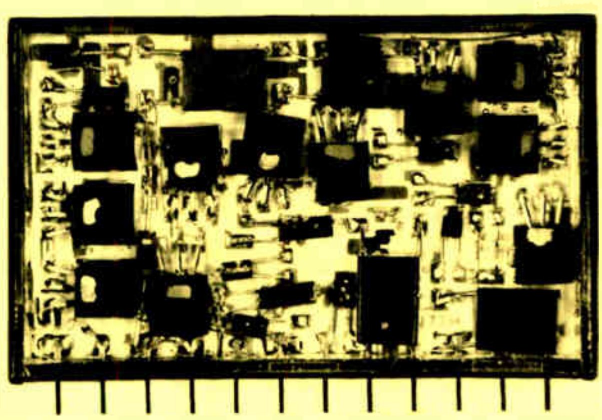
CIRCLE NUMBER 303



UHF Transmitter



UHF Receiver



Voice Amplifier

Hybrid microelectronic circuits from Sylvania for the UHF AN/PRC-63 rescue transceiver. These units comprise entire electronic component system of transceiver.

New 16-diode arrays can drive cores more efficiently—save labor and space.

With Sylvania's newest 16-diode core driver in either a single plug-in or flat package, you gain many significant advantages. Obviously, higher reliability and packaging density. Also, reduced labor assembly time and costs—because there are fewer external connections and fewer components to handle. Our SID-16E arrays also give you these advantages without sacrificing switching speed.

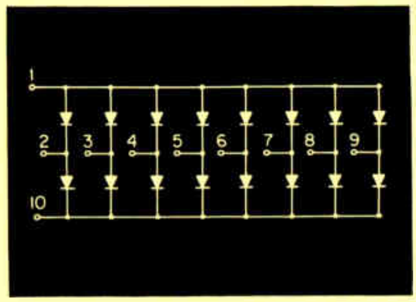
Our 16-diode arrays, such as shown in the diagram at right, reduce labor costs, shorten assembly time and cut external wiring in the manufacture of a computer memory-core-driving system. They have a bank of both common anode and common cathode diodes interconnected in the classic core driver circuit.

Ideally suited for core driving applications, they combine high forward conductance, fast recovery, low capacitance and tight performance tolerances.

These new units include the SID-16E-2 in a hermetically sealed flat package and the SID-16E-20, electrically the same device but enclosed in a 14-lead plug-in package. Both have forward current ratings of 300 mA and power ratings of 300 mW per diode. This power drive capability, together with ultra-fast recovery, gives design engineers diode arrays which meet the demanding requirements for memory drivers in military and aerospace computers as well as commercial computers.

Reverse recovery time of these diodes is a maximum of 60 nsec, even at such extreme switching conditions of a forward current of 300 mA and an I_r of 30 mA. Typical values for the recovery time of I_f and I_r switching from 300 mA to 30 mA in 35 nsec.

Like the SID8A-2 (common cathode) and SID8B-2 (common anode) 8-diode arrays, these 16-diode arrays



feature silicon dioxide passivated construction. They are fabricated on a high resistivity layer which is epitaxially grown on a low resistivity substrate. Passivation insures that performance remains stable over a long operating life. Manufactured to standard MIL quality assurance requirements, these packaged arrays meet MIL-S-19500.

The 8-diode arrays are now also available in dual-in-line plug-in packages, in addition to the hermetically sealed flat packs (0.250" x 0.175").

CIRCLE NUMBER 304

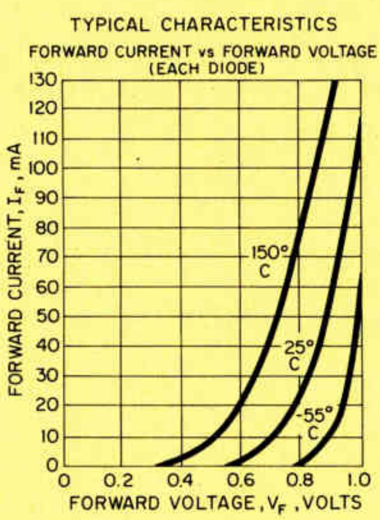
Maximum Ratings at 25°C (each junction):

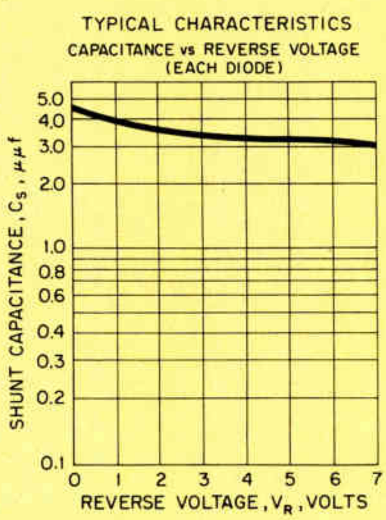
Reverse Voltage, V_R	40 volts
Forward Current, I_F	300 mA
Peak Forward Current, I_{FP}	1.0 amp (0.0 μsec, 25% D.C.)
Average Power Dissipation, P_D(2)	300 mW (500 mW total package)
Junction Temperature, T_J	−65°C to +150°C
Storage Temperature, T_{stg}	−65°C to +300°C

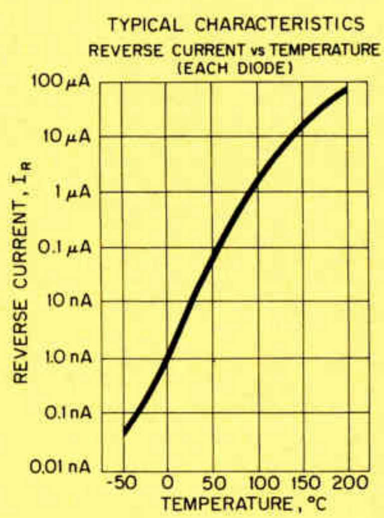
Notes:
1. Pulse test ≤ 300 μsec, ≤ 2% duty cycle.
2. θ_{JC} 0.1°C/mw; θ_{CA} 0.2°C/mw. Linear-derating +25°C to +150°C.

Electrical Characteristics at 25°C (each junction):

	Conditions	Min	Max	Unit
Forward Voltage Drop, V_F (Note 1)	I_F = 300 mA	–	1.25	V
Forward Voltage Drop, V_F (Note 1)	I_F = 500 mA	–	1.40	V
Forward Voltage Drop, V_F (Note 1)	I_F = 800 mA	–	2.00	V
Reverse Current, I_R	V_R = 30 V	–	0.1	μA
Peak Inverse Voltage, PIV	I_R = 10 μA	40	–	V
Capacitance, C	0V = 1 MHz		6.0	pF
Reverse Recovery, t_{rr}	I_F = 300 mA I_R = 30 mA i_r = 3 mA R_L = 100 ohm	–	50	nsec







Especially for modern set designs—lightweight, economical color CRT line expanded.

Now Sylvania adds a 25″ *color bright 85*® tube to its Kimcode-protected line, available to manufacturers for sets they'll make this year. Screen area is 295 square inches (viewable).

The Kimcode rim protection system being offered by Sylvania extends over a broad range of rectangular screen sizes including 15″, 19″, 22″ and now the new 25″ size. Besides the inherently excellent performance of *color bright 85* picture tubes, designers can add the benefits of lighter weight and lower cost by specifying Sylvania's Kimcode line.

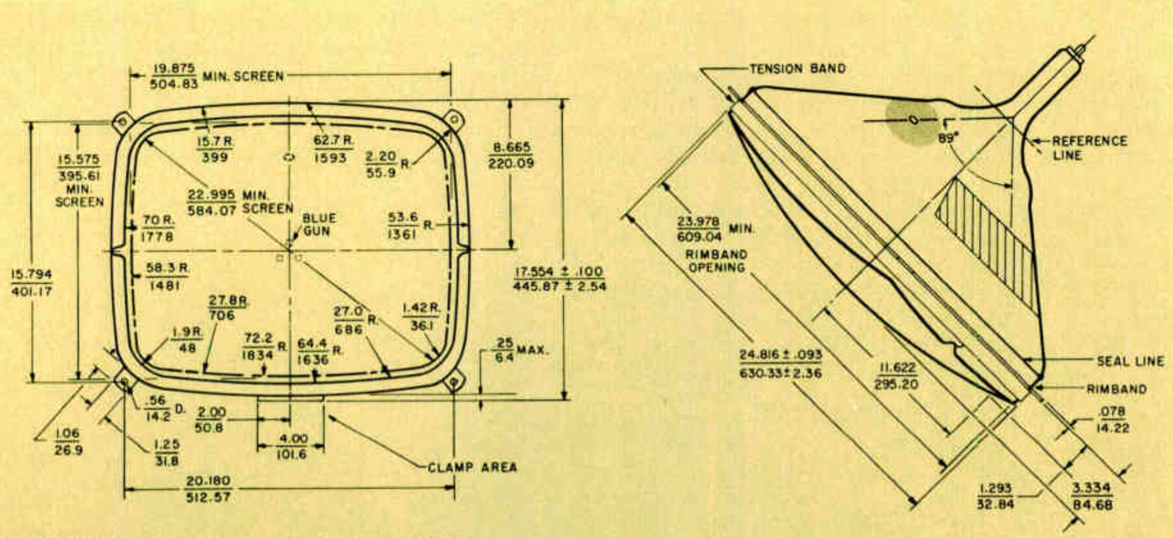
They're light in weight because their integral implosion protection system eliminates the need for separate safety glass in the set chassis, or heavy glass cap that is laminated directly to the tube. On the 25″ tube, the weight saving is approximately 6 pounds.

For manufacturers who prefer these other designs, Sylvania will continue to make them available.

Our new 25″ tube is manufactured with spherical faceplate and has dark-tint 42% transmission glass for high contrast. Glass transmission characteristics for other tubes in the line are as follows: 15″, 32%; 19″, 43.5%; and 22″, 42%. Each uses three electrostatically focused electron guns spaced 120° apart; axes are tilted to facilitate convergence of the three beams at the shadow mask. Each uses magnetic deflection and convergence, an aluminized screen and is capable of producing high-resolution pictures in both color and black-and-white. The screen incorporates the unique Sylvania screening process and high light-output rare-earth phosphor system.

Sylvania designed these new tubes to help you broaden your set line, cut set costs. Complete specifications are available from your Sylvania representative.

CIRCLE NUMBER 305



Detail drawings of the newest 25″ Kimcode CRT.

IDEAS / *Manager's Corner*

Field Engineering: What it can do for you.

It's not enough to offer good electronic components to a customer.

His needs must be served—both on today's production line and during development of tomorrow's equipment.

He must keep his line rejects and field returns low and at the same time seek improved performance and reliability in his products at competitive prices.

This is a tough job.

Sylvania's field engineers make his job easier. For example, if a customer's production line rejects are high for one of our tubes, it costs him money—and us too. Our field engineers, in cooperation with our field salesmen, assist the customer in analyzing the problem and determine if the fault is really with our tube or with some other component. If our tube is at fault, the field engineer immediately informs the Sylvania Plant Quality and Product Engineering Departments. He then seeks help from the Sylvania Applications Laboratory and Division Quality Staff. Our customer saves time and minimizes lost business.

If a production change is made to correct a field problem it's field engineering's responsibility to insure that *only* the revised product will be shipped to his customer.

Similar action is necessary to help keep our customers "in-warranty" cost low. This is a critical situation involving life and consumer acceptance of our products; it demands closely coordinated evaluation between our customers and ourselves.

To further assure customer satisfaction and to see that our production will match customer needs, field engineering plays a major role in the initiation and approval of testing specifications and published data. What electronic components will our customers need next year—and the years after? Here too we provide a strong market-oriented authority for our customers' benefit. In conjunction with our marketing people, the field engineers participate in customers' plans for new equipment and guide our resultant developmental and production activity. This involves planning meetings between customer engineers and Sylvania engineers, as well as continuous monitoring of our mutual progress.

SEC field engineering is a unique group in the industry. Its responsibility covers receiving tubes, picture tubes, semiconductor devices, and other special products in the entertainment, industrial and government equipment market and in the distributor and renewal markets as well. We believe this group has helped to establish Sylvania's leadership in electronic components.

In receiving tubes we have long had a reputation for supplying the most reliable horizontal deflection tubes and high voltage rectifiers in the business. Our new 6LR6 and 6JE6C deflection tubes and our posted filament 3CU3 are prime examples.

In semiconductors, Sylvania has pioneered fast switching diodes, UHF mixers, video detectors, glass rectifiers and much more. Our latest developments in this area are variable voltage capacitance diodes for a multitude of electronic tuning applications.

We believe Sylvania has a most effective concept of technical liaison with our customers, and our customers firmly support this belief. Why? Because we have effectively accomplished our goal: serving our customers.

A W Peterson

A. W. Peterson
SEC Field Engineering

This information in Sylvania Ideas is furnished without assuming any obligations.

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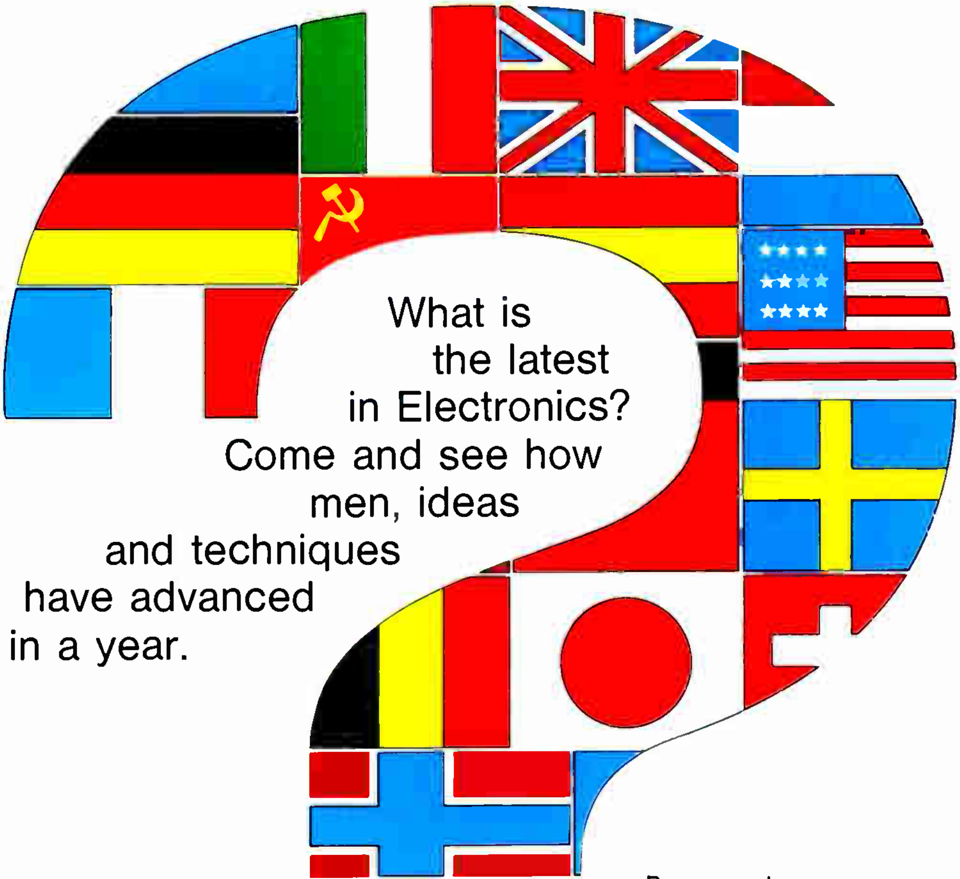

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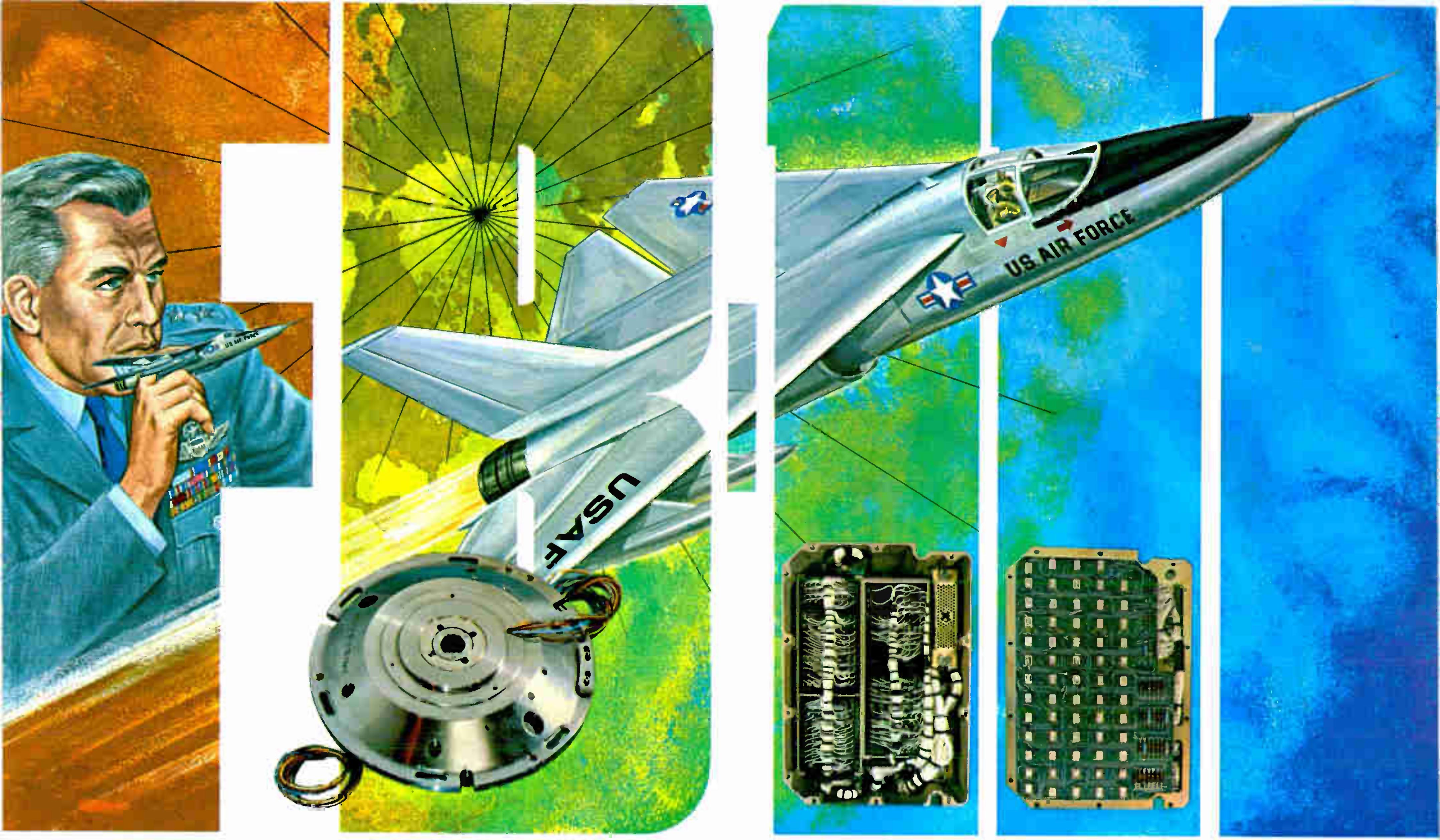

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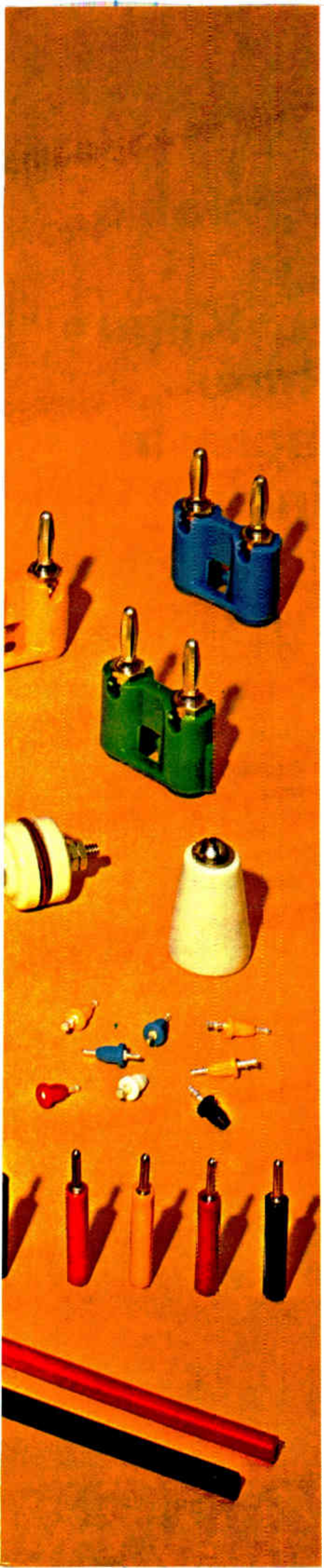
USAF

Portrait of a most reliable family



More accurately, the portrait shows only *part* of a most reliable family. The E. F. Johnson Company makes hundreds of fine quality electronic components, including:

CAPACITORS—A dozen basic series of air variable capacitors, each in a wide choice of capacity values. They range from sub-miniature machined plate capacitors with maximums of 4.2 to 24.5 pf., to larger, heavy-duty types with capacity values to 1700 pf. and voltage ratings to 9000 volts peak.

There is a reliable Johnson capacitor to fit your application. Whatever the size, it offers excellent stability, high Q, low temperature coefficient, uniform capacitance, and excellent overall performance at competitive prices.

CONNECTORS—The Johnson line of jacks, plugs and terminals meets the needs of both military and commercial designers effectively and economically. For printed circuit applications, there are sub-miniature insulated tip plugs and jacks, plus the unique Test Point Strip/Handle for fast, efficient circuit testing.

Johnson's line of standard insulated connectors includes tip, banana and dual banana plugs, tip and banana jacks, military tip jacks, and binding posts.

RIB-LOC™ components consist of new miniature, one-piece, insulated terminals and jacks that press-mount with excellent retention characteristics.

TUBE SOCKETS, INSULATORS, PILOT LIGHTS, RF COMPONENTS AND HARDWARE—Dependable Johnson tube sockets include HF, VHF and UHF types for tubes of various power levels.

Low-loss, high-voltage-breakdown insulators are available in either steatite or porcelain.

Johnson offers 47 pilot light assemblies in neon and incandescent types. Standard and wide angle lens caps are available in glass and acrylic.

Other hardware includes panel bearings, shaft couplings, crystal sockets and RF chokes, plus a number of heavy-duty RF components for broadcast transmitting, RF heating, antenna phasing and other commercial applications.

FREE CATALOG gives complete details and specifications, including net prices, of E. F. Johnson quality electronic components. Write for your copy today, or ask us about your specific application requirements. Special components, to your exact requirements, may be available in production quantities.

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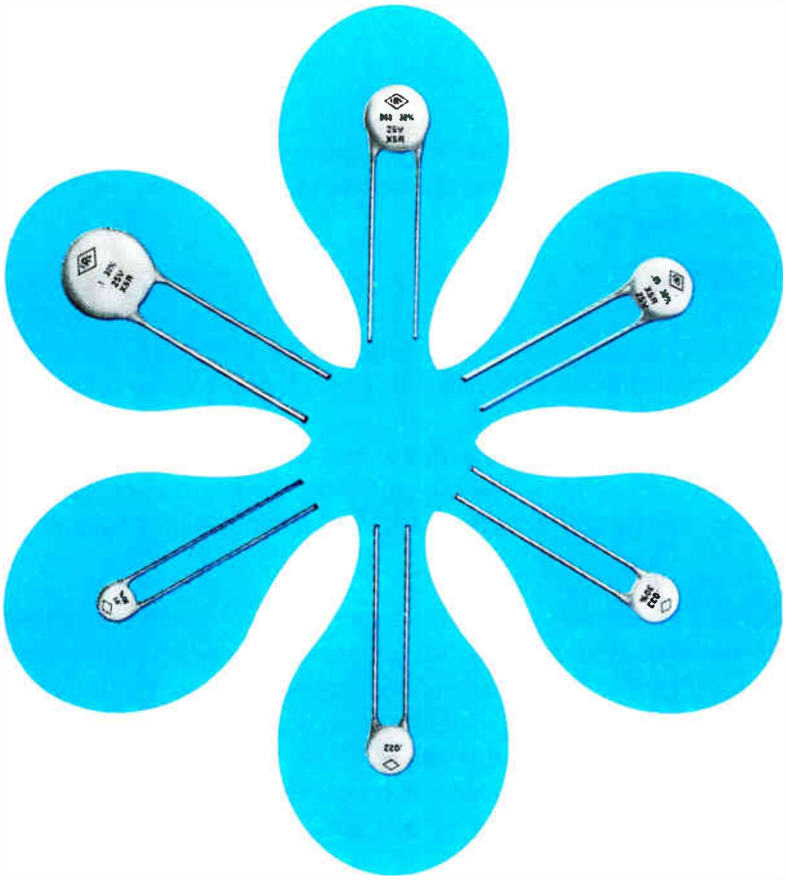
Providing nearly a half-century of communications leadership

Circle 39 on reader service card



Centralab's "Ultra" Ultra-Kaps® put new capacity in shrinking design space

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"Inner space" continues to shrink in this trend to transistorization... but not the capacitance values you need in your design applications.

Centralab's answer: an improved 25V Ultra-Kap Disc Capacitor . . . smaller in size but not in performance.

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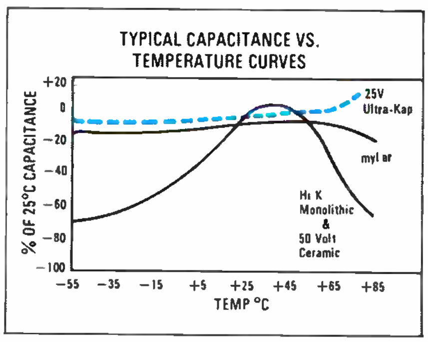
RANGE CHART

Maximum Dissipation Factor 5% @ 1 kHz

Nominal Lead Spacing	Capacitance MFD	Maximum Diameter*	Tolerance	Minimum Insulation Resistance At Rated Voltage
.250	.01	.290	IMPROVED ULTRA-KAPS 16 Volt: +80−20% (Z) or ±20% (M) 25 Volt: ±30%	10 MEGS
.250	.022	.405		10 MEGS
.250	.033	.405		10 MEGS
.250	.05	.515		10 MEGS
.375	.068	.590		10 MEGS
.375	.1	.760		10 MEGS

*All Ultra-Kaps have a maximum thickness of .156 inches.



M-6723R

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Our new "4th-generation" 12.5 MHz universal counter/timer. Wonderful versatility in a wonderfully small package — at an even more wonderfully small price.

With the new Model 100A you can measure average frequency, frequency ratio, single period or time interval, or count total events. It has a crystal-controlled clock, Monsanto integrated circuit construction, and built-in compatibility with a rapidly growing assemblage of accessory modules.

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Circle 41 on reader service card

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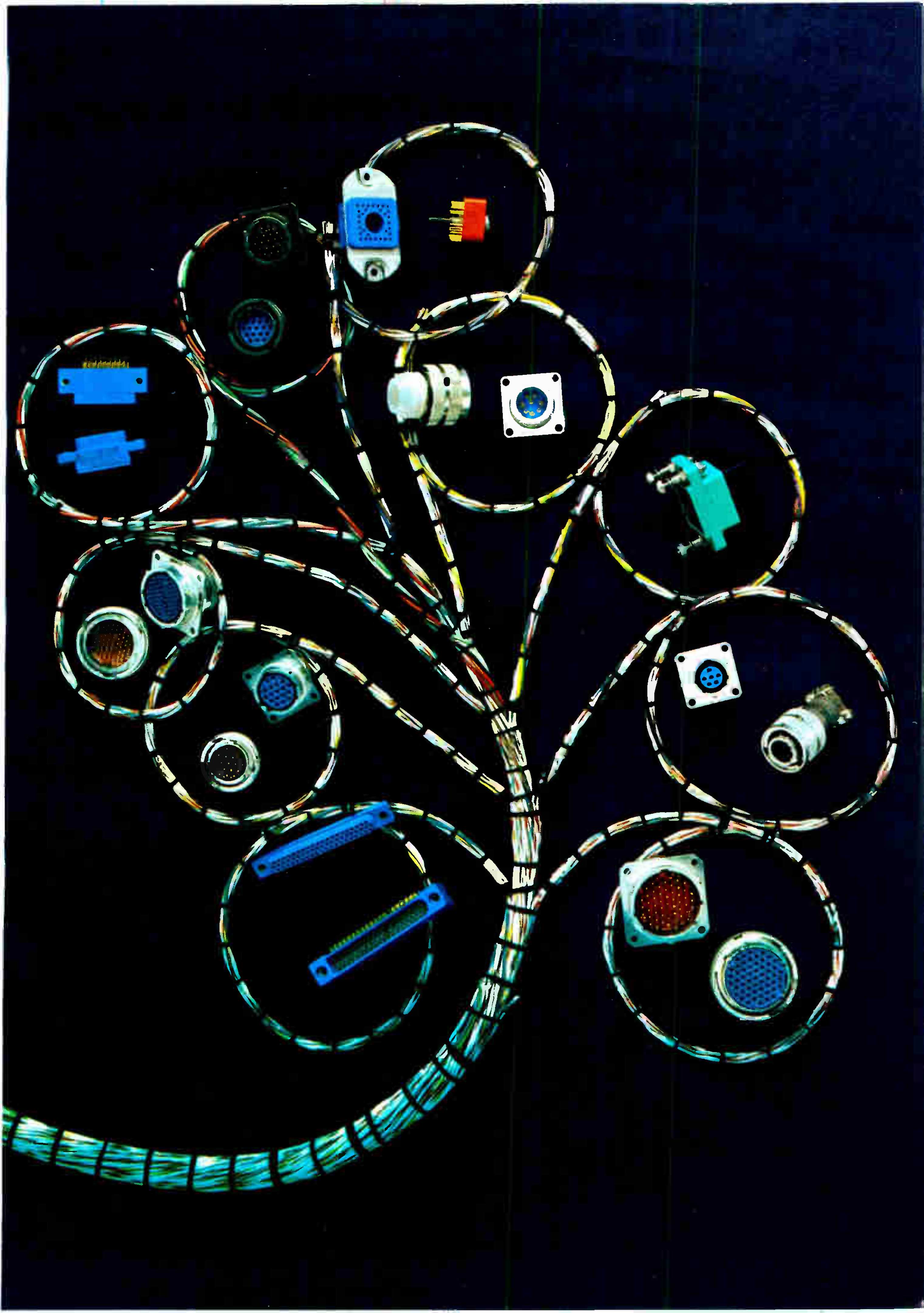
Bendix Electronics



Complement Your Rugged Designs With 30-Watts of Thermopad Plastic Silicon Power!*

The 2N4918-23 series of NPN/PNP silicon power transistors is designed to put extra performance in — and take the cost out of — industrial switch/amplifier and driver applications that demand premium, plastic-type capability and reliability.

Besides offering the traditional circuit-simplifying design advantages of eliminating expensive, impedance-matching driver transformers and resistors and offering a high degree of frequency stability, these 3-ampere devices actually handle 30-watts of power . . . 5-watts more than their TO-66 counterparts — yet they cost about 15% less!

Extensive testing has proven Motorola Thermopad units — with the exclusive, ultra-short (less than 0.030″) and efficient chip-to-heat sink thermal path — exhibit optimum reliability in *all* phases of testing from operating life, temperature cycling, humidity and thermal shock. For example, they have passed 42,000 hours of life-testing under ambient temperature, high humidity, reverse bias conditions and 100,000 hours of 150°C storage testing, with no failures.

These unique capabilities plus their low saturation voltages (0.6 V @ 1 A), high beta (20 min @ 500 mA, 1 V) and good frequency response make them ideal for your price-vs.-performance applications . . . particularly where metal-can units prove too costly.

The complementary approach . . . in audio and servo amplifiers plus mounting procedures and thermal aspects of Thermopad devices is discussed thoroughly in 3 application notes we will send you when you circle the reader inquiry number. Or, write Box 955, Phoenix. Do it today and receive them by return mail.

Type		$I_{C(MAX)}$ Amps	V_{CEO} Volts (sus)	h_{FE} @ $I_C = 500$ mA	P_D @ $T_C = 25°C$ Watts	$V_{CE(SAT)}$ @ $I_C =$ 1A (max) Volts	f_t (min) MHz	NPN/PNP Comb. Price (100-up)
NPN	PNP							
2N4921	2N4918	3	40	20/100	30	0.6	3	$2.00
2N4922	2N4919		60					2.26
2N4923	2N4920		80					2.70

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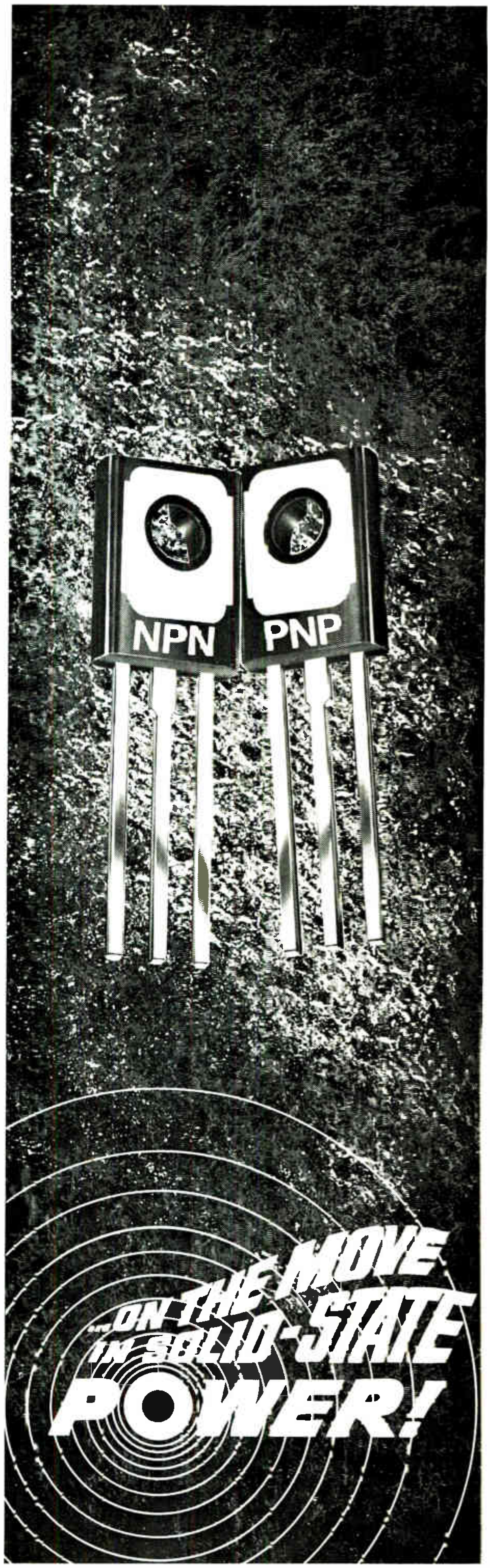

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Can you afford to buy less?

Not if you need the kind of performance and reliability you get from Bendix® Autosyn® Synchros.

And you have a wealth of types to choose from. Ultrahigh-temperature synchros that perform accurately at sustained temperatures up to 800°F. Ultracompact (size 08), lightweight (1.3-oz.) synchros for critically tight designs. Ultraprecise synchros with tolerances to 50 millionths of an inch. Dependable corrosion- and radiation-resistant synchros. And there's a complete line of Bendix Mil-Spec synchros, too.

AUTOSYN® SYNCHROS

Size	Max. Diameter (In.)	Typical Weight (Oz.)	No. of Models
08	0.750	1.3	16
10	0.937	1.7	25
11	1.062	3.2	29
15	1.437	4.7	24
22	2.161	18	5

Altogether there are hundreds of types—your largest single source. What's more, our synchro design service can promptly solve your special problems. You can depend on it. As they do at GE, Sperry, RCA, Lear Siegler, Motorola and many other value-conscious firms. Ask for our catalog today. Write: The Bendix Corporation, Flight & Engine Instrument Division, Montrose, Pa. Or phone: (717) 278-1161.

Bendix Aerospace Products

Electronics Review

Volume 41

Number 6

Integrated electronics

Buyers' choice

Customers of Fairchild Semiconductor have complained that the popular 709 operational amplifier, with its high-gain building blocks, did not meet their needs. As a result, the customer has, in effect, been forced to design his own circuits. "And it's true that we have ignored some markets, so that in turn they have ignored us," concedes Jack Gifford, linear circuit marketing manager of Fairchild.

With the industrial market for linear integrated circuits taking more and more units, and the consumer market expected to open up next year, Fairchild is clearly trying to come up with devices that can be designed directly into equipment. In the next three months, Fairchild will unveil the first of a new series of complex linear IC's billed as second generation descendents of the 709. The new circuits are user-oriented devices designed to compete directly with discrete rack-mounted amplifiers.

Following demand. Most work on new op amps has focused on production of truly monolithic devices, requiring no external compensation. One of the new Fairchild circuits will be a fully compensated version of the 709. But the main feature of the new circuits, on which 50 engineers worked a year, is that they are tailormade for specific functions Fairchild's customers demand.

First out, for instance, is a digital-to-analog current source, designated the μA722, that works as a d-a and a-d converter. Due in June is the line's real star, the μA715 op amp—a high-speed device that operates at an unprecedented slew rate of 25 volts per microsecond; thus it can switch high voltages at rates of up to 10 megahertz.

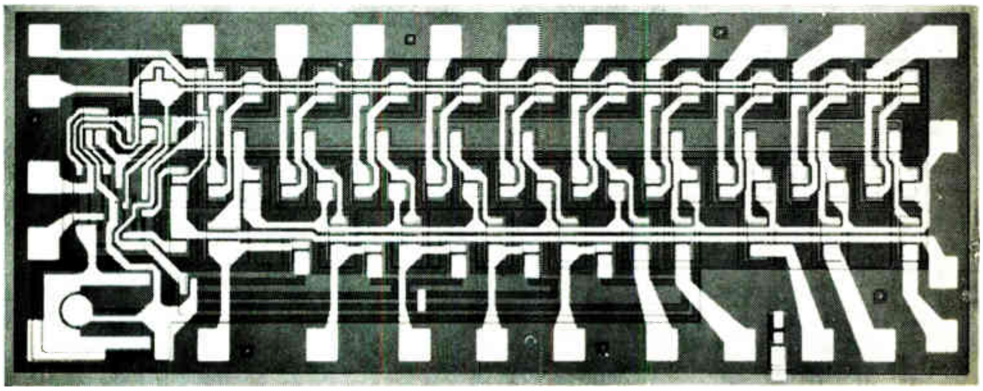
Also among the first circuits are a core-memory sense amplifier and a temperature-stabilized op amp, plus the 709 substitute that has its own metal oxide semiconductor capacitors for compensation. Coming at midyear will be a color television demodulator already being sold to one manufacturer.

Late circuits include a device that will function as a low-noise preamplifier for stereo high fidelity sets, a voltage regulator, a low-power op amp, and a dielectrically isolated device for use in radiation environments.

Price cuts. The new circuits represent Fairchild's blockbusting attempt to retain preeminence in a field thrown into turmoil by weakening prices. Last year's linear IC sales were about \$40 million, says Gifford. This year the industry will sell only \$45 million or \$46 million, despite an increase in units from less than 6 million to 10 million. From mid-1967 to mid-1968, Gifford adds, prices will have dropped by a factor of four; in that same period Fairchild's unit production will have increased by only 2½ times.

Competitors have pecked away at Fairchild's share of the market by second-sourcing the 709 and introducing improved versions. But Fairchild made only two linear circuits—op amps and comparators—and comparators were only marginally successful.

"This year, we will have peripheral circuits for special applications," Gifford says. "These new products will account for the bulk of our business in 1969 and 1970. Each circuit will amplify a given parameter of the general purpose op amp. Even though the large companies will eventually standardize on a few circuits, you will never see another standard like the 709."



Second generation. Fairchild is about to unveil a series of linear IC's in a move to enter new markets. Shown here is the μA722, which works as a d-a and a-d converter.

Bigger wafer. Fairchild calls the new circuits medium-scale integration devices. The 722, for instance, will have 90 matched active elements on a 60-by-120-mil chip; it will come in a 22-lead flatpack or dual in-line package, and cost about \$65 at first. To obtain reasonable yields on circuits of this size, Fairchild has switched all of its linear production to two-inch wafers and devoted considerable effort to temperature control on the chip.

By incorporating a special amplifier on the chip, which senses ambient temperature and drives a heating element, Fairchild has been able to keep fluctuations in chip temperature to within 4°C during ambient temperature swings of 100°C.

"But the real beauty is in the matching," says Gifford. Because all elements are fabricated at once, the active devices are matched to within a millivolt.

Yet the move to complex chips has not been easy, and Gifford concedes the same techniques that made it possible to build the 715 with such high slew rates also make it extremely difficult to compensate. Half of the compensating elements—the resistors—will be on the chip itself, but the external capacitors must be so large that they can play havoc with the slew rate.

Computers

Opening a new deck

The ubiquitous punched card may be on the way out.

The Univac division of the Sperry Rand Corp. has developed a plastic card coated with a magnetic film that can store 12 times as much data as the conventional punched card and is potentially capable of storing 100 times as much. And the card can be erased and reused indefinitely.

As a further plus for sensitive types, the new card need not bear that familiar admonition, "Do not bend, fold, spindle, or mutilate"; it can't be damaged by rough handling and can even withstand stapling.

In a related development, Univac has designed a card-processing transport mechanism that relies on fluidics, or fluid logic. From input hopper to output stacker, the cards float on a film of air controlled by fluidic devices. Both developments were financed by the Army Electronics Command, Ft. Monmouth, N.J., and the military plans to begin testing the system soon.

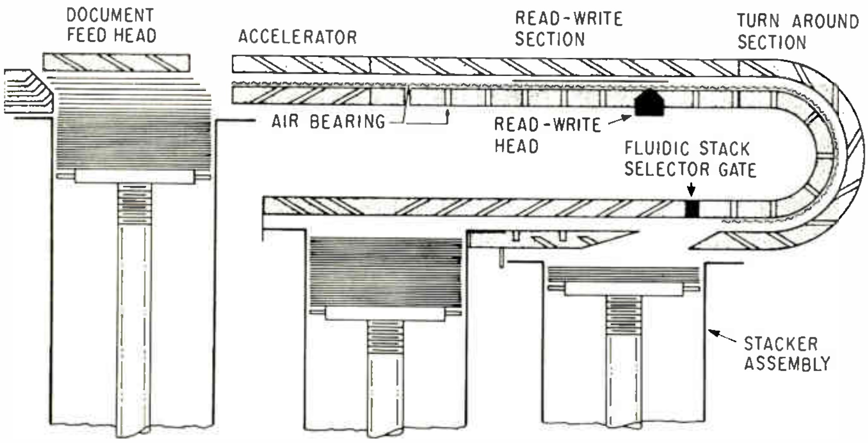
On the track. The cards, which resemble playing cards in size and thickness, are coated with a thin nickel-cobalt film. In the present experimental models, a machine-readable sector 1 by 2½ inches records up to 1,000 characters. Other sectors are available for printed information, signature, and photograph. The data is stored in densities up to 500 characters per inch on nine parallel tracks in much the same way as information would be entered on magnetic tape; in fact, the card functionally resembles a small piece of magnetic tape snipped off the reel.

Up to 8,000 characters could be stored on both sides of the card, compared with 80 on the present standard punched card. Interference between the recordings on either side wouldn't be a problem because the characters are written 500 to the inch, and the thickness of the card is large relative to this spacing.

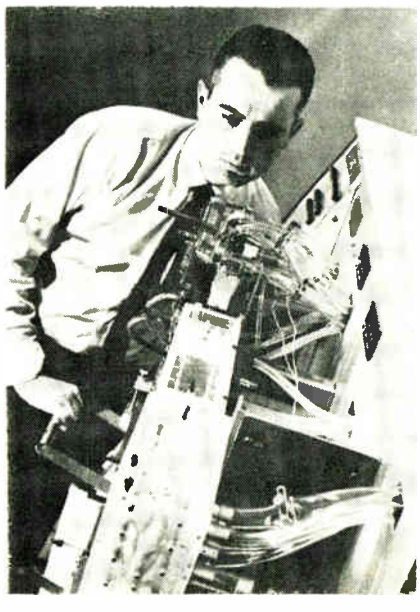
The fluid transport system includes an input hopper, read-write stations, and—in the prototype—two output stackers. A stack of cards in a metal cartridge rises on an elevator mechanism until the top one is blown off by a stream of air. The cards ride on this stream, one by one at a 300-per-minute clip, past a station that can either read data from the cards or write new data on them. As the cards leave this station, they encounter a fluidically controlled gate that directs them to one of the two output stackers. One stacker might accept only error-free cards, for example, while cards containing errors would be directed to the other.

The prototype design could be extended to process up to 1,200 cards per minute, or to combine the functions of several conventional card tabulating machines, such as sorting, collating, and updating.

Handy units. The new development is particularly significant in view of current interest in devices that bypass punched cards as a computer input medium. Most of these devices write data on a magnetic tape that is either directly computer-compatible or can be easily transcribed onto computer tape.



No punch, but rugged. Magnetic computer card developed by Univac can be bent, spindled, and even stapled.



Floating on air. Data cards, which can contain signatures and photographs, are processed by fluidic mechanism.

But magnetic tape is not a unit record. Payroll information cannot be snipped off a reel of magnetic tape and given to an employee to cash at his bank, for instance. A punched card can be handed out, of course, and Univac's new development combines the advantages of magnetic recording with this punched-card flexibility.

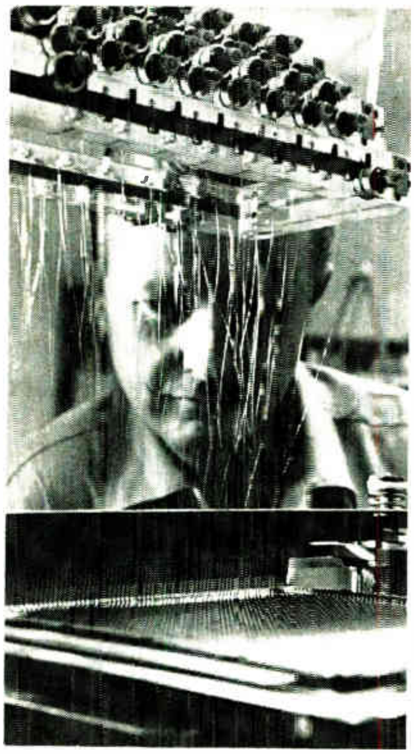
Forward, march

The National Cash Register Co. took a flying leap last week into what it hopes is a substantially larger share of the computer market than it has now. With just under 3,000 computers, of half a dozen or so different models, now installed, the company hopes to sell at least 5,000 of its new Century Series during the next few years.

The firm claims the new machines have a lower price-to-performance ratio than any other similarly priced machines—achieved by two new hardware designs and highly standardized parts. The fresh designs include a second-generation thin-film rod memory and a new disk file design.

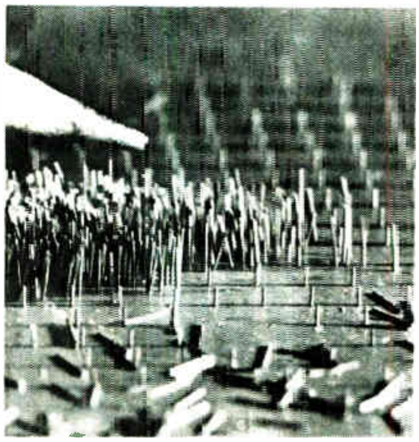
Moving ahead. The thin-film rods are really "whiskers" a tenth of an inch long. They are snippets of a plated wire made in a continuous process and assembled by a method that reminds one of "The Sorcerer's Apprentice." Whiskers are scattered across a metal plate full of little holes, under which has been placed an assembly of interlaced twin solenoids resembling a miniature chain-link fence. An alternating magnetic field is applied to the plate, causing the whiskers to stand on end and march in a phalanx across the plate. One whisker falls into each hole as the phalanx passes; left-over whiskers fall off the edge of the plate and can be reused.

The memory plane contains 4,608 whiskers, one whisker per bit. Planes are assembled into modules of 16,384 eight-bit bytes, the smallest memory size available with the new machines; they can be combined into memories of up to 524,288 bytes. The memory cycle time is 800 nanoseconds—the same as the company's four-year-old rod memories, made with plated rods 4½ inches long, each storing several bits. As with the older rods, the magnetic film is magnetized lengthwise in one direction to store a binary 1 and in the other direction to store a binary 0.



Coil weaver. Automatic machine produces interlaced twin solenoids for new rod memory.

Price is bright. The new memories are inexpensive—the customer pays $23 per month per thousand bytes, compared to an industry average of around $50 per thousand bytes, according to Paul Lappetito, NCR's assistant vice president for marketing.



Marching whiskers. Tiny memory rods, shown under pencil point, "dance" into place as rod memory is assembled.

Two disk storage units are standard on even the lowest-priced Century systems. The units, which use removable disk packs, with nickel-cobalt plating instead of the conventional magnetic oxide, have 12 read-write heads per disk surface. The large number of heads and the small movement of the single access mechanism carrying them can retrieve any data from the disk in an average of 48 milliseconds—less than that of any other disk-pack unit, according to NCR.

81 cards. Practically all of the logic in the Century computers is implemented with one standard integrated circuit—two four-way diode transistor logic gates in a dual in-line package. The IC's are mounted on only 81 different kinds of circuit cards, as compared with 1,200 on most other computers; six of these 81 handle most of the logic functions in the machine. The IC's are made to NCR's specifications by several semiconductor manufacturers, including Signetics and Fairchild.

Software is being checked out on several machines already installed in NCR's own locations, and will be ready when customers get their first machines in September, the company says.

The Century series represents for NCR the same kind of gamble, on a somewhat smaller scale, that IBM took when it introduced the System 360—a gamble that has been called, "You bet your company." NCR has invested $150 million in developing the new line. Although the first two announced models are aimed largely at NCR's previous markets—retailers, financial institutions, and small industrial users—larger models to be announced within a few months will have multiprocessing and time-sharing capability. These will put the company in a new sector of the computer market that it has not previously exploited.

The Century 100 rentals begin at $1,910 per month with a five-year contract; for the basic Century 200, the rental is $3,355 per month.

Instrumentation

Outside testing

Checking all shipments of integrated circuits for defective devices is a procedure recommended to all users but beyond the capacity of many. Some either can't afford the equipment to do their own testing, or lack the engineers capable of programing and maintaining IC testers. Others having the equipment and personnel sometimes take on more IC shipments than they can process themselves.

These firms will soon be able to let Texas Instruments do the testing. The Texas Instrument Supply Co., a subsidiary of TI, this week will open centers at Lake Success, N.Y., and Houston, Texas, for the testing of all types and brands of IC's—the first such service ever offered.

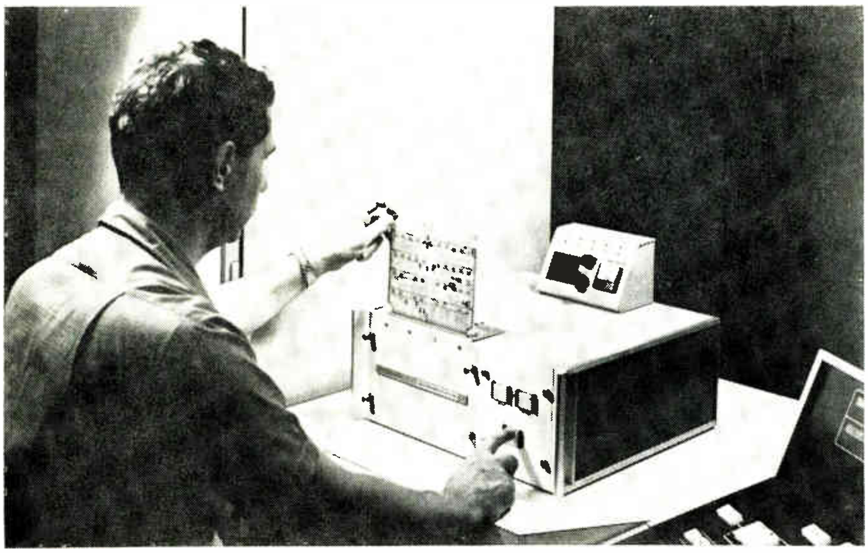
Unprejudiced. Both centers will be equipped with TI's 553 tester in combination with a company-developed 860 special-purpose computer. Typical tests that can be performed are d-c and pulse, d-c and dynamic, and burn-in and component aging. The facilities can handle both medium- and large-scale integrated devices, as well as printed-circuit boards. And to insure unbiased results, the centers will develop standard test programs for all standard IC's.

Computer printouts of the test results will be made available if the customer requests them. Results of all testing will be confidential.

The cost of using these facilities can be as low as pennies per device for a functional, go/no-go test on a standard device, the TI subsidiary says. Parametric tests of nonstandard IC's will cost more, of course, to cover the expense of developing special software. And environmental testing will add even more to the price.

Library. Each center will maintain a library of standard test programs both for the center's own operations and for IC users with their own test equipment.

Texas Instrument Supply would like to eventually combine the IC tester with a time-shared computer, and lease testing terminals to each customer.



Check-out service. Texas Instruments subsidiary is initiating a testing service for users covering any brand of integrated circuit.

Laser recording

Sixteen months ago, the Precision Instruments Co. developed a laser-optics computer mass-memory system that promised packing densities 1,000 times better than the best magnetic tape.

The system seemed fine for real-time permanent recording. But the small Palo Alto, Calif., company could find no way to retrieve the information once it had been recorded.

Now the company has not only developed an agile retrieval system based on the same principle, but has also found a way to use it to record wide-band, high-resolution color video.

Top speed. The system promises a retrieval rate of two megabits per second, more than most computers can handle, the company says. One track—grooved slantwise into a drum 60 centimeters long—contains 120,000 bits and can be scanned in 1/30 of a second.

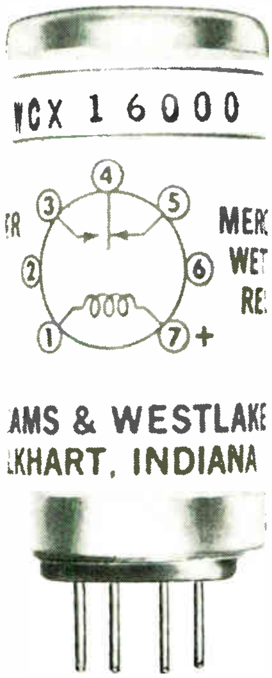
The company says it can produce color video pictures with 1,000-line resolution, or 10 megahertz, double the consumer tv standard. It expects to demonstrate this system within two months.

The company foresees potential markets in wideband-frequency recording and reproducing, geophysical exploration, and mass information storage. Right now, it's showing the demonstration model to interested civilian and Government groups and will build the first standard model when a buyer appears, says Joseph V. Shane, general sales manager.

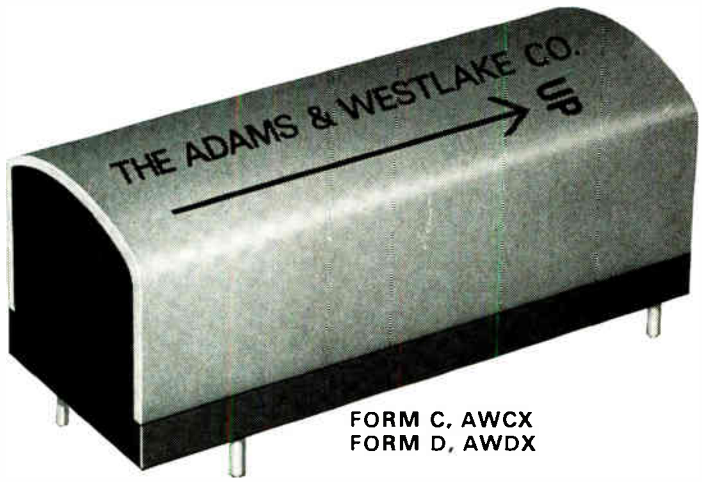
Called Unicon, the basic system uses an argon ion continuous-wave laser to punch one-micron diameter holes in specially designed nonmagnetic medium so that, in binary fashion, a hole means 1 and a no-hole 0. By assembling these 1's and O's into five-by-five micron bits and spacing these bits five microns apart, the system records in pulse-code modulation. Theoretically, the nonmagnetic system could reduce the information on 4½ miles of magnetic tape to one 3-by-30-inch strip.

Changes index. Unicon, developed by Carl H. Becker, director of research, uses a laser beam through an electro-optical modulator (Pockel's cell) that transfers the input signal to the laser beam by changing the refractive index. From there it passes through a rotating optical system that focuses the light on a recording track, which may be on a tape, disc, or drum. The system offers two basic advantages over conventional magnetic tape mechanisms:

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.

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Cricle 51 on reader service card

- It requires no secondary processing of the recording medium, which is a proprietary thin film of uniform optical density. Last year, the Itek Corp. dropped its years-long work on a photographic laser-recording technique because of technical problems [Electronics, March 20, 1967, p. 47].
- It also gives instantaneous verification through a photo diode behind the film, which indicates whether the laser actually burned the hole it intended. If the laser was supposed to record 5,000 holes and only recorded 4,999, the system would register an error within nanoseconds, Becker says. Over-all accuracy is one error in 10 million bits.

Unicon reads by picking up the variations of reflections of a laser beam on a photelectrical detector. This also gives the system instantaneous read-while-you-write data processing.

But in devising a way to retrieve the information later, Becker had to find a way to make the laser beam follow the same position and the film tracking at the same speed as in recording. He then chose a flying-spot scanner that follows the track by galvanometer-directed servo controls. The galvanometer keeps the laser pointed to the middle or brightest part of the track as in radar tracking of a satellite. The galvanometer transmits the holes or no-holes signals back to the photodetector as information.

The system would permit either single-frame, helical multiple-frame incremental, or helical multiple-frame continuous recording and reproducing. Helical tracking on a drum, for example, would permit compact information storage on a principle analagous to a slanted filing cabinet drawer: at the top of each track would be an identifying code, like file drawer tabs, so that with one quick spin around the top of the drum a laser scanner could search a memory system for the correct track.

The whole track would have to be reproduced to pick out just a few bits, but the system would regurgitate the track of bits so quickly it wouldn't matter, Becker says.

Ahead of tape. Becker claims that as a video system the unit has a potential bandwidth of 1 gigahertz. If the transport system could scan at 1.8 kilometers per second (versus the 18 meters per second now), laser power would also have to go up. "What is holding us back is the transport system" Becker says. "What we need is beyond the state of the art."

But, he adds, "magnetic systems are limited to 5 Mhz. Our first experimental model is already beyond the limits of magnetic tape systems."

Military electronics

A question of priority

Electronics companies and military program managers are becoming acutely aware of the financial facts of life as more and more money gets shifted to Vietnam-related programs, draining the budgets of lower-priority efforts.

One casualty, the FSR-2, an optical satellite-tracking system, is a case in point. The system, part of the Spacetrack program, 496L, has had its share of technical difficulties [Electronics, April 3, 1967, p. 168], but late in February RCA's Aerospace Systems division, Burlington, Mass., thought it had the solutions—then found it didn't have the money.

There will be no more money for the system until fiscal 1969—and even then Vietnam may suddenly drain it away. And it's no consolation to RCA that other programs are experiencing equivalent money troubles.

No reflection. The funding halt isn't a judgment of the FSR-2, rather it's typical of the fortunes of several other Air Force-sponsored programs. "If it can't be used in Vietnam, it almost doesn't have a chance," says an insider at the Electronic Systems Division, Hanscom Field, Mass.

Programs like TACS (407L, Tactical Air Control System), usable in Vietnam, are being fed as much money as possible. TACS is near final development and procurement now, with only one manufacturer remaining to be selected for its 45 major subsystems. The first TACS system could be operating by late 1969, supplying communications, radar, and computer capabilities with which to control tactical aircraft.

Nor should there be much problem with money for TACS during the remaining months of fiscal 1968. The $44.2 million for procurement and final development allocated last year, plus an added $5.5 million for advanced TACS research makes it the largest program at the field.

But cutback rumors fly about other programs; even about already-approved programs like Awacs (411L, Airborne Warning and Control System), and systems already realized in hardware like Aesop, a data-retrieval system for air-strike commanders. Some of the more distant programs, like Control and Surveillance of Friendly Forces (Casoff), are even more likely to be delayed.

Behind schedule. Awacs is moving to contract definition more slowly than expected and is already about one month late. Although there are a variety of reasons, Vietnam funding is the rumored cause.

The Air Force originally requested $25 million for fiscal 1968 funding for Awacs; the Defense Department cut this to $10 million, which was to pay for demonstration of overland radar technology. It's estimated that $20 million to $25 million was included in fiscal 1968 "emergency funds" for Awacs, to be drawn upon after successful demonstration of the radar—but some of this money may have found its way to Southeast Asia, and full funding might have to await fiscal 1969.

Aesop, which would display the data needed for efficient deployment of tactical aircraft at first would seem to have a good chance. It is designed for tactical operations and might mate well with TACS. Somewhat like a time-sharing computer terminal with graphic displays, plus keyboard access, Aesop has already been demonstrated in the United States and it's

proposed that a few Aesop centers be given to the Seventh Air Force's tactical air strike planners in Vietnam.

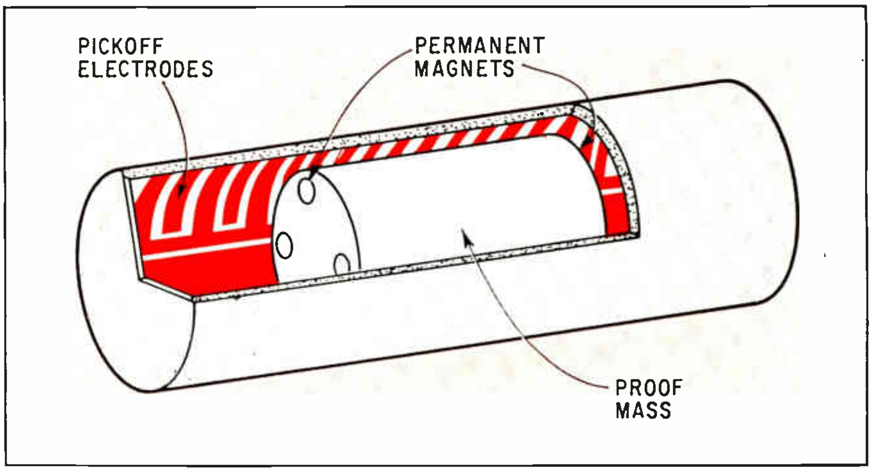
Where it is now. When last seen, the proposal for a Vietnam test was still being considered by the air staff in Washington; Aesop's Asian arrival could be delayed for money reasons.

Casoff, which attracted proposals from 64 electronics firms in October 1967, was originally scheduled to enter the study contract phase last December. But Casoff hasn't surfaced since the request for proposals, and insiders place it far on the back burner.

If the green light ever flashes, contractors would study an integrated navigation, communication, and digital data system for command and control of friendly aircraft, one which might supersede TACS. But if "money green" is the color of the light, it could stay unlit till the war slackens in Vietnam.

Avionics

Done with magnets



Sensing movement. Ultrasensitive accelerometer uses a magnetic fluid rather than large electromechancial arrangements to suspend sensing element.

With only one moving part, and a minimum of electrical contact with the outside world, a new magnetic fluid accelerometer may help simplify rate-sensing equipment and inertial-guidance platforms. Developed for the Air Force under a $50,000 contract by the Space Systems division of the Avco Corp., Lowell, Mass., the accelerometer uses a magnetic fluid to suspend its proof mass, or sensing element, rather than cumbersome electromechanical arrangements.

According to the developer, Ronald E. Rosensweig, earlier single-axis devices had been developed using a lightweight proof mass in a dense fluid to sense movement or acceleration; the tube-like housing of the accelerometer was spun and the resulting centrifugal force drew the fluid to the tube's periphery leaving the lighter proof mass centered and free to move back and forth in response to outside forces.

No spin. In Rosensweig's device, magnetic fluid replaces centrifugal force, eliminating the large motor and spinning tube—and with them, their large power requirements, heat, and bulk.

The magnetic fluid is a colloid; a suspension of finely ground magnetite in a hydrocarbon, fluorocarbon, or silicon liquid. The tiny magnets are about 100 angstroms long—"about the size of some viruses," says Rosensweig. The fluid contains about 10^{18} particles per cubic centimeter.

The fluid's magnetic field, together with that of eight small Alnico-28 bar magnets in the nylon proof mass, combine to center the proof mass about 20 mils away from the surrounding tube. Now, any force exerted along the axis of the accelerometer tube will betray itself in a movement of the proof mass.

How do you know? The pick-off technique is simple: the proof mass is coated with a metal film and the interior of the tube has 16 finger-shaped aluminum film electrodes deposited on its interior. As the proof mass moves, its metal film jacket makes it one plate of a variable capacitor and changes in capacitance are proportional to changes in the velocity of the accelerometer.

All this makes for a very sensitive device—one capable, it is believed, of sensing forces as small as 0.00005 gravities. The device's sensitivity has never been fully measured.

"Ordinary disturbances in the lab, like someone walking, are enough to mask the lower limits of its sensitivity," says Rosensweig.

He is sure the unit can detect movements smaller than 10 microns, and thinks perhaps the lower limit could be nearer 1 micron.

These characteristics add up to an uncomplicated device that could perform well on the inertial platforms of aircraft or spacecraft guidance systems. With such goals in mind, Rosensweig's next goal is development of a smaller unit with integrated circuit pick-off electronics.

The present unit is about two inches long and one inch in diameter. The new accelerometer will be about the diameter of a pencil, and proportionately shorter.

Microwave

Gunn in the West

Taming gallium arsenide to perform Gunn-effect tricks has given the few companies that have tried it a rough ride. In fact, it's thrown a few completely out of the corral.

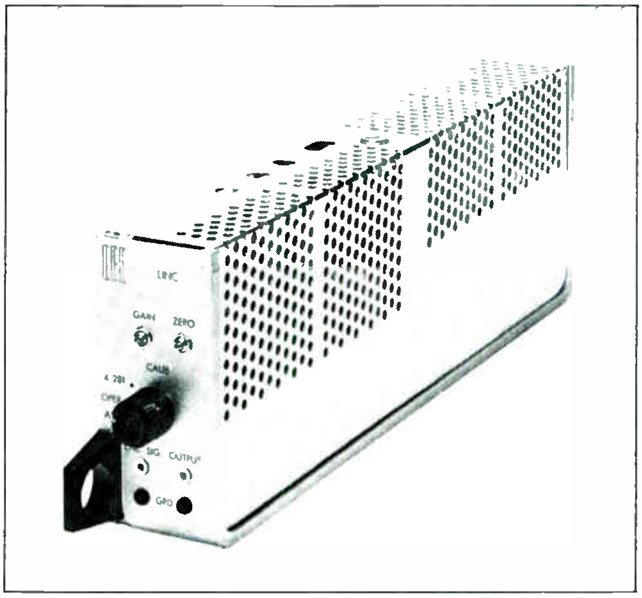
Later this year, Varian Associates of Palo Alto, Calif., will enter the field with four off-the-shelf Gunn-effect continuous-wave oscillators in the X, Ku and K microwave bands with mechanical tunability. The X-band device, for example,

PIEZO ACCELEROMETER REPORT

CEC

REPORT NUMBER 4

New normalizing coupler with abnormal capability



Every once in awhile something is created that literally eliminates competition. Such is CEC's new LINC, or 1-161 Low Impedance Normalizing Coupler.

LINC is described as an all solid-state device designed for coupling low impedance piezoelectric instruments to tape recorders, galvanometers and other recording equipment.

But from here on, its "abnormal" capabilities become unique indeed. Note how they compare with those of the next best concept.

1. LINC provides the necessary *decoupling capacitance, amplification* and *impedance matching* for piezo accelerometers and piezo electronics having output impedances as high as 2000 ohms. In fact, it is also fully compatible with virtually any transducer with relatively low output impedance and nominal sensitivity.

   Other concept will effectively accept only special piezo accelerometer input.

2. LINC features a self-contained excitation supply for use with low impedance accelerometers or piezo electronics which require an operational voltage of 24 V dc at 20 ma.

   Other concept has no excitation supply.

3. LINC provides a *continuously adjustable* gain of 0.1 to 10, thus permitting input voltages varying from 1 millivolt to ±105 volts peak.

   Other concept relies on a gain selection switch only and is limited to a maximum input of 10 V p-p.

4. LINC achieves a frequency response of ±0.4 db (±5%) from 0.2 to 30 KHz.

   Other concept is rated at ±3 db from 0.5 to 20 KHz.

5. LINC has calibration positions for internal amplifier gain and dc offset control, plus *precise* transducer calibration.

   Other concept possesses a push-button continuity check for transducer monitoring—but no calibration controls.

Is LINC much more expensive?

Much less. In fact, the cost-per-channel is significantly lower than any other piezo coupling system. Additionally, LINC's low impedance design eliminates the cost and problems associated with long lines and expensive cabling.

And—there are the dual advantages of LINC's greater *compatibility* with existing transducers and electronics, and output *capability* for superior interface with present recording devices.

Obviously, LINC is destined to be the new standard for every application from engine test stands to structural testing and vibration analysis.

And it's one more "LINC" in the chain that has made CEC the leading producer of low and high impedance accelerometers, plus associated electronics.

For complete information, call your nearest CEC Field Office. Or write Consolidated Electrodynamics, Pasadena, California 91109. A subsidiary of Bell & Howell. Ask for Bulletin 1161-X2.

CEC/TRANSDUCER PRODUCTS

BELL & HOWELL

has a frequency range from 9.0 to 12.4 gigahertz, a maximum power output of 25 milliwatts and operates on 8 volts at 350 milliamps.

Varian stresses that these oscillators are pre-production devices, "available for sale for experimental use by our customers." But, from customer evaluations the company will be able to stabilize, maybe even boost, the specs for regular production, tentatively scheduled for Wescon in August.

Sees expansion. GaAs is one of the new frontiers of semiconductor materials technology [Electronics, Nov. 13, 1967, pp. 105-136] and Varian plans to expand its small stable into a large spread of microwave devices. Within the next few months RCA and Texas Instruments may also be in the market with Gunn devices.

Growing the crystals with a purity of 10 parts per billion is necessary for fabricating the devices. "Anyone not doing his own epitaxial growth is not going to be in this business very long," says Daniel G. Dow, manager of Varian's solid state operations.

Only GaAs, prepared with exacting specifications, shows the right properties for the effect first observed in 1963 by J. B. Gunn, a physicist at the International Business Machines Corp.

Dow's group began working on the problem 30 months ago, but it wasn't until last December that it decided to make an X-band oscillator. A month later it produced the first five, all with an output of 50 mw or more into a matched load. Last month, it made the first K and Ku band samples.

Besides the X-band (VSX-9001 series) devices, Varian offers two Ku band series (the VSU-9002) with a frequency range of 12.4 to 15 Ghz, minimum power output of 20 mw and a typical voltage of 7v; and the VSU-9003, with a 15 to 18 Ghz range, minimum power output of 15 mw at a typical voltage of 6. The K-band VSK-9004 operates at 18 to 26.5 Ghz, 10 mw minimum power output at a typical voltage of 4.5. The last three have typical currents of 300 milliamps and all have mechanical tunability of 1,000 megahertz.

Low noise. Dow says Varian unexpectedly got exceptional low a-m noise recorded on the Ku-band units. For example, in a 100 hz bandwidth about 20 Khz from the carrier, the a-m noise was down to −130 decibels below the carrier, which is on a par with some klystron oscillators Varian also makes.

Varian is mum on the prices, which it says "reflect the state of development," but a good guess might peg the devices between $750 and $1,500. Varian will also sell the diodes separately.

Dow thinks the real impact of the Gunn-effect devices will occur as the volume and control builds up. "It's basically an economical, low-noise, long-life device," he asserts, for such military applications as countermeasures, radar and low-power transmitters and possibly the police communications markets. "Increases to one watt should be feasible in a few years," Dow says. His group is also experimenting with pulsed and limited space-charge accumulation modes; and the combination of the two would be useful for pulsed radar systems and transponders.

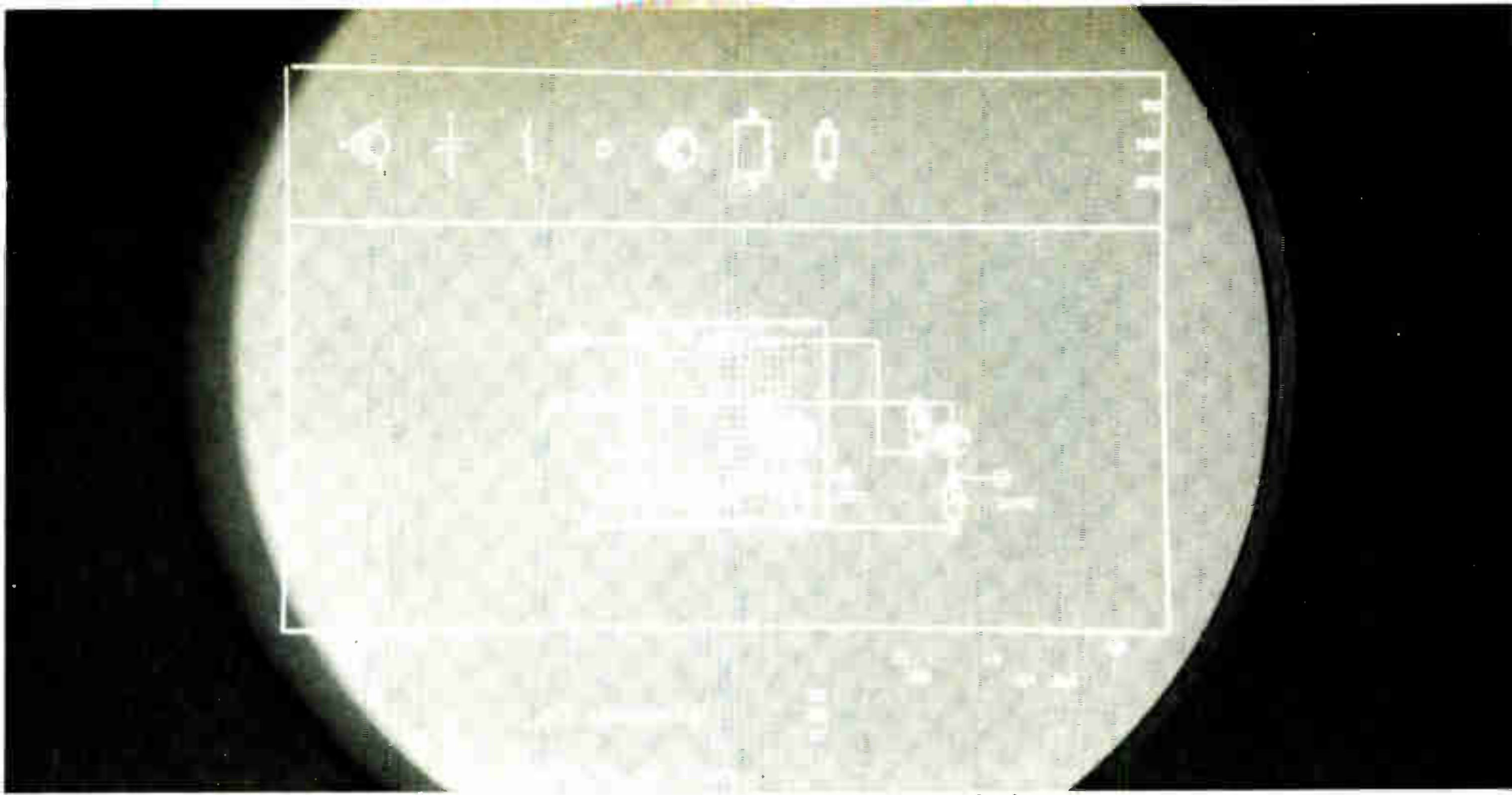
Competition. Strangely, Varian's work with Gunn-effect devices may put it in competition with its own klystron devices. Not only that, but they could be infringing on the avalanche transit time oscillators made by Varian's Bomac division. Dow says, however, that the "avalanche devices are expected to have the capability of more power."

Dow expects Gunn-effect devices "to capture a major piece" of the microwave oscillator business, and predicts that "in five years, Gunn and avalanche devices will have most of the new business."

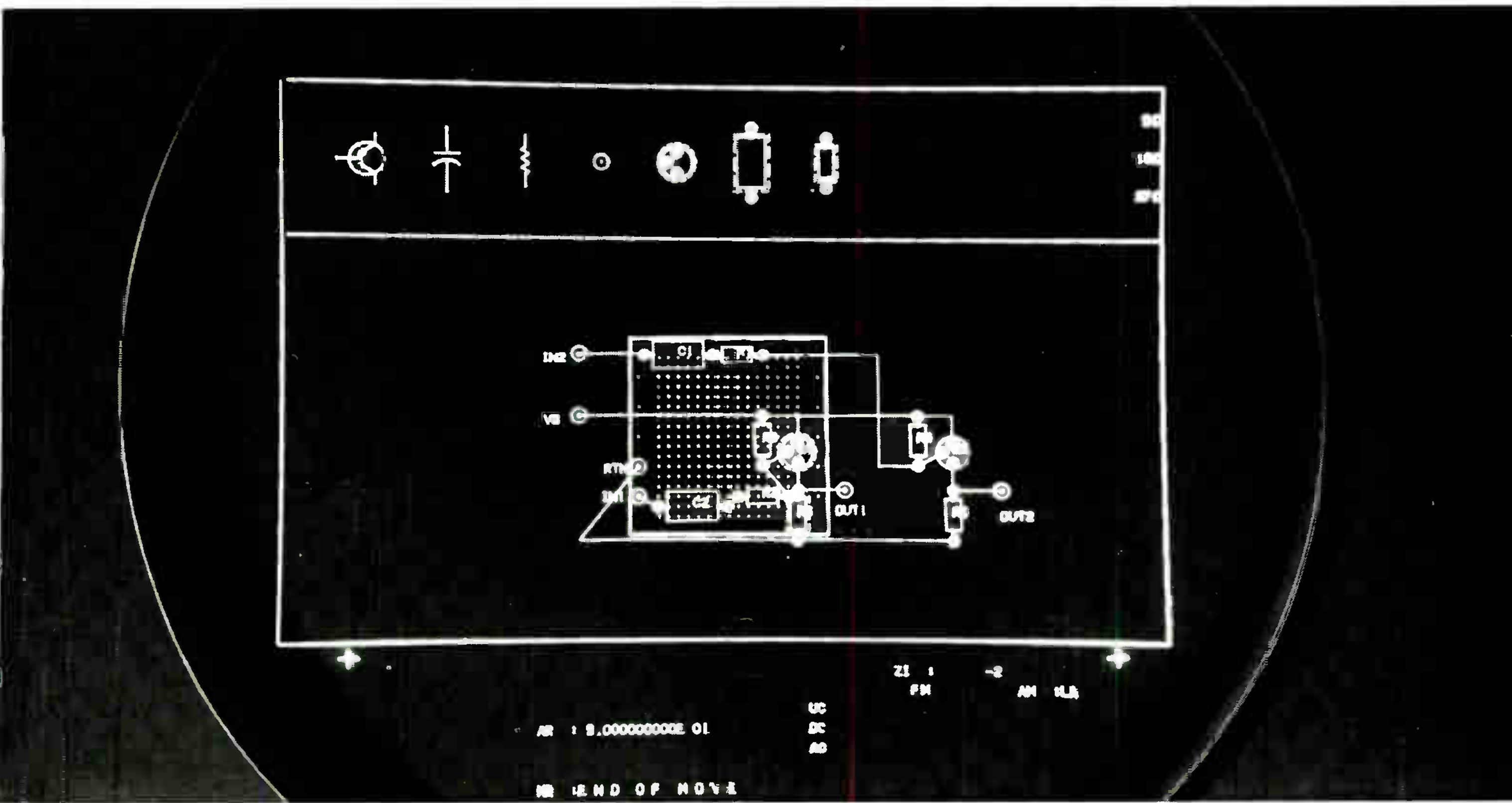
Space electronics

Growing flock of birds

Just as radio-dispatched delivery services and municipal police now fight it out for alloted land-mobile frequencies, so satellite users might someday compete for channels.



Readouts clear up problems.



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Circle 57 on reader service card

This prospect of battles all over the spectrum prompted the Office of Telecommunications Management two years ago to undertake a study of projected satellite frequency needs in the 12 years to 1980.

The just-completed study, which cost the Government more than $200,000, predicts that Federal agencies and Comsat will have 273 satellites in orbit by 1980 as part of 49 separate systems supported by "hundreds of ground stations." Half these craft will be in synchronous orbit, the report goes on, and two-thirds of those will be communications satellites.

Crowded skies. The 273 roughly break down into these categories: 57 observation, 53 scientific, 34 navigation, 83 communications, six broadcast, 13 data collection from earth sensors, 13 manned, 10 geodesy, and four for calibration of equipment.

The report states that the current allocation to satellites of bands below 11 gigahertz will "prove to be inadequate" before 1980 and that the increasing number of terrestrial microwave stations will inhibit the development of communications satellites.

Proposals. The following steps are recommended by the study to support the needs it estimates will be required between ground stations and orbiting craft by the year 1980:

- An expansion of the number of frequencies allocated solely to space. But the agency didn't say where it will get the channels.
- An increase in the number of frequency bands space systems can share with earth systems.
- The direct transfer to satellite users of some bands now allocated solely to terrestrial systems.

The report urges the greatest application possible of new technologies to the spectrum problem. For example, it suggests the use of modulation techniques and newly developed antennas to provide maximum signal discrimination. And as a prime theme, it stresses that now is the time to begin providing for frequency "coexistence" between space and ground systems.

First slice

NASA's $4.4 billion request for fiscal 1969 got its first trim last week as the House Science and Astronautics Committee lopped off $153 million.

With other authorization and appropriation sessions still ahead, the request will probably be reduced to about $4 billion before a final budget is approved. The space agency's budget will next appear before the full House, which is expected to cut another $200 million. As one NASA official puts it, "This was just the first slice. I'm afraid to think what may happen as it gets farther along on Capitol Hill."

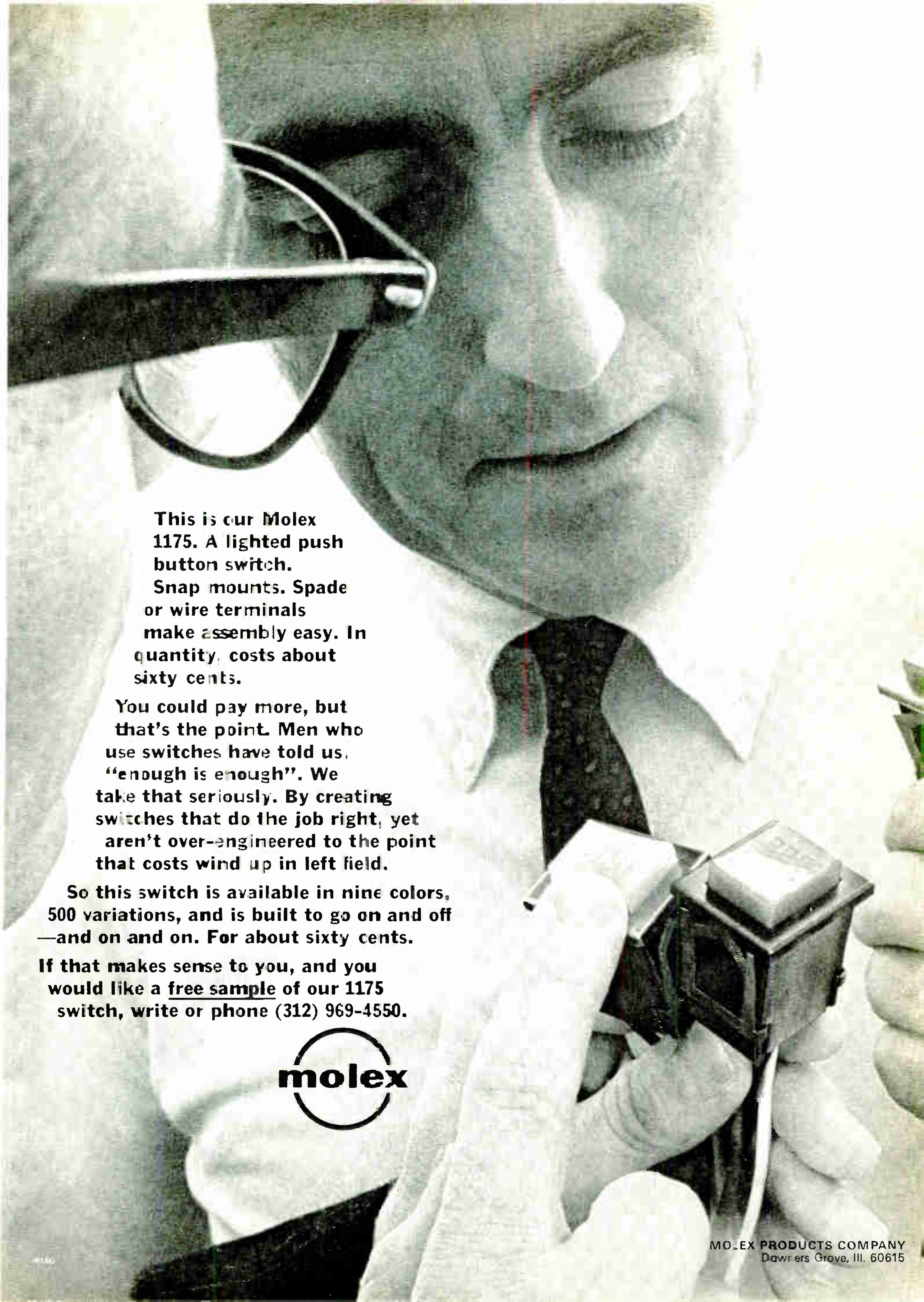
The casualty list in this initial encounter with Congress is impressive:

- The outlay for Nerva, the project to develop a nuclear-powered rocket was pared from $60 million to $11.7 million.
- In the manned space program, the advanced missions studies request was halved to $2.5 million, while a 10% chop was made from the requested $439 million for Apollo applications.
- Four satellites – atmospheric Explorers C and D and two 21-day-mission biosatellites—were knocked out of the plans of the Space Science and Application Program.

Two additions were made by the House committee; they only amount to $3.5 million but may indicate a trend towards space programs with down-to-earth applications. The panel added $1 million to the Office of Advanced Research and Technology's request covering research in such areas as airplane safety and jet noise abatement. And the slated expenditure for development of an Earth Resources Technology Satellite was more than doubled from $2.2 million to $5 million.

For the record

Water works. The Coast Guard has established the feasibility of a single national data buoy system. It would do most of the chores now envisioned in 48 separate programs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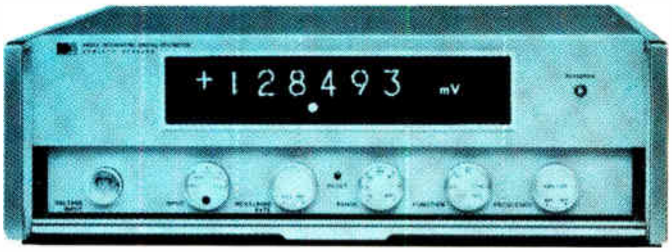
being studied for various Federal agencies. However, the cost is $500 million and Congress has been asked to approve only $5 million of that amount for fiscal 1969. The program would require approximately $50 million a year for nine years thereafter. Although few technical details have been worked out, it is thought much of the $500 million figure would go for electronic gear. If all goes well, the Coast Guard hopes to have a demonstration system by the early 1970's. It has been working under orders from the Marine Sciences Council.

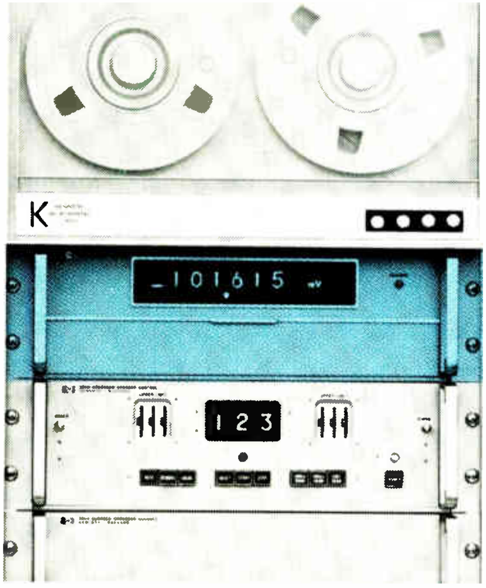
Soaring sales. The Electronic Industries Association reports that integrated circuit sales climbed more than 50% last year to a total of $228 million. Leading the parade were the digital IC's with approximately $182 million in sales for 1967, up 55% in the year.

Where are you? The Chicago Transit Authority plans a $2 million bus identification system that will include a two-way radio hookup, a computerized display pinpointing the location of each bus, and an alarm system. The city expects to award a contract for the system within three months to one of the three competing companies—Sylvania, Raytheon, or Motorola. Transit officials say 500 buses will be hooked into the system within a year.

Keyboard education. The D.H. Baldwin Co. has developed this electronic teaching system for keyboard instruments. Now being tried at Baltimore's Peabody Institute, the system permits one teacher to handle up to 24 students.

bench accuracy at system speed





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The 2402A: $4800. Plug-in options are reasonably priced—AC, for example, only $450.

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

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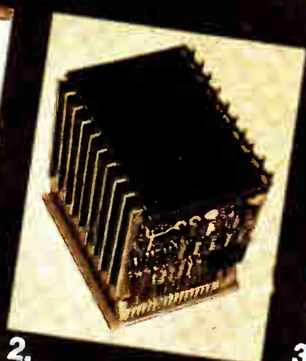
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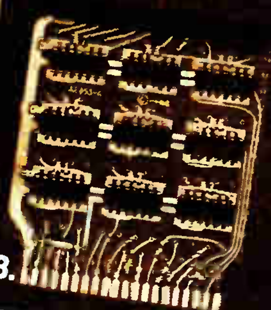
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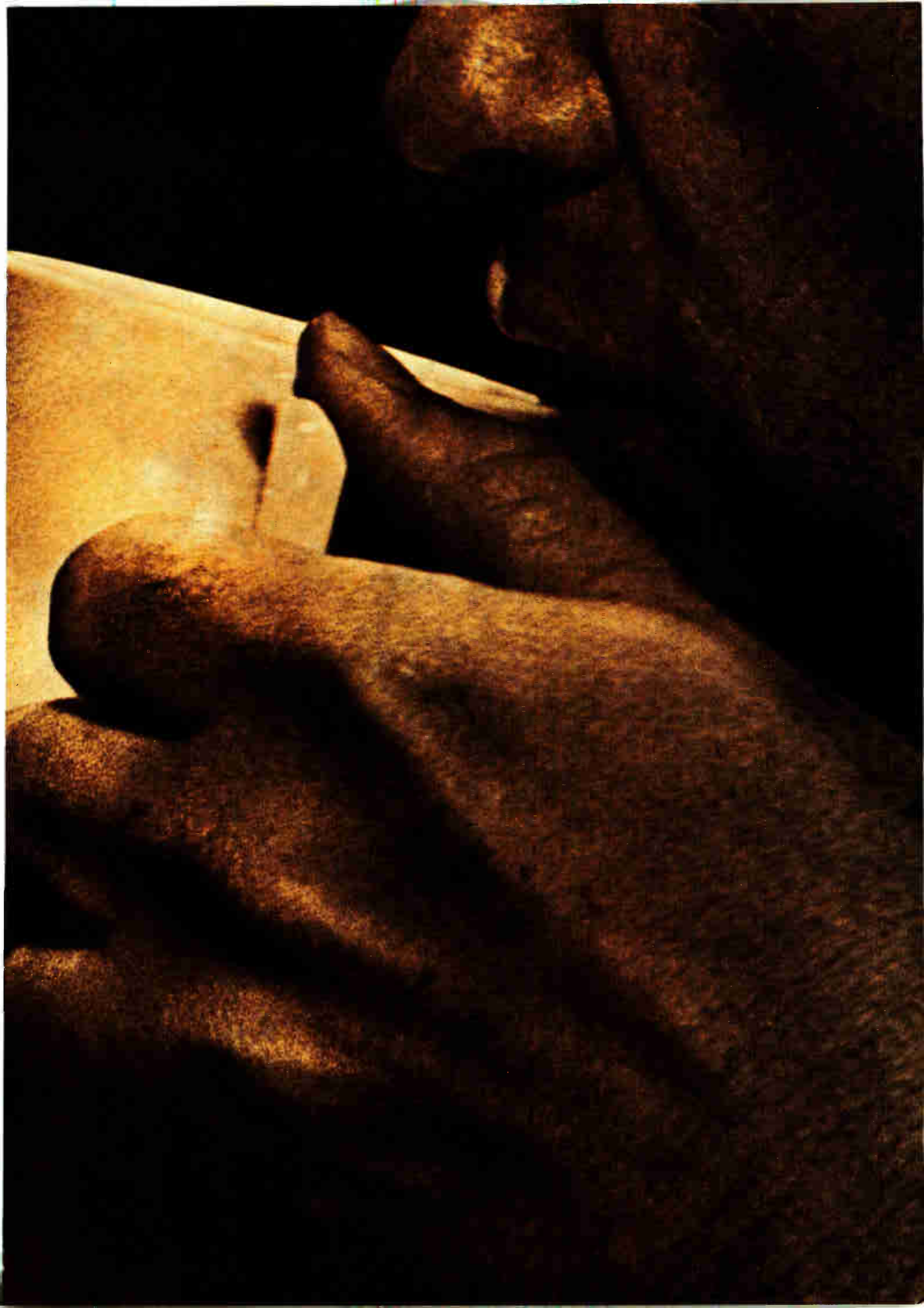


RECAP:

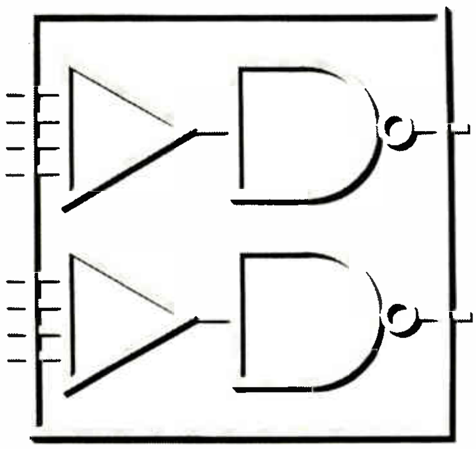
Starting October 9, 1967, Fairchild promised to introduce a new integrated circuit each week for 52 weeks. This is number **17.**

9620 DUAL DIFFERENTIAL LINE RECEIVER

The 9620 is designed to take differential logic from transmission lines and convert it to CCSL levels. It also has the capability for conversion to higher levels. It is ideal for use in data net collectors, or in data processing applications where the central processor and data source are in separate locations. The 9620 can also be used as a CCSL compatible differential comparator.

Each section of the Dual IC consists of a differential amplifier driving a saturating inverting DTL gate with uncommitted collector. Maximum differential threshold voltage is ±500mV in the presence of ±15 volts common mode. Typical power dissipation is 55mW per receiver. Propagation delay is 50ns maximum at 25°C. High common mode rejection is also provided.

The 9620 comes in a 14 pin hermetic DIP and will operate in both military and industrial temperature ranges (−55°C to 125°C and 0°C to +70°C). It's available in volume quantities. Your Fairchild distributor has it in stock now. Write for complete specs and applications information. Ask about our other new products, too.



FAIRCHILD SEMICONDUCTOR

CIRCLE READER SERVICE NUMBER 117

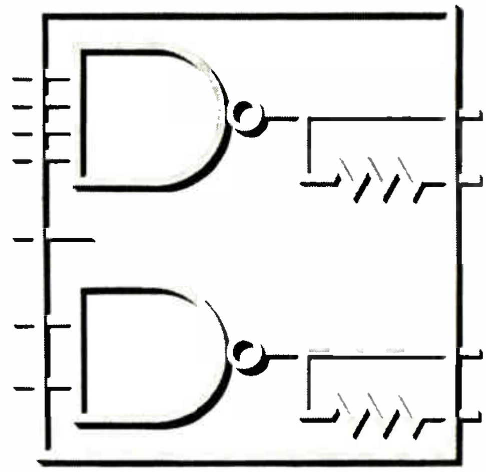
Starting October 9, 1967, Fairchild promised to introduce a new integrated circuit each week for 52 weeks. This is number **18.**

9621 DUAL LINE DRIVER

Fairchild's 9621 is used to transmit CCSL level logic down transmission lines. It can also be used to drive high capacity loads. It consists of a 4-input inverting DTL gate and a 2-input inverting DTL gate. There is a termination resistor available on each stage which permits you to backmatch 130-Ohm lines either directly or differentially. An extender is available on the 2-input gate which allows you to add additional external diodes, and thus obtain more inputs. The 9621 can also be used as a low output impedance device. Each driver provides minimum output current of 20mA at 0.4V. Diode clamps are provided to damp reflections on the output.

Maximum power dissipation for the new IC is 210mW. Propagation delay is 25ns maximum into a 30pF load. It comes in a 14-pin hermetic DIP and will operate in both military and industrial temperature ranges (−55°C to +125°C and 0°C to +70°C).

Applications for the 9621 include data processing and computer peripheral equipment. It is designed specifically to operate in conjunction with our 9620 dual differential line receiver (New Product No. 17). Both devices are available in volume quantities. Fairchild distributors have them in stock now. Write for complete specs and applications information. Ask about our other new products, too.



FAIRCHILD SEMICONDUCTOR

CIRCLE READER SERVICE NUMBER 118

Starting October 9, 1967, Fairchild promised to introduce a new integrated circuit each week for 52 weeks. This is number **19.**

3300 25-BIT MOS STATIC SHIFT REGISTER

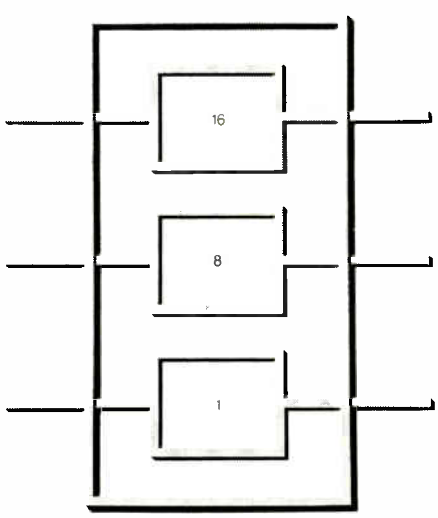
The 3300 is the fifth MOS device we've introduced since December 11, 1967. (The first four were the 3701 six-channel multiplex switch, 3102 three-input gate, 3700 four-channel multiplex switch, and the 3300 dual 25-bit dynamic shift register.)

The 3300 is a monolithic IC utilizing Planar II* P-channel enhancement mode MOS technology. It is designed to be used for digital delay lines and long serial memory storage in radar systems and computers. It is also applicable for data storage in telemetry systems.

The 25-bit device comes in a TO-5 can and will operate over the entire temperature range from −55°C to +85°C. There are independent 16-, 8- and 1-bit data strings within the package. Power dissipation is typically 2mW per bit. Speed is typically 500KHz. The clock drive circuit is simplified by a single-phase clock input. The output is buffered to improve drive capability.

Volume quantities of the 3300 are now available. Fairchild distributors have it in stock. Write for complete specs and applications information. Ask about our other new products, too.

*Planar is a patented Fairchild process



FAIRCHILD SEMICONDUCTOR

CIRCLE READER SERVICE NUMBER 119

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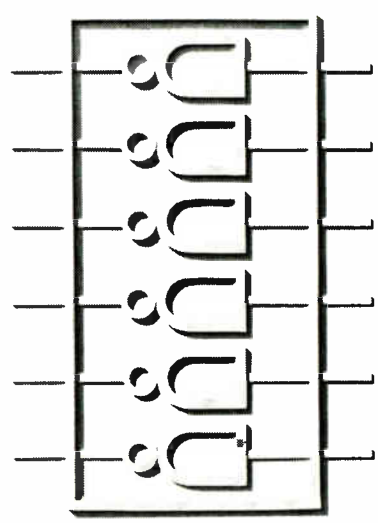
9110 HIGH LEVEL LOGIC HEX INVERTER

The 9110 is the fundamental element of our new high noise immunity family. It features worst case DC noise immunity of 5.5 volts. And AC noise immunity is even better (it can reject pulses of 100 nanoseconds duration and 20 volts amplitude minimum). Other members of the family provide interfacing capability to make the 9110 compatible with CCSL levels.

The 9110 consists of six high level DTL gates without input diodes. It can be expanded with external diodes on the input. There is active pull-up on the output for good driving capability. Propagation delay is typically as slow as 170 nanoseconds to reduce sensitivity to high level noise pulses. Output voltage swing is typically 0.5 to 15 volts. The 9110 operates over the entire range of 12 to 20 volts at temperatures of 0°C to +70°C. It comes in an hermetic DIP and is available in volume quantities. It's in stock at your Fairchild distributor now. Write for complete specs and applications information. Ask about our other new products, too.



FAIRCHILD SEMICONDUCTOR

CIRCLE READER SERVICE NUMBER 120

← Circle 65 on reader service card

Washington Newsletter

March 18, 1968

LBJ panel studies spectrum leasing

The President's task force on telecommunications is taking a hard look at the possibility of leasing portions of the frequency spectrum in the 30-to-1,000-megahertz range. The aim, of course, would be more efficient use of overcrowded frequencies. The task force has GE-Tempo studying the leasing question, priorities for frequency assignments, frequency management, and the sharing of microwave bands. Tempo will make its first progress report next week and its final report in June.

The problem of crowded spectrum will get a public airing during the next few weeks when Rep. John D. Dingell (D., Mich.) takes his inquiry on frequency allocation on the road. He'll hold hearings in Newark and Detroit, two cities where police have complained of a lack of frequency space.

Three teams bid for ATS studies

It's full speed ahead for the second series of Applications Technology Satellities (ATS)—models F and G—scheduled for launch in 1970 and 1971. Industry proposals for two parallel design studies of the spacecraft were due last week and contractor teams led by Fairchild Hiller, GE, and Lockheed Missiles responded. Though not yet approved by Congress, the $5.6 million needed to keep the program going in fiscal 1969 is considered a sure bet in light of the present insistence on Capitol Hill on "practical" space programs [see story on p. 58].

May 1 is **the deadline for proposals of experiments the communications satellites will carry.** The only experiment definitely scheduled so far is a test of a deployable, 30-foot-diameter antenna for transmitting and receiving signals in the range from 400 megahertz to 8 gigahertz. About 150 pounds are available on each craft for other experiments.

Tv firms are called to second uhf parley

FCC Commissioner Robert E. Lee will call a second meeting of television-receiver makers next month **to try to get the firms to detent the uhf tuners on their sets.** Uhf stations complain that they are at a disadvantage because, with present dials, viewers can lock onto only vhf stations. The first meeting called by Lee this month failed to produce any results primarily because few manufacturers attended. The EIA handled invitations to the meeting, but several manufacturers claim they never were told about it.

Observers believe **manufacturers will take the opportunity at the April meeting to announce plans for all-channel tuners on their 1970 models.** Low-cost solid state devices that can lock onto both vhf and uhf stations are now available [Electronics, Feb. 19, p. 46].

Tough radiation bill expected in Senate

Though the House Commerce Committee didn't go along with several key features of the Administration's radiation protection bill, it's likely **the eventual Senate version will be closer to what the White House wants.** The final compromise version is expected to win speedy passage once it's hammered out [Electronics, Feb. 19, p. 54].

The House committee reported out a radiation bill much like the original proposed by Rep. Paul Rogers (D., Fla.). It contains no directives concerning recall of products or in-plant Federal inspection—**provisions the White House wants but industry bitterly opposes.** The House measure calls for the Department of Health, Education and Welfare to set performance standards and to test and carry out research on radiation-emitting equipment.

Military to demand more contract data

The Pentagon, which hasn't been rigidly enforcing the truth-in-negotiations law, will start bearing down harder on companies. The move is in response to a report from the House Armed Services subcommittee on special investigations, which called enforcement of the statute spotty and inadequate. **If contractors don't provide "full and factual" pricing data to contracting officers, the Pentagon could start barring offenders from future Government work.**

The subcommittee urged the Defense Department to improve procedures for getting cost data, to demand historical data from contractors, and to continue to monitor contracts after they are awarded.

FAA wants airliners to carry responders

The FAA will propose that all commercial airliners carry responders that automatically alert pilots to signals from crash-locator beacons. **The proposal will be made at a Washington meeting of the Radio Technical Committee for Aeronautics next month.** The FAA feels the airlines may go along with the plan because of its public relations value and because of the relatively low cost of the responders—$50 a unit. The agency, after much urging by Sens. Peter Dominick (R., Colo.) and Richard L. Ottinger (D., N.Y.), has finally asked for comments by May 31 on a proposal that general aviation planes be required to carry crash-locator beacons [Electronics, Dec. 25, 1967, p. 26].

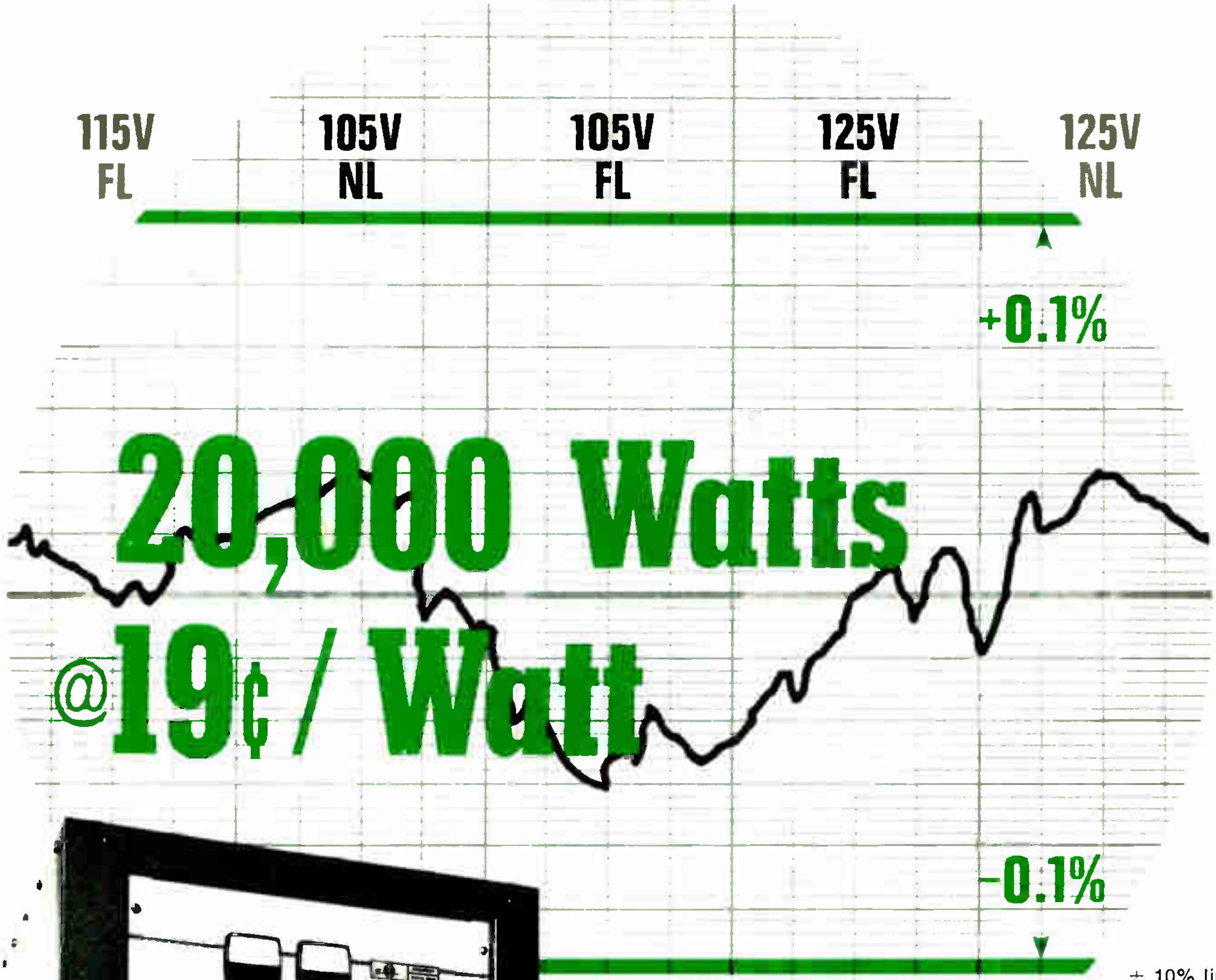
Langley studies point to role in Mars shots

Despite denials by officials at NASA's Langley Research Center of reports that Langley will manage the two proposed 1973 Mariner Mars missions, **the Virginia facility is now accepting industry proposals for three low-funded studies that could apply to no other program.** While a Langley official says they are looking only for a possible vehicle for future use, sources at NASA headquarters say that if Congress votes the money to keep the 1973 orbiters in the 1969 budget, Langley will manage them.

One reason for Langley's denial: **there's a chance that Congress will kill the 1973 project.** The three contracts Langley will award shortly will be for studies of a vehicle with a five-month lifetime, a lander capsule, and the type of orbital entry needed for a Mars mission.

Addenda

Barring unexpected problems, TRW Systems will deliver the first Intelsat 3 satellite to Comsat by Aug. 1—in time, Comsat says, for orbiting before the October opening of the Mexico City Olympics. Noting that TRW "is now proceeding well with the satellite," a Comsat source estimates that the craft can be operational four to six weeks after delivery . . . **Within two months, the Public Health Service's National Library of Medicine will award a contract to upgrade its computer-based medical library.** The cost of designing, installing, and integrating the equipment for its Medlars system may go to $8 million. A half-dozen major computer makers are in the running for the job. The PHS is still evaluating proposals submitted last August [Electronics, July 10, 1967, p. 57].



20,000 Watts @19¢ / Watt

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± 10% line voltage swings combined with full load changes fail to force the DCR 40-500 A's output voltage outside of the specified regulation band!

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If your requirements do not call for 500 amperes, there are 23 other models available from stock with power levels ranging from 400 watts to 10,000 watts at voltages to 300 Vdc . . . all with comparable penny-per-watt ratios.

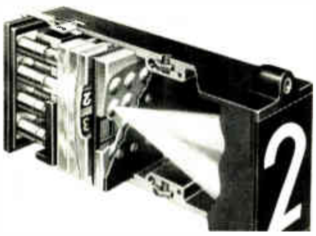
Like many of todays quality power supplies the DCR series offers two modes of regulation (voltage and current) with automatic cross-over, remote sensing, programming by signal or resistance in either regulation mode and series or parallel operation flexibility.

These user benefits are made possible through the combination of basic phase control regulation techniques (efficiency: 20-40% higher than other methods) with sophisticated feedback circuitry and over 25 years of experience in producing high reliability power supplies.

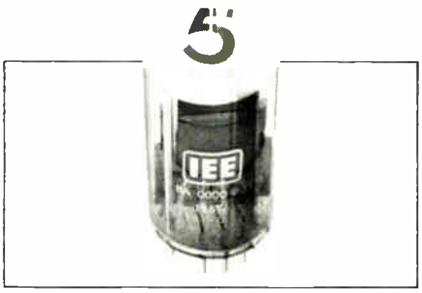
Contact your local Sorensen representative or: Raytheon Company, Sorensen Operation, Richards Ave., Norwalk, Conn. 06856 TWX 710-468-2940.

RAYTHEON

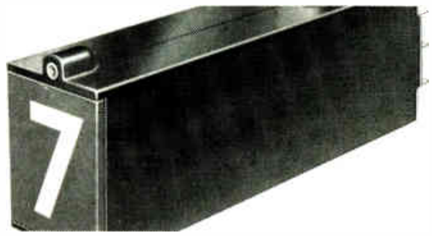
Quick guide to bright, legible, wide angle readouts



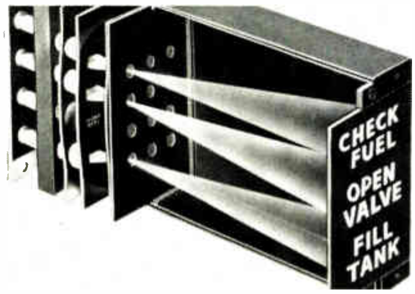
Series 360H Displays 2″ high characters easily read from over 50′. Yet unit is just 3″ H x 2″ W x 7.75″ D. New lens system provides bright, crisp display.



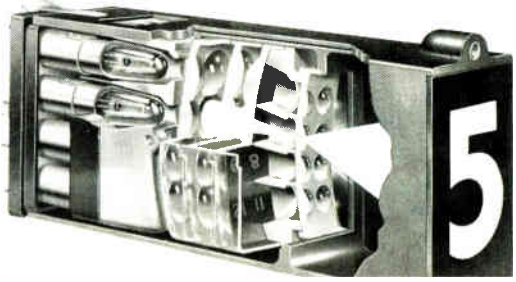
CRT Display 10-gun CRT projects single-plane digital or word displays onto fluorescent screen. Easy reading, even in direct sunlight. Wide viewing angle. Ideal for instrumentation applications.



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.

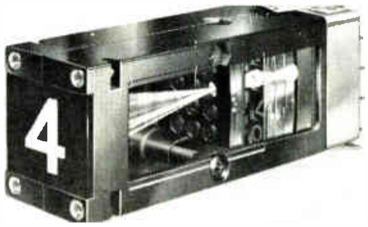


Series 80 Large screen unit particularly suited for annunciator applications . . . factory call systems, production control boards, etc. Message or character 3⅜″ high; can easily be read at 100′. 160° viewing angle.



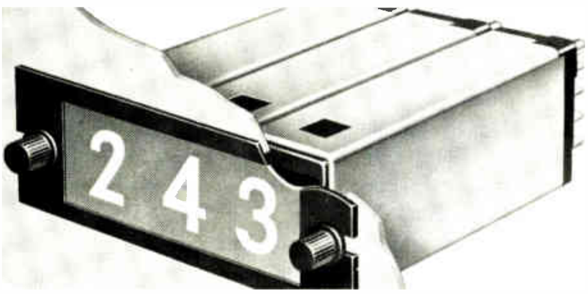
Series 10H It's the world's most popular readout. And we've improved it. New lens system increases character brightness 4 times. Greater clarity at wider angles and longer distances, even under high ambient light. .937″ H x .937″ W viewing area. Mil-spec version also available.

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.

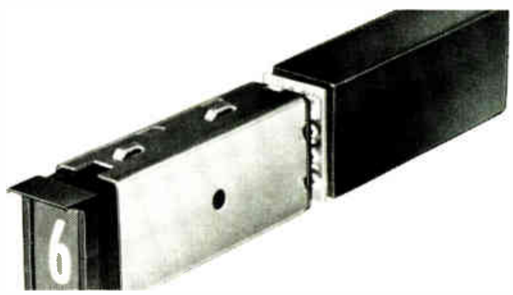


Series 120H Miniature (.62″ H x .62″ W) rear-projection readout. New lens system increases character brightness 50%. Easily read from 30′ even with high ambient light. Quick disconnect lamp assembly for speedy lamp replacement.

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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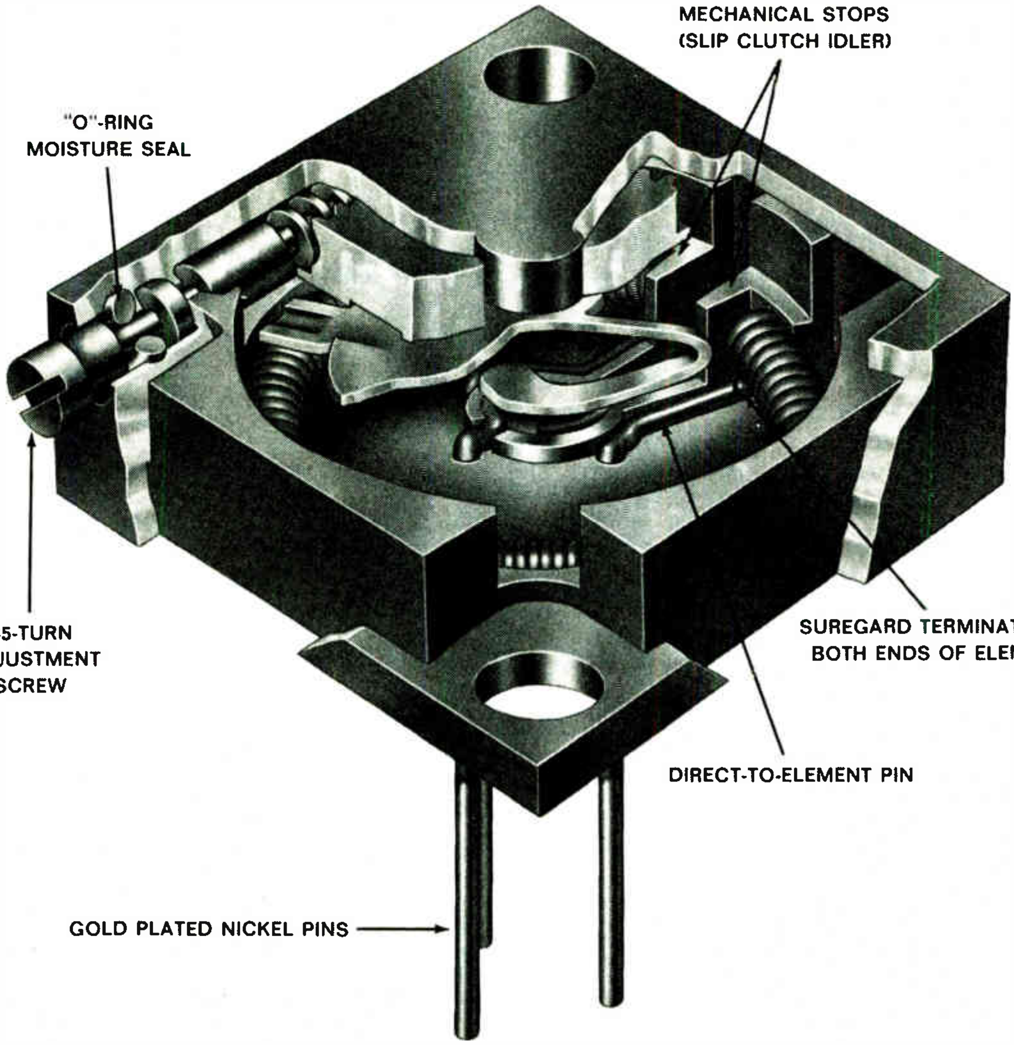
See them all at the IEEE Show, March 18-21, Booth 3B22-23

IEE

Circle 72 on reader service card

Industrial Electronic Engineers, Inc., 7720 Lemona Ave., Van Nuys, California



MISSING: a few connections
GAINED: new reliability at a bargain price

Design omissions can be as important as additions in product performance. An inside look at the new DAYSTROM Squaretrim® 554 Series pot, for example, shows that intermediate pin connections have been eliminated. Two of the weldable base pins are affixed directly to the resistance element. The center pin pivots directly against the rotating tap assembly. Result? A simplified design which also lowers your cost. Made in accordance with MIL-R-27208, these half-inch units are rated for a full watt in still air at 70°C. Sealed models have passed Weston's 100% immersion test. Now thrifty-minded military, industrial or commercial users can have Squaretrim quality features at a bargain price. *Write today for complete data and evaluation samples of our 550-555 Series potentiometers.*

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- **−55°C to +150°C temperature range**
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- **Choice of sealed and unsealed models**
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DAYSTROM *potentiometers are another product of:*

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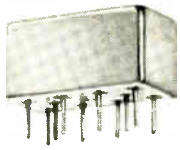
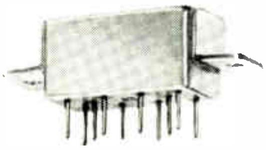


2 Amps.

All Welded

NEW  LATCHING RELAY

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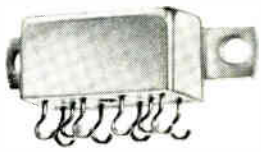
0.37 oz.



The new KL Series combines the proven performance of Hi-G 1/2 size crystal can relays with a unique new latching design. These relays meet all the applicable requirements of MIL-R-5757 and are available for fast delivery in all standard configurations and header styles.

Write or call Hi-G for Bulletin #103. If you need applications engineering assistance, an experienced Hi-G representative awaits your call. Telephone: (203) 623-2481.

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Federal Electronics, P.O. Box 1208, Vestel Parkway E., Binghamton, New York 13903 TEL: 607-748-8211

Lectronix, Incorporated, 214 North 2nd Street, P.O. Box 188, St. Charles, Missouri 63301 TEL: 314-723-1122

Moulton Electronics Distributors, Inc., 1058 Terminal Way, San Carlos, California 97078 TEL: 415-591-8292

Moulton Electronics, c/o Banks Sales Corp., 2785 N. Speer Blvd., Denver Colorado 80211 TEL: 303-433-5455

Tomelco/Moulton, 531 N. Brown Avenue, Scottsdale, Arizona 85251 TEL: 602-945-5030

Tomelco/Moulton, 15846 Pacific Highway South, Seattle, Washington 98188 TEL: 206-246-1727

Radio Products Sales, Inc., 1501 South Hill Street, Los Angeles, California 90015 TEL: 213-748-1271

R and D Electronics, Inc., 71 Pearl Street, Cambridge, Mass. 02139 TEL: 617-864-0400 and 8401; ENterprise 7135 in Major Cities

Solid State Electronics Co. of Texas, 2643 Manana, P.O. Box 20299, Dallas, Texas 75220 TEL: 214-352-2601

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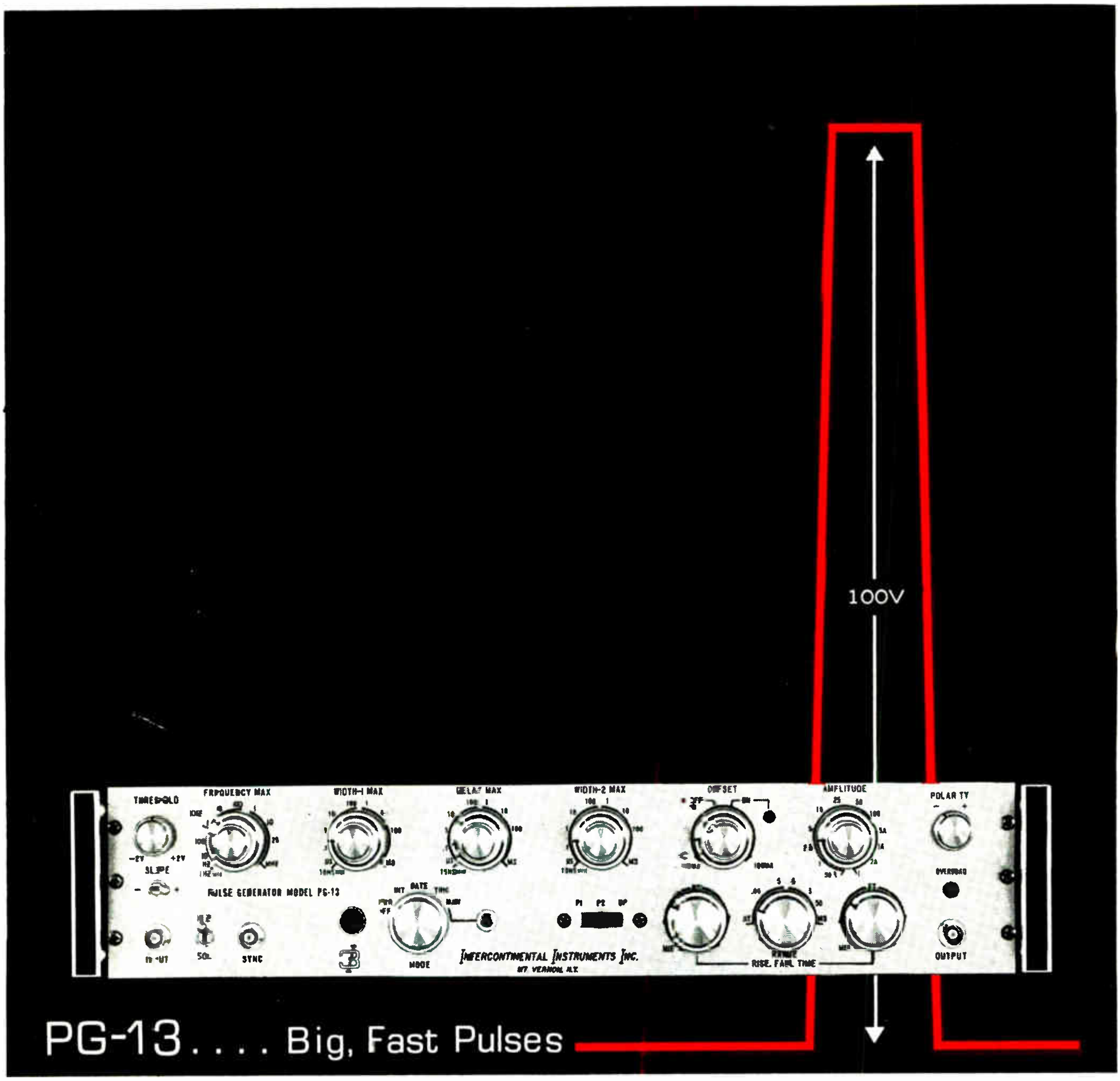

With our new PG-13 you can get ±100V or, as a current source, ±2A pulses. And 10 ns rise and fall times; repetition rate 1 Hz to 25 MHz; duty cycle 50% at 1A out with a pulse width to 5 ms. No hedging. The specs are real specs: when we say ±100 volts we mean ±100 volts; 10 ns rise time means 10 ns rise time, worst case, at 100 volts. So if you need a truly fast high-output pulser for, say, magnetic core testing, radar pulse simulation or similar applications you would do very well to consider the PG-13.

The PG-13 is all solid-state (rack height 3½"). Operates in either voltage or current modes; in the voltage mode the range is ±100 mV to ±100V from a 50 ohm source; in the current mode it is ±50 mA to ±2A from a 1K, min, source. PRF, 1 Hz to 25 MHz. Single or double pulses plus sync. Instantaneous overload protection and a front panel warning light. Can be gated or triggered up to the max rep rate. Manual one-shot. DC-offsets either direction to 100 mA. Independently variable rise and fall times, 10 ns to 50 ms. PRF, rise, fall, amplitude, width (of either pulse independently), offset and delay are all variable continuously.

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Telemetry experts needed a battery rugged enough to "bug" wild grizzly bears.

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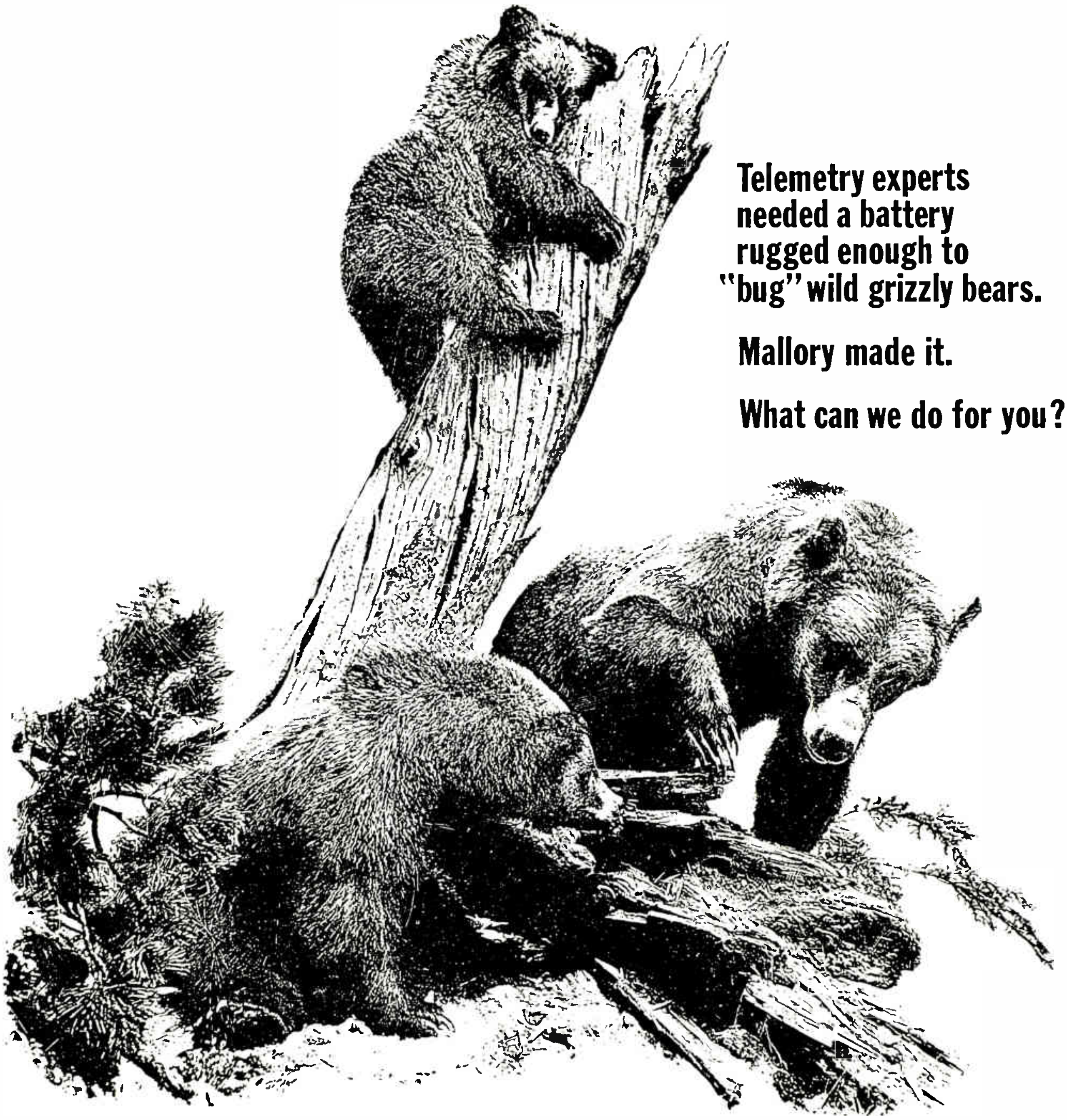

Telemetry experts needed a battery. A battery to power small radio transmitters attached to wild grizzly bears. A battery that could fit inside the compact transmitters, yet hold enough power to keep "beeping" for weeks, even months. A battery tough enough to take anything bear country dished out.

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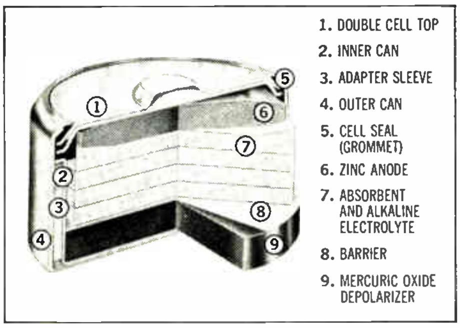

OVER 1000 DIFFERENT TYPES

Mallory currently makes over 1000 batteries of all sizes and capacities. If we're not actually producing the battery you need, we'll be glad to work with you in designing a new one. Please write the Technical Sales Department, Mallory Battery Company, a division of P. R. Mallory & Co. Inc., South Broadway, Tarrytown, New York 10591. Telephone: 914-591-7000. (In Canada: Mallory Battery Company of Canada Limited, Sheridan Park, Ontario.)

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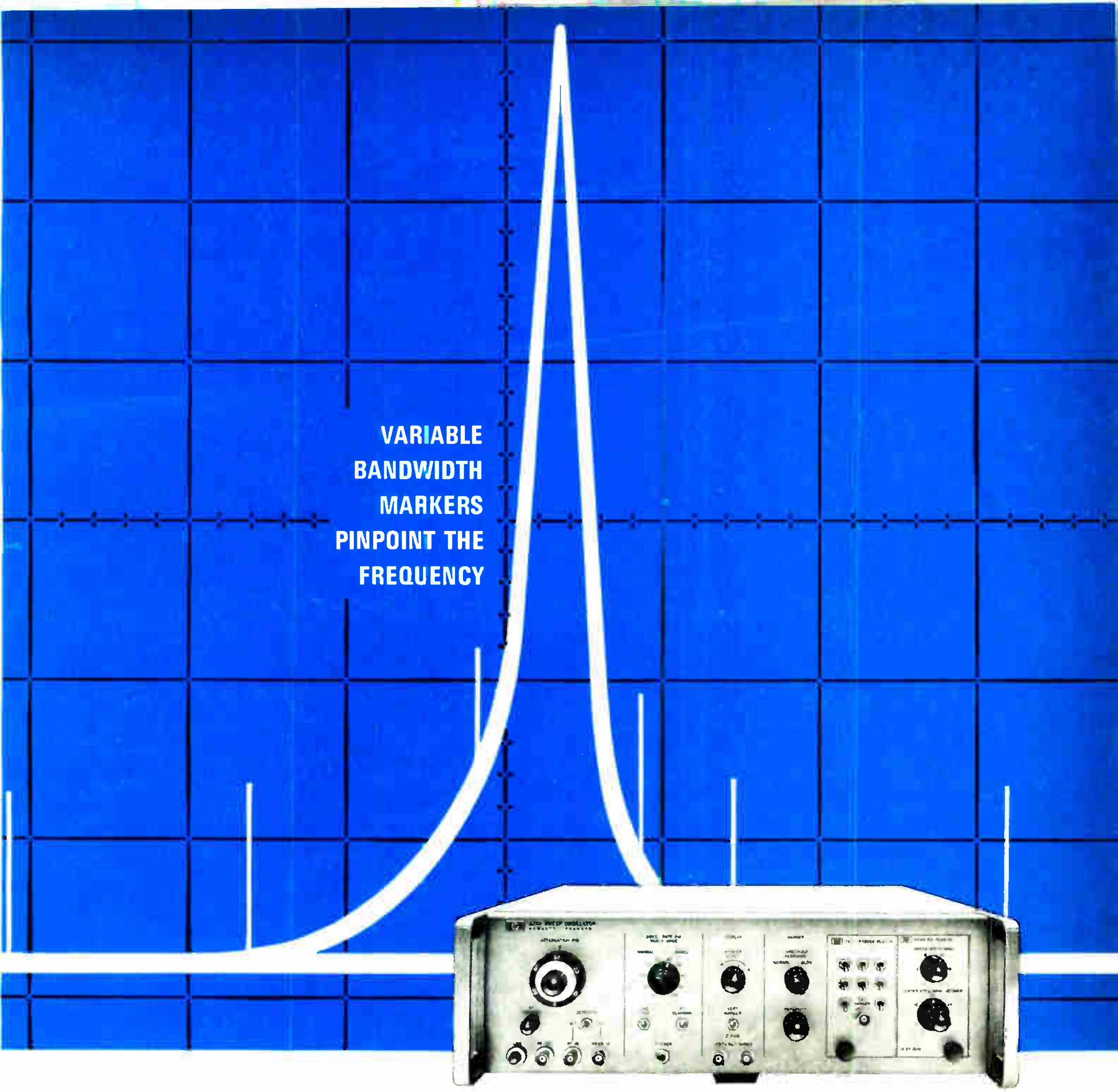

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The main frame of the 3211A contains everything you could hope to find in a sweeper. RF plug-ins operate at fundamental frequencies with good linearity and spurious mixing products are eliminated. Plug-in markers offer not only variable bandwidth, but also Z-axis or pulse-type marking. An accurate 59-db attenuator makes the unit a valuable tool for testing both high- and low-gain circuits.

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Circle 77 on reader service card

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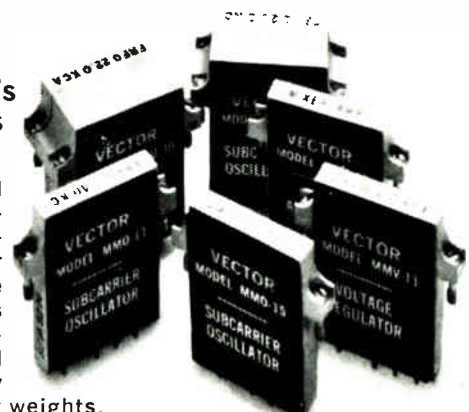

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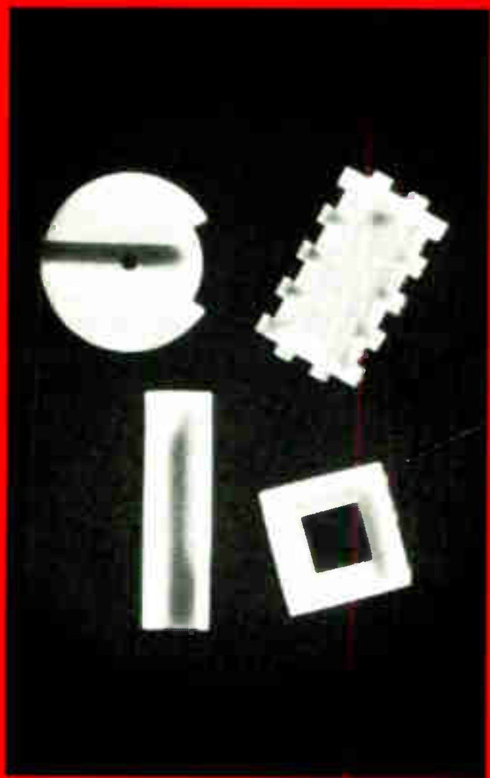

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	CV-144	CV-164	CV-18	CV-1104
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CHAMBER	14" Pyrex Bell Jar	18" Pyrex Bell Jar	18" Pyrex Bell Jar	24" or 30" Stainless Steel Bell Jar
DIFFUSION PUMP	4" BlueLine	6" BlueLine	6" BlueLine	10" BlueLine
BAFFLE	Choice of multi-coolant or liquid nitrogen	Choice of multi-coolant or liquid nitrogen	Choice of multi-coolant or liquid nitrogen	Choice of multi-coolant or liquid nitrogen
EVAPORATION POWER SUPPLY RATING (Continuous Duty/20% duty)	2 KVA/3.9 KVA	2 KVA/3.9 KVA	2 KVA/3.5 KVA	4 KVA/8 KVA

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* package interchangeable with standard 8 pin 709 type amplifiers.

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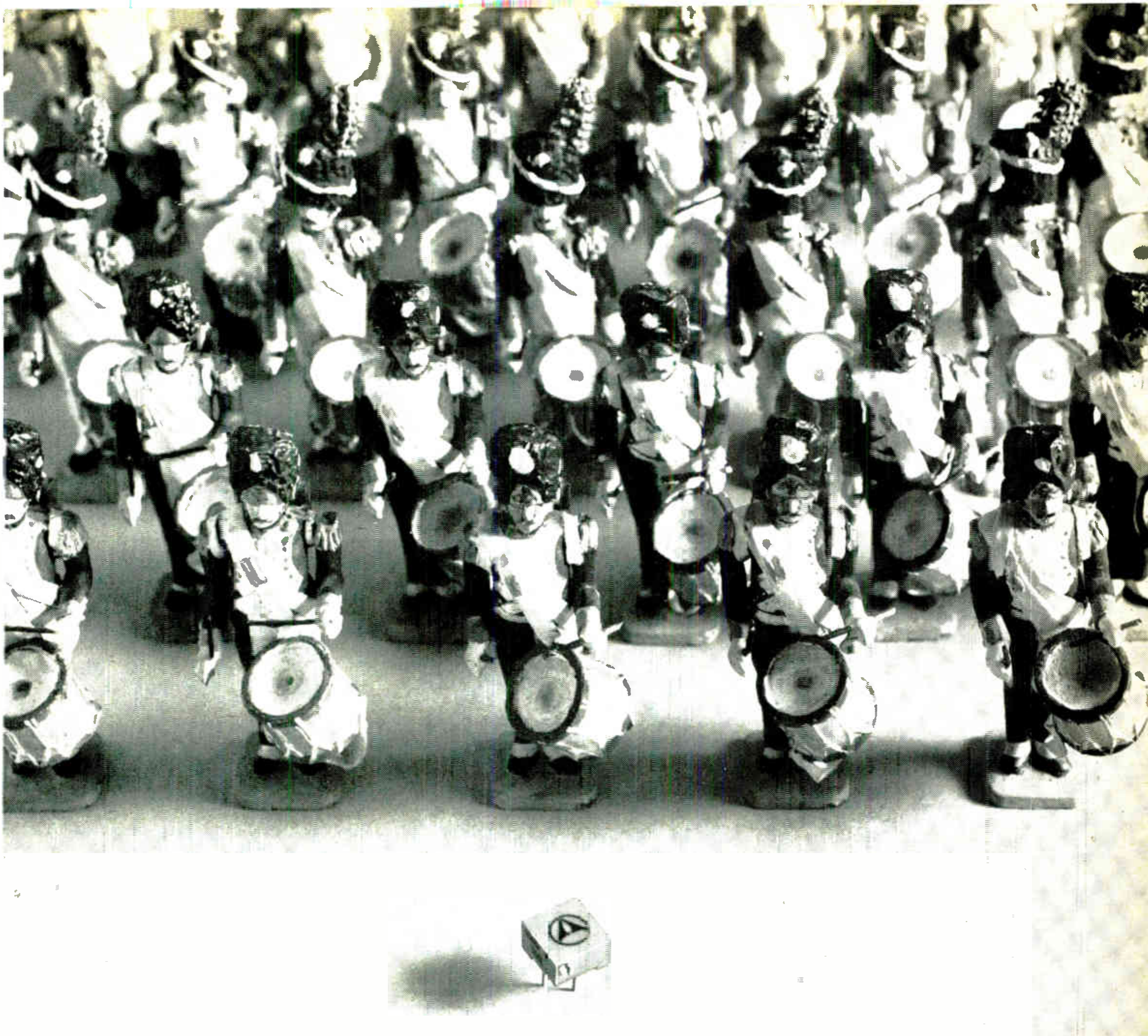

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VOL. I
ISSUE XVI

DCL Bulletin

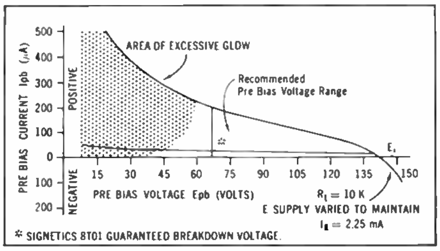
WHETHER or not you use Designer's Choice Logic, you have to admit that Signetics' idea of guaranteeing cross-family compatibility in integrated circuits can save you time and money in design.

PUBLISHED BY SIGNETICS: THE RESPONSE/ABILITY COMPANY

NEW IC NIXIE DRIVER GETS UNGLOWING REPORT

Guaranteed 67V Breakdown

Signetics Corporation today announced the first monolithic IC Nixie Driver that permits Nixie* tube operation without excessive background glow and does not require any discrete external components for interfacing. "We've whipped the problem of getting a state-of-the-art 2.5-ohm centimeter process into production, so we can guarantee a 67V breakdown," a company spokesman said.



Pre-bias Voltage vs. Current Characteristics of a typical NIXIE Tube.

Officials also said that the new device, designated 8T01 Nixie Decoder/Driver, is the only one of its kind that will interface directly with all commonly used DTL and TTL circuits and drive Nixies directly. The new member of Signetics DCL family is offered in a 16-pin silicone DIP.

When told of this new device from Signetics, a competitive manufacturer stated, "Dammit."

**Nixie is a registered trade mark of the Burroughs Corp.*

Big shift to new Shift Register

Unique Device Announced

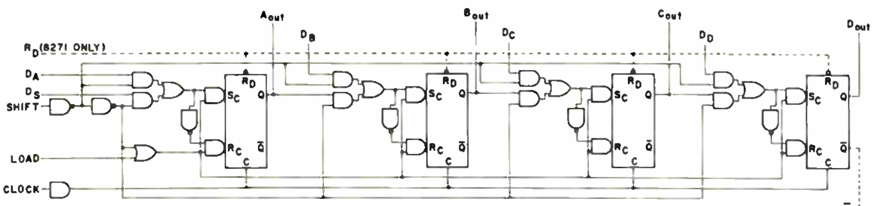
"Your new shift register is the answer to my prayers."

That quote, from a Dallas designer, is typical of the response to Signetics' introduction of a new 4-Bit Shift Register in the DCL line, according to Bill Slaymaker, a Signetics Product Marketer.

"This device has a unique organization and functional capability," Slaymaker commented.

The new 8270/8271 4-Bit Shift Register is fully synchronous and offers parallel or serial input and output. The device operates at clock rates up to 20 MHz and has a mass reset line (in the 8271, a 16-pin configuration) that is independent of the clock. A unique feature is separate load and shift controls that make it unnecessary to gate the clock to inhibit the shift, thus eliminating clock skew problems. Power consumption is 40mW per binary.

The 8270/8271 is supplied in 14 lead flat pak, and 14 or 16 lead silicone DIP in both full MIL and industrial temperature ranges.



Signetics new 8270/8271 4-bit shift register.
Comes in 14 lead flat pack or DIP and 16 lead DIP.

Signetics announces new publication

Signetics launched a new publication today, the DCL Bulletin. As you can see in the masthead the first issue is the 16th issue, the first fifteen issues having never been published. DCL has been famous and well-loved since 1966, so it would be just plain silly to call the first issue the first issue.

TODAY'S BUZZ WORD

"Designer's Choice Logic"
You didn't expect it to be "Fairchild"?

FOR SPEC SHEETS

Specifications on our new Nixie Driver and Shift Register are now available. Send for information on our complete DCL line. Write: Signetics, 811 East Arques Ave., Sunnyvale, Calif. 94086.

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March 18, 1968 | **Highlights of this issue**

Technical Articles

A cure for drift in thin-film transistors
page 88

Thin-film methods have long offered the possibility of low-cost, large-area arrays. But thin-film transistors until now have been notoriously unstable. The trouble has been traced to the material that was used for the insulator—silicon monoxide—and a new method employing aluminum oxide may now produce stable TFT's suitable for such applications as memories, solid-state vidicons, and scan generators.

Using infrared to measure film thickness
page 101

The measurement of the thickness of an epitaxial film has always been time-consuming—either the sample was destroyed with a lap-and-stain method, or manual optical-interference techniques took several minutes. But now there's a method that speeds up the optical-interference measurements.

Sighting in on narrow light beams
page 106

It's difficult to check out a laser-beam communications system that's intended for long-distance transmission—to the moon, for instance. In particular, exacting measurement of each optical-coupling device between the laser output and the antenna is needed. An infrared radiometer is pressed into service to yield accurate power profiles of laser beams.

Semiconductor strain gages start to take hold
page 109

Metal strain gages, relied upon for many years to sense displacement, acceleration, pressure, and force, are being threatened by pressure-sensitive transistors and semiconductor resistors. These devices produce higher outputs and have better sensitivity than metal strain gages.

Large-scale integration for small computers
page 119

With LSI applied to an arithmetic unit, a small computer can be built with only one other major unit, a read-only memory. The MOS unit processes eight bits simultaneously through a register, an adder, an accumulator, and an output buffer.

Computers test and grade tires
page 125

Today's smooth roads have magnified the impact of automobile tire nonuniformities on riding comfort. These irregularities—hard and soft spots—can cause the tire to interact with the car's suspension system, creating a shake at high speeds. To eliminate this problem, car makers specify tolerable peak-to-peak force variations, and tire makers use analog computers to grade each tire on its dynamic balance and fundamental harmonics.

Television in 3-D may be possible
page 132

A simple stereoscopic tv system can be achieved with a monochrome camera fitted with separate lenses for left and right information, a standard color-tv receiver, and a pair of spectacles with red and blue filters. At the transmitter, the left channel output modulates, say, the red input during odd fields while the right channel output modulates the blue input during even fields. The spectacles give the effect of depth.

Coming April 1

- **Satellite antennas**
- **Radiation effects in thyristors**

Thin-film transistors don't have to be drifters

Use of aluminum oxide as the gate insulator in an inverted structure frees these devices from the drift that has blocked their application

By Albert Waxman
RCA Laboratories, Princeton, N.J.

Thin-film technology has always promised big advantages over silicon monolithics for low-cost, uniform, large-area integrated circuits. Deposited on glass substrates measuring several inches on a side, thin-film transistors are fully isolated and free of the parasitic coupling effects that continue to plague monolithics.

However, TFT's have been handicapped by drift and deterioration of electrical characteristics with time, a problem now being eliminated by a new method of depositing the insulating material between gate lead and semiconductor. Instead of the usual silicon monoxide, the new technique applies a layer of aluminum oxide.

The way thus appears clear for thin-film IC's to gain a place in image sensor arrays, where even large-scale integrated bipolar circuits can't deliver the necessary thousands of gates on a single substrate.

Though TFT's, thin-film diodes, photoconductors, resistors, and capacitors have been built into complex integrated circuits for solid state vidicons and scan generators, none of these circuits has yet been used in commercial or military applications. However, their practicality has been demonstrated in the lab, and research also points to uses in scratch-pad memories, counter circuits, and addressing arrays.

The TFT has developed more slowly than its single-crystal silicon MOS counterpart, but this isn't surprising since the advance of the TFT has required the development of new techniques for passivating semiconductor surfaces. The MOS transistor has benefitted from the wealth of information available about silicon and the already highly developed silicon technology.

Frequency response limits the TFT's applications to speeds of less than 50 megahertz. But the device has great potential in image sensing devices and memories such as those developed at RCA Laboratories by a group led by P. K. Weimer.

Defending the gates

The TFT has three electrodes: two low-resistance ohmic contacts to the semiconductor film—source and drain—and a metal gate electrode separated from the semiconductor film by a gate insulator.

The source contact is normally at ground potential, the drain electrode is positively biased, and the gate voltage is either positive or negative, depending on the particular mode of operation. The gate insulator presents a high impedance, and little gate current is drawn for either bias. For typical devices 100 mils wide with a source-drain spacing of 0.4 mil, d-c input resistance is greater than 10^{10} ohms with the most common insulators, Al_2O_3 and SiO.

If the semiconductor film is deposited so that it has a resistivity higher than about 20 ohm-centimeters, as is often the case with cadmium sulfide (CdS) and cadmium selenide (CdSe), then little or no drain current is drawn when there is no gate voltage, and the device operates in the enhance-

The author

Albert Waxman has been working on thin films since 1963 as a member of the technical staff of the Materials Research group at RCA Labs. He received his doctorate in electrical engineering from Princeton University in 1966. His master's was also earned at Princeton.

ment mode. Positive gate voltage attracts additional electrons into the semiconductor film and increases the conductivity. A positive voltage on the drain will then set up an electric field to collect the induced electrons. Typical characteristics with drain current I_D plotted against drain voltage V_D have the pentode-like shape typical of field effect devices. Such an enhancement device is useful in direct coupled logic and complementary symmetry circuits.

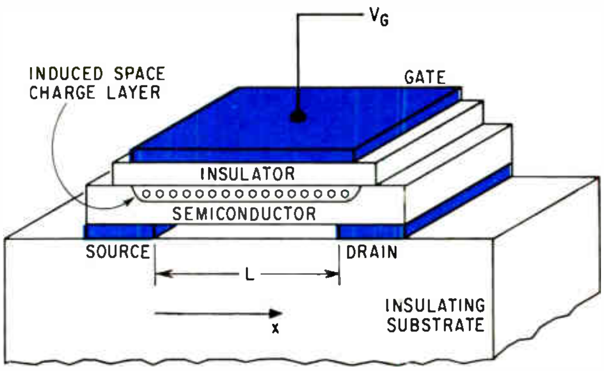
If a highly conductive semiconductor film is deposited (with a resistivity less than 20 ohm-cm for typical dimensions), the current when there's no gate voltage will be significant. The device in this case can be operated with either positive or negative gate voltage. The negative voltage will deplete the number of electrons in the semiconductor, reducing the drain current; a positive voltage will increase the film conductivity and, hence, the drain current. This transistor can be used in a linear low-power amplifier.

Figure it out

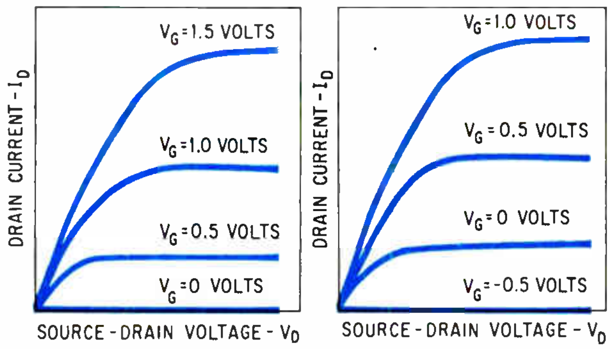
The basic equations for current-voltage characteristics can be easily developed. The analyses of depletion and enhancement types are quite similar. For an enhancement-mode device—the one that has shown the most promise as a useful circuit element—the total induced mobile charge in the semiconductor film at a given position between source and drain is given by

$$Q(x) = C_g(V_g - V(x) - V_o)$$

where C_g is the input gate capacitance, V_g is the gate voltage, $V(x)$ is the potential at a given point



Thin film method. A conducting layer is induced in the semiconductor by the voltage on the gate, which is separated from the semiconductor by an insulator.



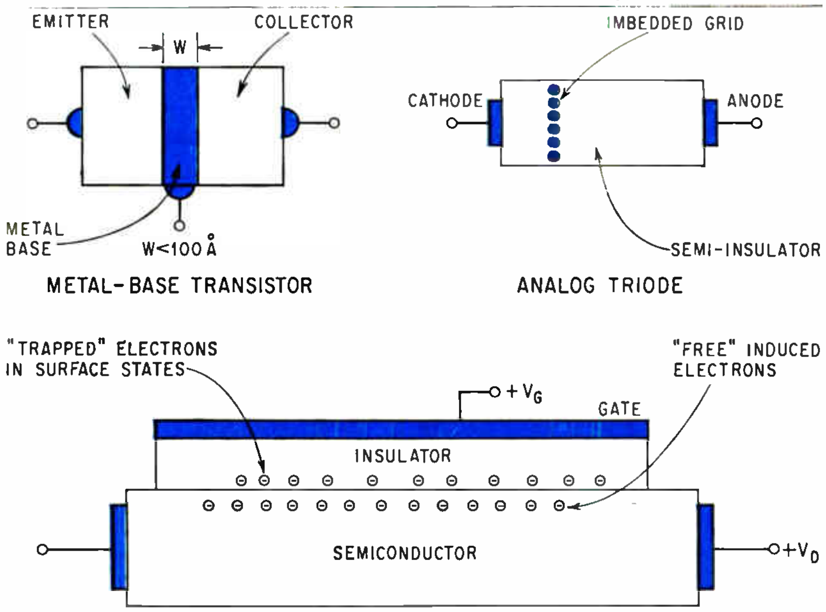
Gate control. Characteristics of enhancement-type TFT (left) and depletion type (right) show that the latter conducts when there's no voltage on the gate. The enhancement mode device is the one that has shown the most promise as a practical TFT.

Second effort

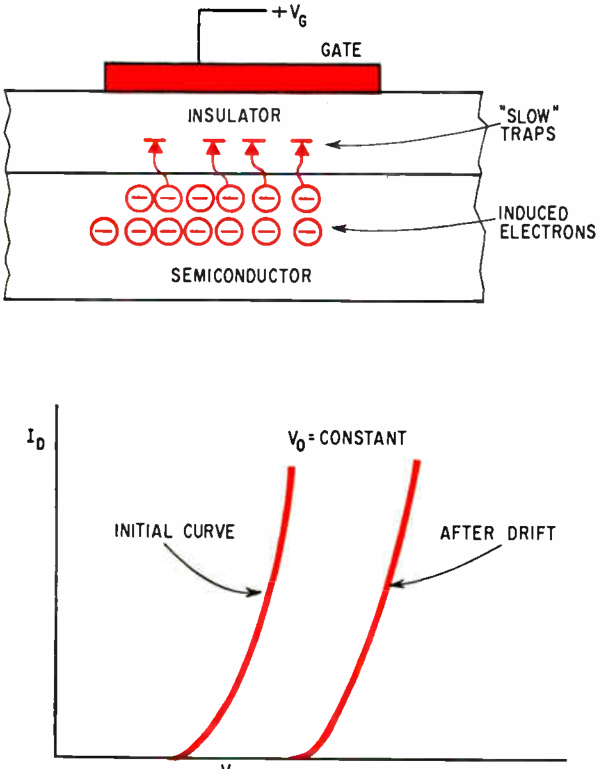
One of the first attempts to build an amplifying device using an electrode to modulate a semiconductor's conductivity between two other electrodes was reported in 1948 by William Shockley and C.L. Pearson of Bell Telephone Laboratories. But in putting an insulated field plate atop a germanium film, they found that the change in conductivity for a corresponding change in field voltage was much less than they had initially predicted.

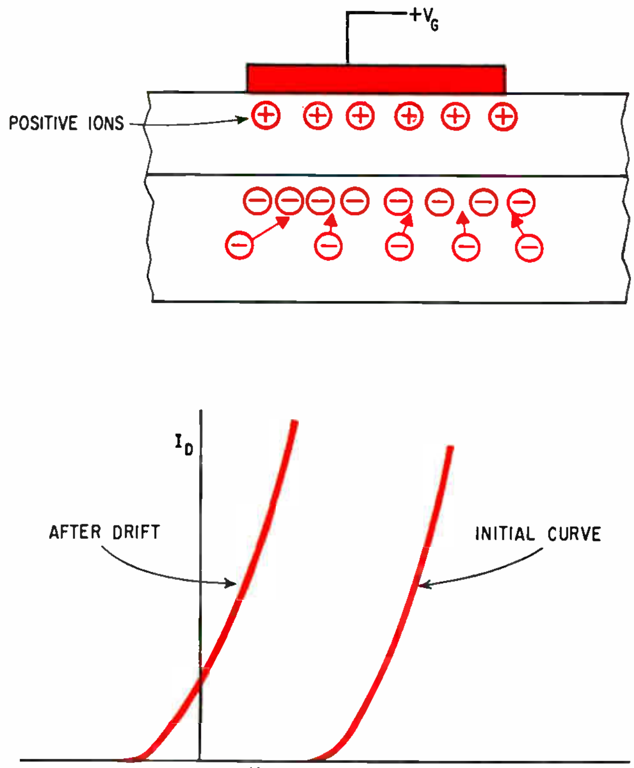
The inefficiency was attributed to the presence of surface states that prevented the gate's field from penetrating the semiconductor. Later improvements in thin-film technology, and the discovery that the thermal oxidation of silicon reduced surface states at the silicon-silicon dioxide interface, revived interest in these devices, however.

In 1961, P.K. Weimer of RCA Laboratories reported the first major success: an insulated-gate thin-film transistor with cadmium sulfide as the semiconductor and silicon monoxide as the insulator. The thinness of the insulator—less than 500 Å—made it possible to fill the surface states and modulate the conductivity of the semiconductor film at low voltages.



Forerunners. The metal-base transistor and the analog triode, early thin-film devices, were followed by the thin-film transistor.





SLOW TRAPPING OF ELECTRONS

ION MOTION IN GATE INSULATOR

Sources of trouble. Two causes of instability in the electrical characteristics of TFT's are the trapping of electrons in the insulator, left, and the presence of positive ions in the insulator, right. The first causes the threshold voltage to increase, while the ions reduce the threshold voltage.

between source and drain, and V_o is the gate threshold voltage for conduction in the semiconductor. V_o, the voltage necessary to fill the surface states present at the insulator-semiconductor interface, is given by

$$V_o = \frac{qN_{ss}\,wL}{C_g}$$

where q is the electronic charge, N_{ss} is the density of surface states, L is the source-drain spacing, and w is the device length.

The drain current is then given by

$$I_D = \frac{\mu C_g}{L}\left[V_g - V_o - V(x)\right]\frac{dV}{dx}$$

This equation can be integrated to yield

$$I_D = \frac{\mu C_g}{L^2}\left[(V_g - V_o)\,V - \frac{V^2}{2}\right]$$

when $V_D = V_g - V_o$. At higher voltages, the drain current saturates and is independent of V_D because of the formation of an insulating region near the drain and the overlying gate electrode that electrostatically shields the rest of the semiconductor film from rises in drain voltage.

The current in the saturation region is given by

$$I_D = \frac{\mu C_g}{2L^2}(V_g - V_o)^2$$

and the transconductance by

$$g_m = \frac{\mu C_g}{L^2}(V_g - V_o)$$

Thus, the TFT is a square-law device and the transconductance is linearly proportional to gate voltage.

The gain-bandwidth product is

$$\frac{g_m}{2\,C_g} = \frac{\mu\,(V_g - V_o)}{2\,L^2}$$

Typical values—g_m of 4,000 micromhos and gain-bandwidth of 20 Mhz at $V_g - V_o = 2$ volts—are obtained with CdS or CdSe as the semiconductor, and with a gate insulator thickness of 500 Å, a source drain spacing of 0.4 mil, and a length of 100 mils. Tellurium (Te) transistors with a gain-bandwidth product of 150 Mhz have been reported.[1]

Drifting along

While TFT's often have good initial electrical characteristics—high transconductance and low threshold—these tend to deteriorate with time as gate voltage is increased. This has been the most serious problem with the transistors using SiO as the gate insulator.

The drifts can usually be attributed to two effects, or more properly, to the predominance of one of these effects over the other. The more difficult of the two occurs when the positive gate voltage attracts electrons at the semiconductor surface, thus initially increasing the drain current. Some of these electrons after a period of time fall into empty states in the insulator near the semiconductor-insulator interface, resulting in a slow decay of drain current with a fixed gate voltage.

This effect is usually dependent on temperature and voltage. In terms of device transfer characteristics (I_D vs. V_g), it can be represented as a shift of the characteristics to the right, corresponding to an increase in threshold voltage with time.

The second drift mechanism decreases the threshold voltage. If positively charged ions are introduced into the insulator, because of water vapor, for example, the ions will move toward the semiconductor surface when the gate voltage is positive, attracting more electrons and causing the drain current to increase. This effect is also dependent on temperature and voltage and is stronger if the SiO film's water-vapor content is increased.

Drifts occur over periods of a few hours to a few days at room temperature and in most cases are reversible. In a typical TFT with SiO as the gate insulator and CdSe as the semiconductor, and with a gate voltage of 5 volts across a 300 Å insulator, the threshold voltage could be expected to increase by 2 to 4 volts at room temperature.

Device fabrication and materials strongly affect the drift mechanisms. Much research effort has gone into improving devices that use SiO as the gate insulator, but to little avail.

More stable TFT's have been fabricated with Al_2O_3 as the gate insulator in an inverted structure. The gate is deposited on the substrate and the aluminum oxide film grown anodically in a dry oxygen plasma. The semiconductor (CdSe) and source and drain contacts are then deposited.

Under positive gate bias, the Al_2O_3 transistors show neither of the two drift phenomena found in SiO devices. Measurements show that even with gate insulator fields greater than 10^6 volts/cm, the gate threshold voltage does not change.

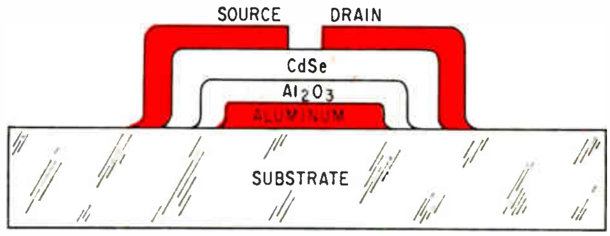
The Al_2O_3 device has also demonstrated a resistance to motion of ions through the insulator, and is less sensitive to atmosphere and water vapor than is the SiO device. The newer transistors have operated without deterioration under extremely humid conditions.

The TFT's have excellent electrical characteristics for digital applications. Because of their reduced surface state density, they typically operate in the enhancement mode with a high transconductance —about 1,000 micromhos—and a threshold voltage of less than 1 volt. A low threshold voltage is required in low-voltage, low-power, complementary symmetry circuits.

In the making

If the TFT is to be used in an integrated circuit, its fabrication must be compatible with that of the circuit's passive elements. The processing of TFT's has reached the state where thin-film circuits have been developed with more than 1,000 active and passive elements.

The two basic TFT structures are built on an insulating substrate such as quartz or borosilicate glass. In one process, the semiconductor film is deposited after the source and drain electrodes and is followed by the gate insulator and metal gate. All elements of the transistor are formed by vapor deposition and all areas are defined by mechanical metal masking. In the other process, source and drain are deposited last.



Inverted. With the gate deposited first, the aluminum oxide insulator can be formed directly on the gate lead.

With either type of structure, the insulating substrate is vapor degreased and ultrasonically cleaned before being put in the vacuum system. The substrate is then placed in the alignment jig used to

Joining forces

The aluminum oxide technique is also being applied to silicon insulated-gate field effect transistors. Author Waxman and RCA Laboratories researcher Karl H. Zaininger have fabricated devices combining the two materials to achieve a resistance to radiation effects better than afforded by silicon insulated by silicon nitride or hardened silicon dioxide.

The use of aluminum oxide, they say, also eliminates the need for the ultraclean procedures commonly followed to prevent contamination of the silicon surface when making metal oxide semiconductor transistors.

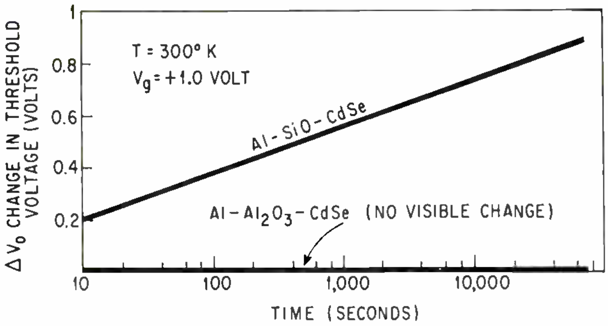
The aluminum oxide is formed much as it is for thin-film transistors. Aluminum is deposited on p-type silicon wafers that are then placed in the vacuum system. Dry oxygen is admitted and a plasma is ignited. With the sample positively biased with respect to the plasma, the aluminum film is anodized to Al_2O_3.

When first made, the samples had a high density of positive oxide charge and a large negative threshold voltage. However, annealing at 300° to 400°C in an inert atmosphere for about an hour has been found to relieve these problems.

The transconductance of the finished device is 4,000 michohmhos and the threshold voltage is less than ±0.5 volt. The work was reported in the Feb. 1, 1968 issue of Applied Physics Letters.

Researchers at Bell Telephone Laboratories' Allentown, Pa. facility also have used aluminum oxide as an insulator for silicon ICFET's, both in discrete and integrated form. The Al_2O_3 is deposited over silicon dioxide on the wafer before a second layer of silicon dioxide is deposited to act as a mask during etching. This mask layer is removed during the last etching step. The resulting devices had a threshold of −1 volt with a 500 Å layer of Al_2O_3 over a 1,000 Å layer of SiO_2.

A shift register built with aluminum oxide was operated with clock rates from d-c to 2 Mhz.



No contest. Comparison of threshold voltage drift for silicon monoxide and aluminum oxide TFT's shows the aluminum oxide device to be more stable.

maintain registration between the various depositions.

Because many transistors are made on a single substrate, the distance from the evaporation sources to the substrate must be great enough—about 13 inches--to maintain uniformity across the substrate. This gives less than 0.5% variation in film thickness.

In the first structure discussed, the source and drain are typically 100 mils long and 0.4 mil apart. Gold about 400 Å thick is commonly used. In n-type CdSe transistors, a layer of indium less than 20 Å thick may be deposited over the gold to improve the ohmic contacts to the semiconductor film. Film thicknesses are monitored by a quartz crystal element, and all depositions are made with a starting pressure of 5×10^{-7} torr in the bell jar.

The semiconductor film is next deposited on a substrate either held at room temperature or heated to increase resistivity. With CdSe, the slower the rate of deposition, the higher the film conductivity. Semiconductor film thickness is typically 1,000 Å.

In the older TFT's, 200 Å of SiO is then deposited as an insulator, followed by an aluminum gate electrode. After deposition, the transistors are annealed at temperatures of 150° to 200°C.

Variations

Special applications have sometimes led to variations from this basic fabrication technique. Wire grills have been used in conjunction with metal masks developed by Weimer to produce arrays of TFT's with source-drain gaps as narrow as 0.1 mil. In addition, multilayer insulator depositions have been employed to minimize the gate input capacitance.

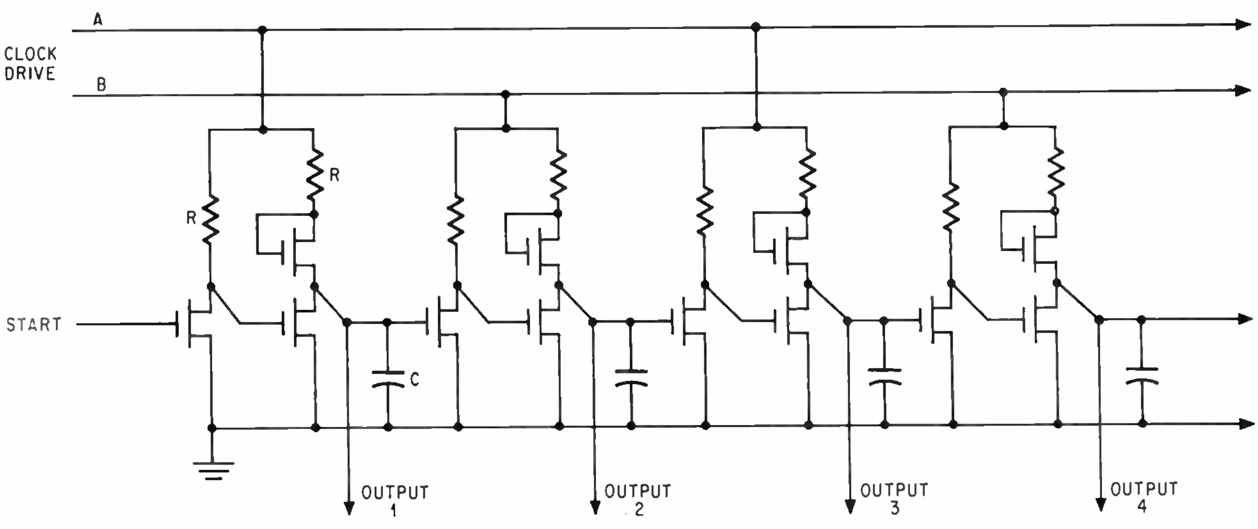
In the inverted TFT structure, the array of aluminum gates is evaporated onto the insulating substrate and the Al_2O_3 is formed anodically on the aluminum in a dry oxygen plasma in the vacuum system. After oxygen is admitted, a glow discharge is ignited between an anode and cathode.

Each aluminum gate on the substrate is connected through a contact jig and biased positively with respect to the plasma. The growth rate of Al_2O_3 is 23 Å/volt applied to the gate. The aluminum gate is usually 1,500 Å thick and the Al_2O_3 layer about 500 Å. The alignment of the gate insulator with the gate electrode is perfect since Al_2O_3 grows only where the aluminum gates are.

Deposition of the semiconductor film—again CdSe—is followed by an alloy of indium-gold for electrodes. The source-drain gap is again 0.4 mil and is defined by metal masks and fine wires. After completion of this process the transistor is annealed in a hydrogen atmosphere.

The fact that these devices show little or no deterioration over long periods of time probably reflects the relatively closed nature of the structure; the conducting channel is under the semiconductor film and adjacent to the insulator, and the Al_2O_3 seals off contaminants.

The primary drawback is that the gates must be connected during anodization, a difficult problem in complex integrated circuits. An alternate approach that has proved feasible is to deposit aluminum over the entire substrate, anodize a 500 Å



Scan generator. Drive circuitry for a 180-by-180-element thin-film image sensor array. The TFT's with the gates connected to the drains act as thin-film diodes.

insulating layer on top, and use photolithographic techniques to define the gate and gate insulator regions. The complex patterns are thus formed after the anodization.

An inverter stage consists of a transistor in series with a load impedance, which may be a resistor, a similar transistor, or a complementary transistor. The complementary-pair inverter is the fastest of these types and draws the least standby power. A flip-flop formed from two complementary inverters, in turn, will draw little current regardless of which state the flip-flop is in. This feature is particularly useful in multistage shift registers and memory stage arrays.

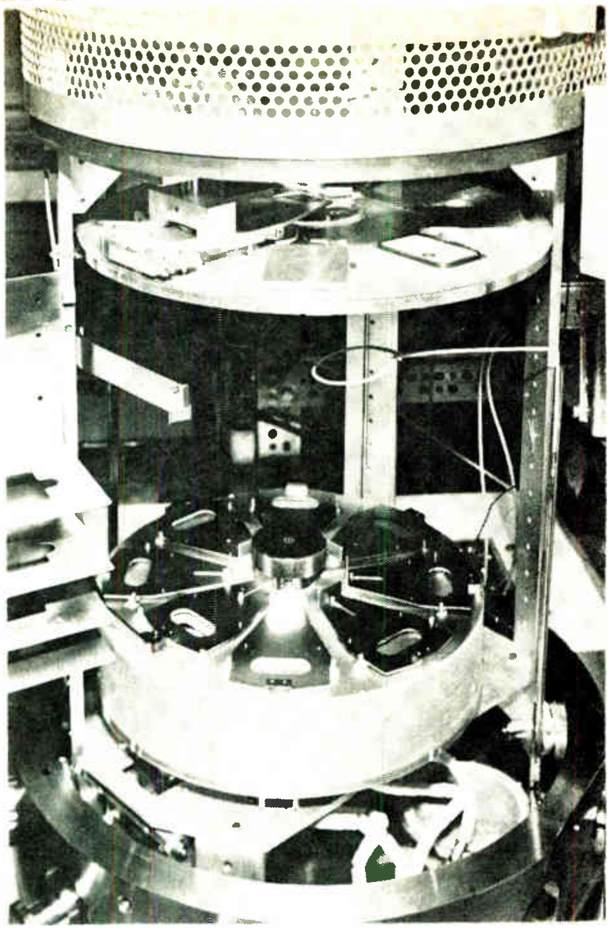
Thin-film inverters have been made in large arrays with pairs of CdSe and Te TFT's.[2]

In a 264-stage parallel-output shift register designed for scanning a photosensitive array, a voltage pulse of either polarity is transmitted from one stage to the next at a rate set by the clock frequency. Each stage of the register comprises two complementary inverters and two or three additional transistors. Another output inverter is included in each stage as an array driver, making a total of 1,320 CdSe TFT's and 792 Te TFT's on a single glass substrate.

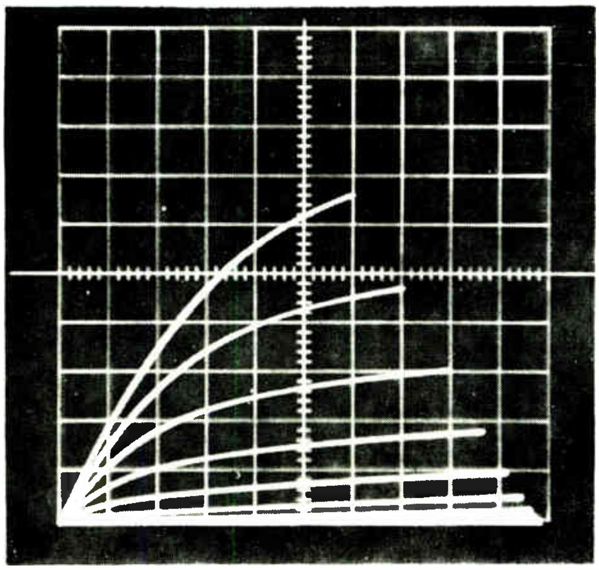
A 180-by-180-element image sensor array with integrated scan generators has been constructed for use in an experimental solid state vidicon.[3] The sensor array has two 180-stage shift registers, a column of 180 TFT's to separate out the video signal, and a 180-by-180 array of photoconductors and diodes. The four subcircuits are deposited on separate 1-inch-square glass substrates that are subsequently joined with epoxy and interconnected by 180 metallic strips deposited across the epoxy joint.

This thin-film circuit contains 540 CdSe TFT's, 360 nichrome resistors, and 180 capacitors. The diodes are field effect types made by connecting the gates and drains of 180 of the transistors.

Deposition of this circuit required about 25 successive evaporations during one pump-down of the vacuum system. Yield was relatively good, and many experimental units have been made in which pulses could be transferred through the entire register. Several units have been life tested successfully for thousands of hours at temperatures up to 85°C, and the unloaded register has operated at clock frequencies ranging from 5 kilohertz to more than 2 Mhz.



Deposition chamber. Vacuum system for anodizing the aluminum gate lead to form the aluminum oxide.



Curve tracing. Characteristics of aluminum oxide-cadmium selenide TFT. Horizontal axis is drain voltage, 0.5 v/div.; vertical is drain current, 0.5 ma/div.; gate voltages step down from 2.4 v, for top curve, by 0.4 v for each lower curve.

References

1. H.L. Wilson and W. Gutierrez, "Tellurium TFT's exceed 100-Mhz and 1-watt capabilities," Proc. IEEE, March 1967, p. 415.
2. P.K. Weimer, G. Sadasiv, J.E. Meyer Jr., L. Meray-Horvath, and W.S. Pike, "A Self-Scanned Solid State Image Sensor," Wescon Technical Papers, August 1967.
3. P.K. Weimer, G. Sadasiv, J.E. Meyer Jr., L. Heray-Horvath, and W.S. Pike, "A Self-Scanned Solid State Image Sensor," Proc. IEEE, September 1967, p. 1591.

Bibliography

W.A. Gutierrez and H.L. Wilson, "Thin-Film Metal Base Transistors," Proc. IEEE, August 1966, p 1114.

P.K. Weimer, "The TFT—A New Thin-Film Transistor," Proc. IRE, June 1962, p. 1,462.

F.V. Shallcross, "Cadmium Selenide Thin-Film Transistors," Proc. IEEE, May 1963, p. 851.

Circuit design

Designer's casebook

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

FET keeps long staircase steps flat

By Kenneth J. Bray

Tufts University, Medford, Mass.

Pulses with a low repetition rate can be counted accurately when a field effect transistor is added to a staircase generator. Acting as a unity gain amplifier, this transistor isolates the waveforming capacitor from the generator's unijunction transistor. Exponential decay of the staircase step voltage—caused by leakage in the emitter base junction of the UJT—is therefore prevented.

Called droop, this voltage decay throws the counting of the staircase generator into error. An extra pulse, which the generator is not adjusted to count, makes up the losses caused by decay.

A narrow pulse turns Q_1 on long enough to allow capacitor C_1 to charge to a value equal to the difference between the supply voltage and the potential drop across R_1. This charge voltage gates FET Q_2 into conduction. The drain-to-source current of Q_2 causes a voltage drop across R_2 equal to the voltage on C_1. This voltage remains on C_1 and across R_2 until the next pulse raises these voltages by an equal amount.

Charging of the capacitor by the pulses continues until the potential across R_2 reaches the trigger voltage of C_3. When this voltage, expressed by the following equation:

$$V_p = \eta V_{cc}$$

where V_p = trigger voltage

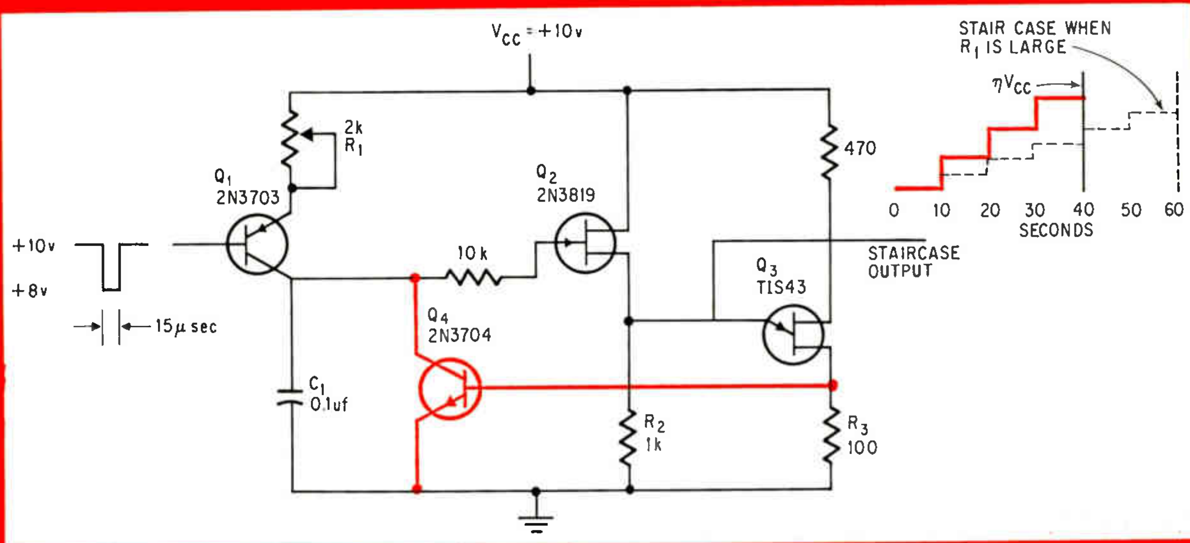
η = intrinsic standoff ratio of UJT

V_{cc} = supply voltage

triggers the UJT into conduction, current flow through R_3 develops a bias voltage for Q_4. This voltage biases Q_4 into saturation and causes an immediate discharge of C_1.

Since the charge on C_1 is dependent on the value of R_1, adjustment of this potentiometer determines the number of pulses necessary to trigger the UJT.

Heart beat, uterine contractions, and the respiration rate are pulses accurately monitored by this counter.



Pulse counter. Each pulse raises the voltage on capacitor C_1 in equal increments until it triggers the UJT into conduction. The voltage that appears across R_2 signals the summation of pulses and makes Q_4 discharge capacitor C_1.

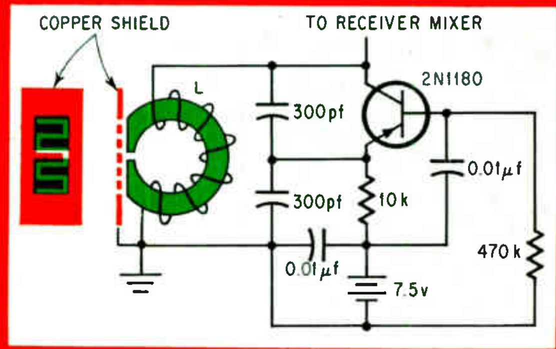
Oscillator as detector

By D.B. Hoisington

Naval Postgraduate School, Monterey, Calif.

Nonmagnetic screws and nails hidden below the surface of a teakwood deck or plywood bulkhead can wreck saw blades and tear sandpaper during a ship's refitting. Since they are nonmagnetic these fasteners cannot be detected by conventional devices that use a soft iron needle. However, they can be detected by an oscillator in which the metallic characteristic of the hidden fastening changes the flux density of the oscillator coil's magnetic field.

The coil is wound on a toroidal core with a small semicircular segment removed. The coil is the inductive element in the tank circuit of a Colpitts oscillator and is clamped to a laminated copper plate that acts as an electrostatic shield. A Faraday window, etched through the plate at the areas where the flat surfaces contact it, allow the field to appear on plate's other side.



Pinpointing hazards. Any metallic object in the magnetic field changes the oscillator's output frequency and the audio output.

If the magnetic field hits a metallic screw or nail while the plate is moved over the wood surface, the oscillator signal changes by 1 kilohertz. This changes the beat frequency output of a receiver mixer and is heard as a change in the audio output.

SCR synchronizes gate

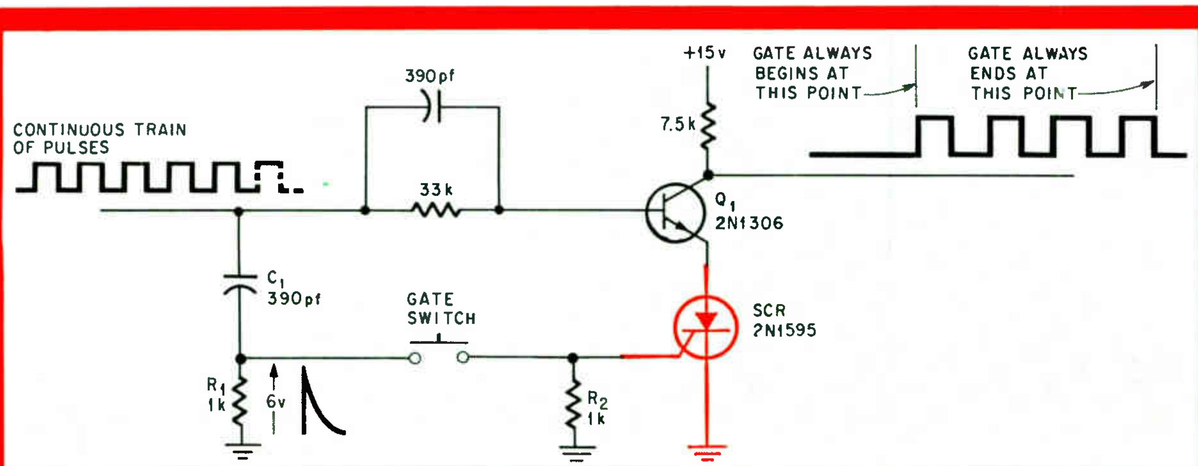
By Roy A. Wilson

Hycon Mfg. Co., Monrovia, Calif.

Trains of clock pulses gated into some digital circuits must start on the leading edge of the first pulse and end on the falling edge of the last. Complete pulses may be necessary for proper synchronization of circuits or because incomplete pulses may not have the power to trigger transistors. Consequently, when only portions of pulses are applied, false synchronization or no synchronization may result, and the operation might be impaired.

Operation of the circuit takes place only when the gate switch is manually depressed, but closing the circuit does not cause immediate gating. If there is no pulse at the input, neither Q_1 nor the SCR will be biased into conduction.

If a pulse is present when the switch is closed,



Ballast SCR. A pulse in the input train does not trigger transistor Q_1 into conduction unless the leading edge of the pulse gates SCR_1 on. Total pulse width is needed to inject carriers to gate the SCR. Slow carrier leakage from SCR_1 prevents Q_1's turn-off when a pulse is present.

gate action does not take place either. The voltage across R_1, which was 6 volts at the beginning of the pulse, has dropped due to the charging of C_1 to a point where it cannot trigger the SCR.

When the leading edge of the next pulse places 6 volts across R_1 and simultaneously biases Q_1 into saturation, the SCR is gated on. The collector voltage of Q_1 moves from 15 volts to ground, thus forming the leading edge of the gate's output pulse. It remains there until the pulse at the base returns to zero and forces Q_1 and the SCR to turn off. Each succeeding clock pulse biases Q_1 into conduction and places a negative pulse on the collector until the switch is opened.

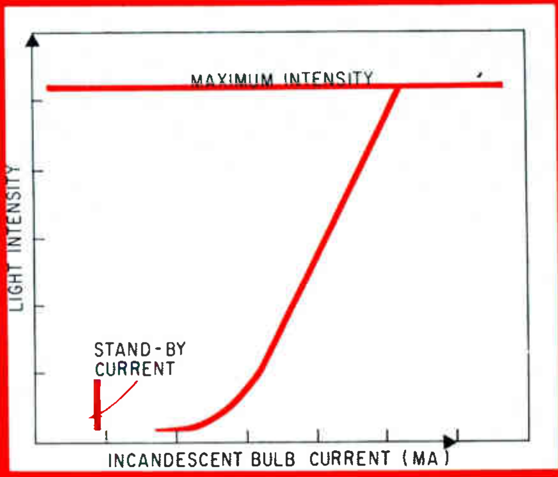
If the switch is opened during a pulse, the circuit does not stop immediately but continues until the pulse is completed. At completion, the SCR current drops below its holding value. With the switch open, the succeeding pulse cannot trigger transistor, Q_1, into conduction.

Photographic printer controlled by UJT-SCR timer

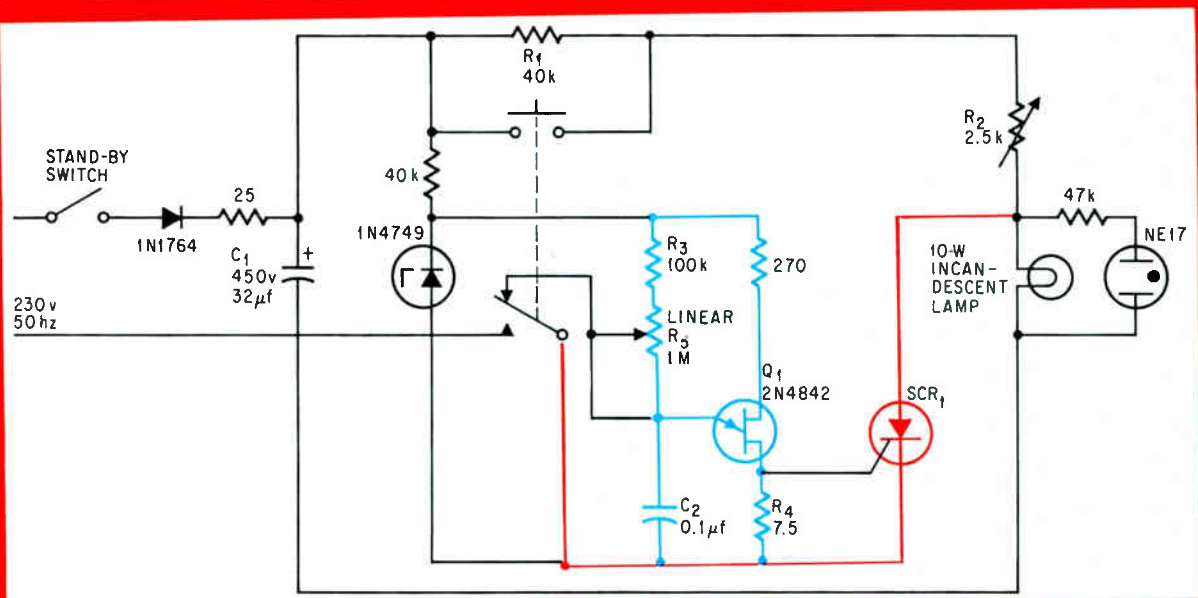
By Doar Lior
Tel-Aviv, Israel

Common incandescent bulbs—controlled by an electronic timer—produce constant illumination for photographic printing. The timer keeps the bulb's filament temperature close to the illumination point so that turn-on current causes a sharp and immediate increase in intensity. When the desired printing time is ended, a silicon controlled rectifier in the timer shunts the bulb and makes the intensity drop quickly.

As long as the standby switch is closed 320 volts d-c appears across C_1 and supplies 6.2 milliamperes to the 10-watt bulb. When the timer switch is



Instantaneous illumination. Stand-by current is allowed into the incandescent bulb to keep the filament warm when the timer is off.



Sharp turn off. When capacitor C_2 charges to the trigger point of the unijunction transistor, a voltage is developed across R_4 that gates SCR_1 into conduction. The SCR's low resistance between cathode and anode provides a path for the supply current and turns off the bulb's illumination.

closed, R_1 is bypassed and 43 milliamperes flows into the bulb, increasing the intensity of light to the maximum. Closing the switch also removes the short circuit from around C_2 thus allowing that capacitor to charge through R_3 and R_5. When the trigger point of unijunction transistor Q_1 is reached, it fires and current flows through the base 1 resistor, R_4. The pulse developed across this resistor gates SCR_1 into conduction and SCR_1 shunts the bulb with the low resistance path of the rectifier.

Opening the timer switch returns the circuit to the standby condition and allows the capacitor C_2 to discharge through the switch.

Time variations are achieved with R_5.

Feedback reduces bio probe's input capacitance

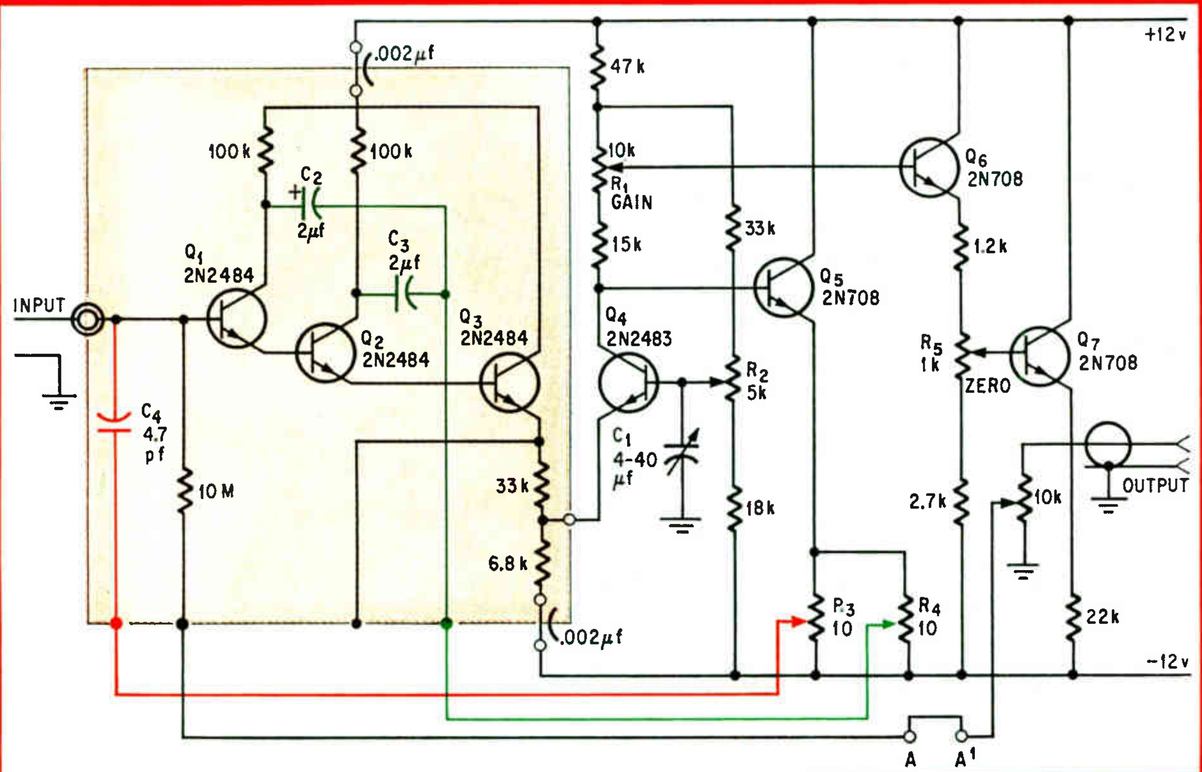
By G.W. Horn

Institute of General Physiology, Torino University, Torino, Italy

A bioelectric probe circuit that amplifies voltage pulses produced in a protoplasmic membrane for input into a recording system can be built so the input capacitance is virtually zero and the input resistance very high. By applying feedback, the circuit overcomes the usual low pass filtering action produced by the extremely high resistance of the small-diameter probe and the input capacitance of the recording instrument.

In living cells, a steady voltage of about −50 millivolts is maintained across a membrane that contains protoplasmic matter by ion exchange. During excitation of the cell, the transmembranic voltage falls to zero and then rises to about +80 mv in a few microseconds; the cell then returns to its initial conditions in about one millisecond.

Transmembranic voltages may be detected by special glass microelectrodes having tip diameters smaller than half a micron; the tiny microelectrodes are filled with potassium chloride. The small tip diameter facilitates penetration of the cell's membrane without interfering with the cell's biochemical behavior. The series resistance of the glass microelectrode, due to its small size and electrochemical junction, is in the 10 to 100 megohm range. In uncompensated systems, the microelectrode resistance combines with the input capacitance of the recording instrument to produce an



Probe circuit. Transistors Q_1, Q_2 and Q_3 form a negative-capacitance impedance converter that is followed by d-c amplifier Q_4 and output emitter followers Q_6 and Q_7. Zero input capacitance and high input resistance are assured by controlling R_3, R_4 and C_1.

RC filter that distorts the transmembranic voltage pulses the system is attempting to detect and record. Such low pass filtering is eliminated by the probe circuit that employs feedback to reduce its input capacitance almost to zero (less than 0.02 picofarads) while presenting a typical input resistance of 20,000 megohms. The probe circuit is essentially a negative-capacitance impedance converter followed by a d-c amplifier and two emitter followers.

The typical input resistance of 20,000 megohms is achieved by arranging three 2N2484 silicon planar transistors, Q_1, Q_2, and Q_3 in a Darlington configuration. It was found that MOS FET's were unsuitable because the electrostatic charge collected by the glass microelectrode during its placement in the cell body usually destroys the MOS FET substrate. Collector bootstrapping of Q_1 and Q_2 via capacitors C_2 and C_3 greatly reduces the input capacitance. Virtually all stray capacitances with respect to ground were neutralized by connecting the guard ring of the input connector and the shielding box containing Q_1, Q_2, and Q_3 to the emitter of Q_3.

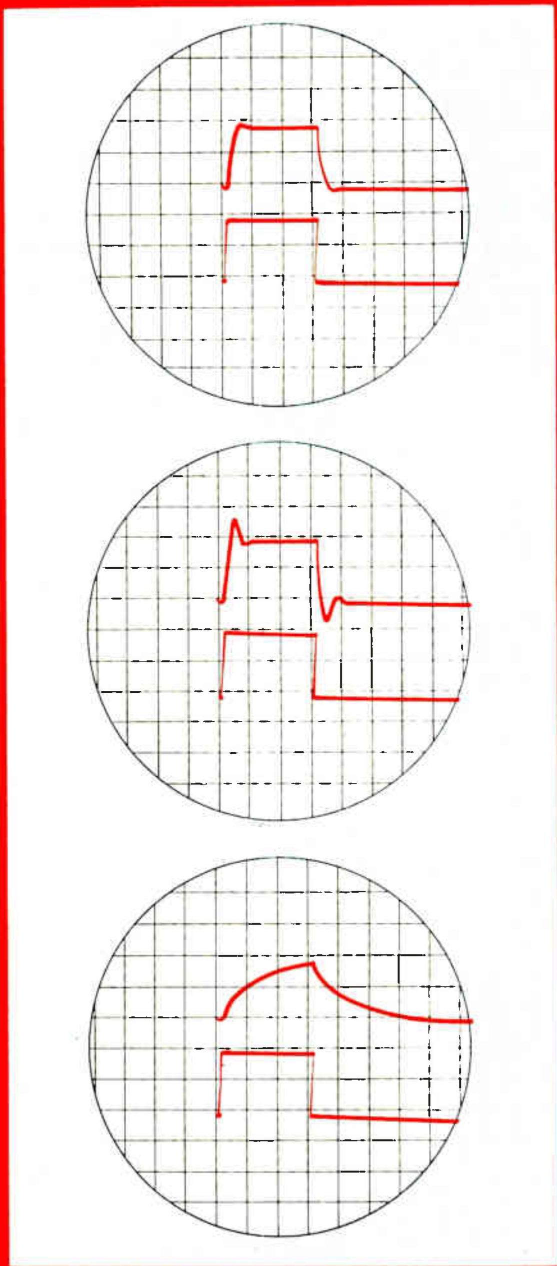
The Q_1-Q_2-Q_3 impedance converter is followed by d-c amplifier Q_4, which is stabilized by strong negative feedback from the collector to the base of Q_4; the negative feedback reduces the stage gain to about 10 decibels. Trimmer capacitor C_1 may be adjusted to reduce the collector-to-base feedback in Q_4 (and thereby raise the gain of Q_4) at higher frequencies—up to the stage's peak response of about 1 megahertz. Two emitter followers Q_6 and Q_7 are operated in cascade to shift the amplified signal from the collector of Q_4 down to zero volts d-c, the base line voltage of the input signal is thus restored. The emitter followers also provide for gain adjustment via potentiometer R_1. The probe circuit is usually operated at unity gain.

Any residual input capacitance is neutralized by the a-c feedback path from potentiometer R_3 in the emitter of Q_5 to the base of Q_1 via capacitor C_4. Potentiometer R_4, also in the emitter of Q_5, provides adjustable bootstrapping current to the collectors of Q_1 and Q_2 via capacitors C_2 and C_3. The operating point of d-c amplifier Q_4 may be adjusted with potentiometer R_2 to assure balanced operation in both positive and negative directions.

By proper adjustment of R_3, R_4, and C_1, the probe circuit can be operated at virtually zero input capacitance (0.02 pf or less) and an input resistance greater than 10,000 megohms (with 20,000 M being typical); thus, a square wave applied to the probe circuit through a 50-megohm resistor (to simulate the microelectrode resistance) shows practically no attenuation in the first scope trace; the square wave's rise time is degraded to about 2.5 microseconds. The other two scope traces show the probe's response to a square wave input for the overcompensated and undercompensated cases, respectively. The sweep frequency of the Tektronix Type 502A dual-beam oscilloscope was 10 μsec per division and the vertical display was set at 100 mv per division to produce the traces.

If a still greater input resistance is required, additional positive feedback may be applied to the base of Q_1 from the emitter of Q_7 (AA′) which is at 0 d-c level.

If the probe circuit is supplied with ordinary mercury cells, the total drift, without regulation, is about 100 μv/°C.



Scope traces. Probe circuit's response to a squarewave is shown for the fully compensated case (top), over-compensated case (center) and undercompensated case.

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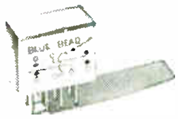

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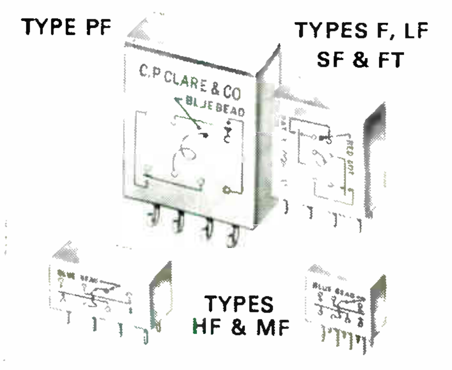

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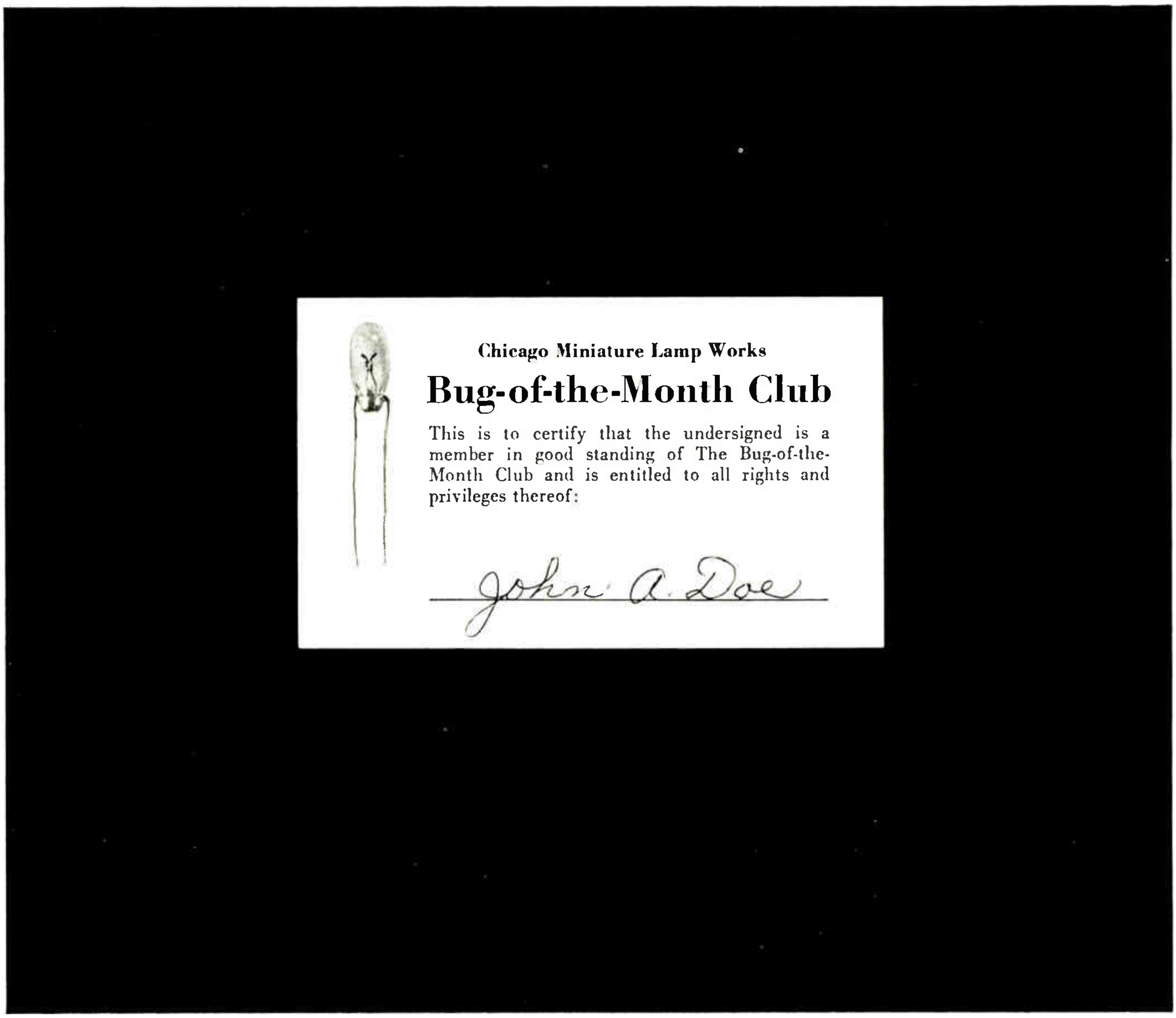

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Through thick and thin with infrared beams

Spectrometers improve nondestructive optical-interference techniques of measuring the depth of wafers' epitaxial layers automatically, and without sacrificing resolution, accuracy and reliability

By Thomas E. Reichard
Monsanto Co., St. Louis, Mo.

Optical-interference methods may be precise when it comes to measuring length, but they tend to be time-consuming. And time is a critical factor on a production line. A semiconductor-device maker, for example, must quickly and accurately measure the thickness of epitaxial films. Recent advances in infrared scanning techniques now make it possible to apply an automated method of interference measurement speedily without any loss in accuracy or resolution.

Because of the optical properties of the materials involved, the useful wavelengths for interference measurements of semiconductor epitaxial films are limited to the infrared range of about 7 to 40 microns. However, measurements in the infrared are particularly difficult for wavelengths greater than 10 microns. One reason is that a very small proportion of the source energy is emitted at long wavelengths; another is the scarcity of optical materials capable of transmitting long wavelengths; a third is the very-sensitive thermal detectors required.

With the optical-interference technique, a beam of light aimed at the wafer is partially reflected from the front and rear surfaces of the film and the resulting interference-fringe pattern is related to film thickness.

The Monsanto Co. has developed a fast-scanning infrared spectrometer capable of making up to 15 thickness measurements a minute. Not only is the approach nondestructive, but the test specimen doesn't have to be removed from its protective plastic bag. Monsanto's system incorporates an optical-mechanical computer to place marker lines on a cathode-ray display of the waveform pattern. All the operator need do is align the markers with the maximum and minimum peaks. A digital readout then gives the thickness ranging from 1 to about 85 microns.

A common way of measuring the layer's thickness is the lap-and-stain method. But this is destructive—a wafer is cross-sectioned, and the exposed surface is stained. Since layers of p material become darker than the n-type layers, a microscope is easily used to measure thickness.

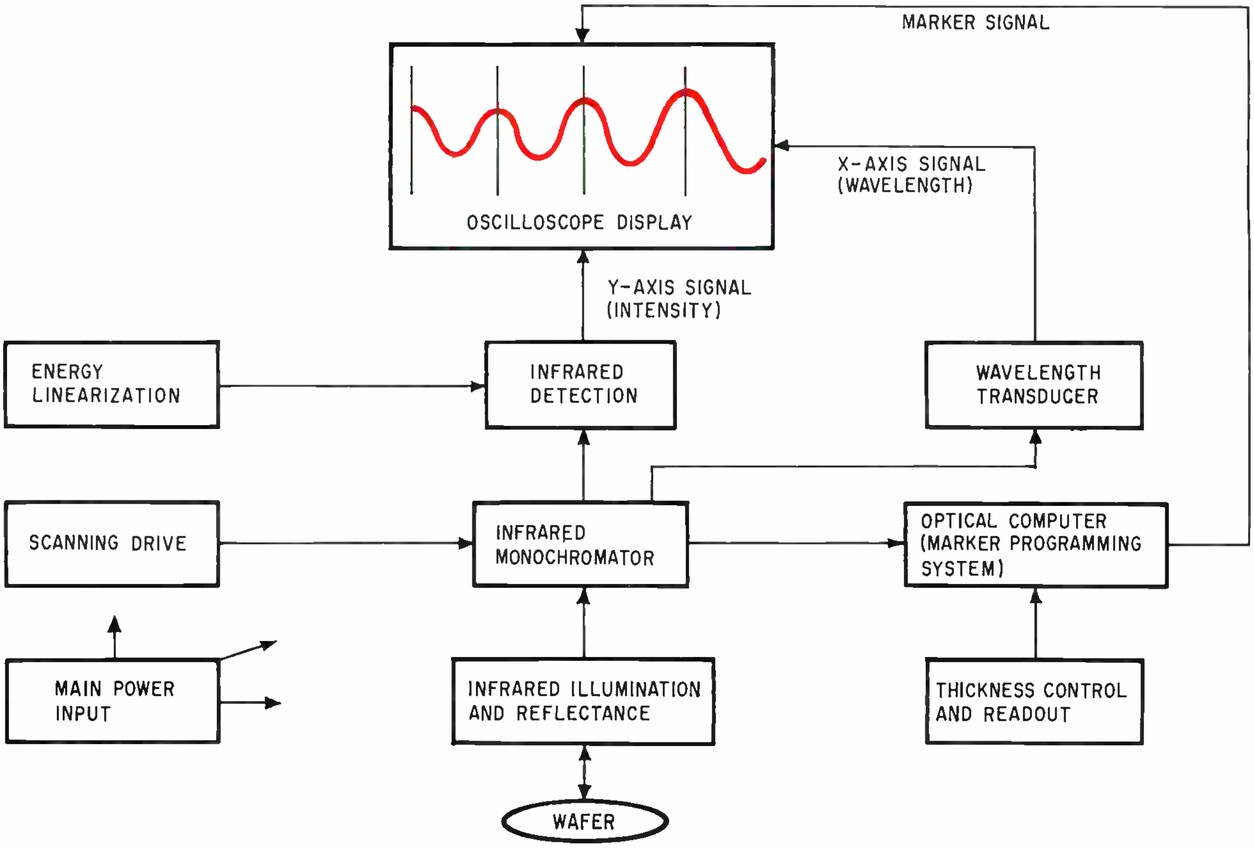
Interfering reflections

Optical-interference techniques are based on the phase relationships of the reflected incident rays. When the reflected light's wavelength is scanned, the interference fringes vary with wavelength on the wafer. Viewed from only one direction, these fringes become brighter and darker as the wavelength is changed.

The brightest fringe occurs at the wavelength at which the waves are in phase; the darkest fringe occurs at a wavelength at which the waves are 180° out of phase. These peaks and valleys occur when the optical-path difference—which is a function of film thickness—between the two reflected rays is an integral multiple of one-half the incident wavelength. Film thickness is thus a function of the wave-

The author

Thomas E. Reichard is a senior research physicist at Monsanto's New Enterprise division. With the company since 1952, he is working on analytical instrumentation and sensors for process-control systems.



The infrared box. The system consists of a fast-scanning infrared spectrometer with an oscilloscope display and an optical-mechanical computer. The spectrometer employs cesium-bromide prism optics. It differs in a number of ways from the conventional infrared spectrometers commonly used for absorption analysis and epitaxial silicon interference-fringe patterns. It is single beam, direct reading instead of double beam, null balancing. The interference fringe peaks are detected and read out directly, without the usual beam-chopping, lock-in amplification, and demodulation, allowing much faster scanning. The detector—a thermistor bolometer—has faster response and greater sensitivity than the more conventional thermocouple detectors. Beam power is increased fourfold by doubling the slit-width program over that normally used for analytical spectrums. Resolution, however, is reduced, but only by a factor slightly less than two. Moreover, the slit height is more than double that ordinarily used for the same monchromator aperture. This gains another factor of two in beam power, with very little additional sacrifice in resolution. The micro-specular reflectance optics are made all-reflecting to avoid lens absorption. The spectrum is scanned rapidly and repeatedly, in both directions. Scanning speed is varied according to the film thickness being measured. Speeds range from 10-scans per second for 0.10-mil thickness to 0.33-scans per second for 3.0-mil thickness. The fringe spectrum is continuously displayed on a large-screen, long-persistence oscilloscope. The computer places marker lines on the oscilloscope trace along with the fringe pattern. When a wafer is placed on the reflectance spot, its spectrum is continuously displayed and the markers independently moved until they are positioned on all peaks of the fringe pattern. The corresponding film thickness is shown on a numerical dial.

length at which the interference-fringe peaks occur.

Lab devices slow

Previously, film-thickness measurements with this method were made with infrared spectrometers that were designed for infrared absorption rather than reflection analysis. This meant special reflection attachments were necessary. Moreover, since these spectrometers were intended for laboratory rather than production-line use, they lacked sufficient speed. With a conventional spectrometer, about two minutes elapsed before a suitable fringe spectrum was obtained. And still more time was required for the operator to interpret the spectrum and determine the film thickness.

A one-minute scan over the wavelength range of 10 to 35 microns is considered fast for a conventional infrared spectrometer, and a 20-second scan over the same range is probably the fastest possible. Attempts at faster and more automatic systems using conventional spectrometers haven't provided the desired speed, precision, reliability, and reproducibility of results.

Conventional spectrometers employ beam chopping with a-c detection and amplification. This requires amplitude-demodulation systems or null-balancing servosystems to form the interference-fringe spectrum. Since a certain minimum number of detector responses are required to form a single fringe, the spectrometer's scan speed is limited by the response time of room-temperature infrared detectors. In the far infrared range, the maximum speed is about 20 seconds.

Picking up speed

However, Monsanto's fast-scanning infrared spectrometer, using a commercially available room-temperature detector, has a scanning rate between 0.1 and 3 seconds. Precision and reproducibility of the measurements are better than those obtained with previously available devices. Direct d-c detection and amplification of the infrared spectrum is achieved without beam chopping. This approach was previously considered impractical for a fast-scan spectrometer because of signal-noise problems, nonlinearities in infrared energy, and thermal drifts.

Because of the extremely low radiant power available at far-infrared wavelengths, detection and readout become difficult; the maximum peak-to-valley height of even the strongest fringe pattern seldom exceeds 0.5 microwatts. Under normal conditions, the fast-scanning instrument can reliably detect, display, and measure interference fringes whose maximum peak-to-valley height corresponds to 1% of the total beam energy. Thus, with a maximum peak-to-valley beam power change of about 0.03 microwatts, a temperature change of about 0.000005°C is produced in the active thermistor flake of the detector. The thermistor flake's resistance changes at the rate of 4% per °C. The corresponding electrical resistance change is 0.2 part per million.

When biased at 160 volts, the active flake alone produces a signal of 32 microvolts.

With the active thermistor in a bridge circuit having an identical compensating thermistor shielded from the infrared beam, the effects of ambient-temperature drift are minimized. The bridge output is then half that of the active element, 16 microvolts. And with each thermistor element having an electrical resistance of 2.2 megohms, the net bridge impedance is 1.1 megohms. Consequently, the electronics' design has to consider the destructive effect of such high impedance. For example, the bias-power source for the thermistor bolometer in the Monsanto system had to have a low-frequency noise level lower than 2 parts in 10^8.

For fast scanning, the detector's signal must be read out directly without the time-averaging, beam-chopping, and phase-locked amplification techniques usually used to extract weak signals from a high-noise background. Furthermore, the nature of the spectrum-scan function, display, and interpretation limits the filtering that can be applied without causing excessive phase lags.

Thus, the active-frequency bandwidth must be left relatively wide; but this, in turn, places extraordinary low-noise requirements on both a preamplifier and the thermistor bias-voltage supply.

The preamplifier introduces only about 2 microvolts equivalent input noise in the passed bandwidth. Mounted within the spectrometer, the preamplifier is separated from the detector by a heat-sink wall and a radiation shield. Electrical connections are short and rigid to minimize any microphonic voltages induced by physical vibration. With a gain of 1,500 and a low impedance, the preamplifier's susceptibility to stray-noise effects is minimal. The output signal is fed to the y-axis input of crt display through a bandpass filter.

Putting light on the subject

A light source in the spectrometer system produces radiation that is directed at the semiconductor wafer. The reflected radiation is broken down into individual wavelengths in a monochromator, which is the spectrometer's basic component. An infrared detector then determines the intensity of each wavelength and a voltage corresponding to it is then transmitted to the crt. This voltage is displayed as y-axis information and a voltage corresponding to wavelength is the x-axis.

The interference spectrum of silicon films at different thicknesses are coded into the system's computing device as are the spectrometer's optical and mechanical correlation factors. This computing device triggers the vertical marker lines that accompany the waveform on the crt. The positions of these marker lines are programed to match the fringe peak corresponding to a specific film thickness.

When the wafer is positioned over the illuminated spot, the interference waveform is continually displayed. The operator, using a single control, moves the marker lines. When the marker lines are positioned, the measurement is completed automatically and the corresponding film thickness is shown on a numerical counter dial.

Eliminating critical parts

Since the display serves only as a reference for both the fringe spectrum and the marker lines, the accuracy and linearity of the wavelength scale aren't critical as long as the same scale is used from one scan to the next. The matching and accuracy are achieved with the computer control.

The scanning drive employed in the Monsanto system has two unusual features: speed is set manually, and scanning is bidirectional.

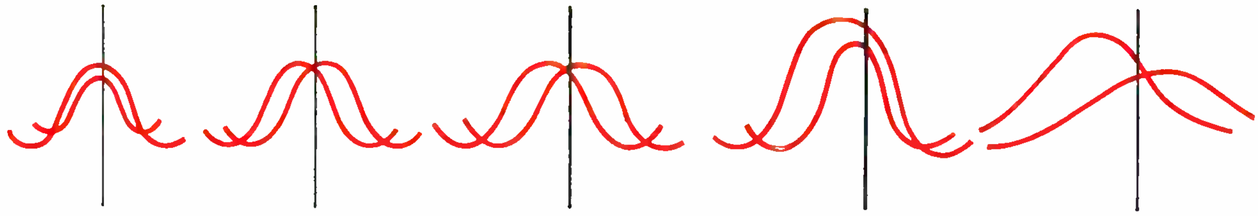
Because the number of fringe cycles per spectrum is directly proportional to film thickness, the scanning speed is adjusted for different epitaxial layer thicknesses. Thus, the time-frequency relationship of the interference fringes remains within a relatively narrow band at about 20 hertz.

The bidirection scanning saves time, minimizes inertia forces, and reduces mechanical wear of parts. More important, it enables balancing both time and phase lags.

Marking the peaks

The marker-programing system provides the display's movable index marks, which are superimposed on the display fringe spectrum.

The manually controlled index marks establish



Lag in time. Time or phase lags show up as slight spreading, or mismatches of fringe waveforms on opposite scan directions. These lags are balanced by manual adjustment of marker line at center of the split.

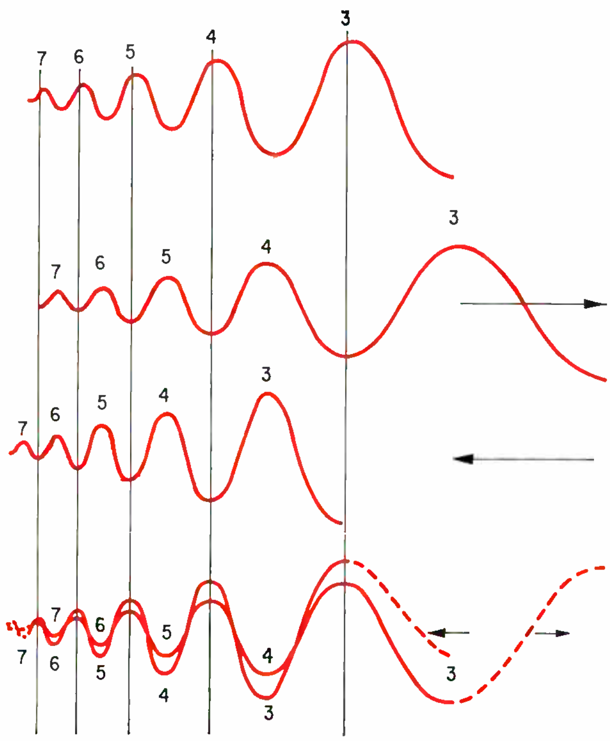
film thickness and can be read directly, or recorded by any suitably calibrated readout system.

Marker lines are generated by a photodiode system.

A silicon photodiode affixed to the spectrometer's Littrow arm, is enclosed in a housing with a 0.002-inch diameter aperture. Immediately above the diode housing is a glass photographic-mask plate that is opaque black except for a series of narrow transparent lines and mounted on a precision micrometer slide. Light focused into a uniform parallel beam illuminates the plate from above.

Whenever the diode housing aperture passes one of the transparent lines on the plate, the photodiode produces a small voltage pulse that is amplified and passed to the marker input of the crt. This pulse triggers a vertical marker line.

The lines on the plate are arranged to correspond with fringe-peak wavelengths for any given film thickness. Moreover, the lines are arranged so that linear movements of the plate continually change the programed pulses of the photodiode to match other film thicknesses; each inch of plate movement corresponds to a 1-mil wafer film thickness.



Stretched spectrum. Because scanning speed is nonlinear in time and x-axis distance is linear in wavelength, the fringes are stretched out on the crt and appear as an expanding time scale.

Variations in emissivity, reflectivity, and absorptivity of various optical components in this measuring instrument may cause systematic short-range fluctuations in infrared-beam energy throughout the spectrum. Because of resolution and mechanical inertia considerations, these fluctuations cannot be fully smoothed out with a programed slit movement. An auxiliary linearization system introduces programed amounts of compensating radiant energy into the bolometer detector to smooth out any remaining fluctuations. A moving optical-mask device makes abrupt energy changes without inertial limitations.

On the right track

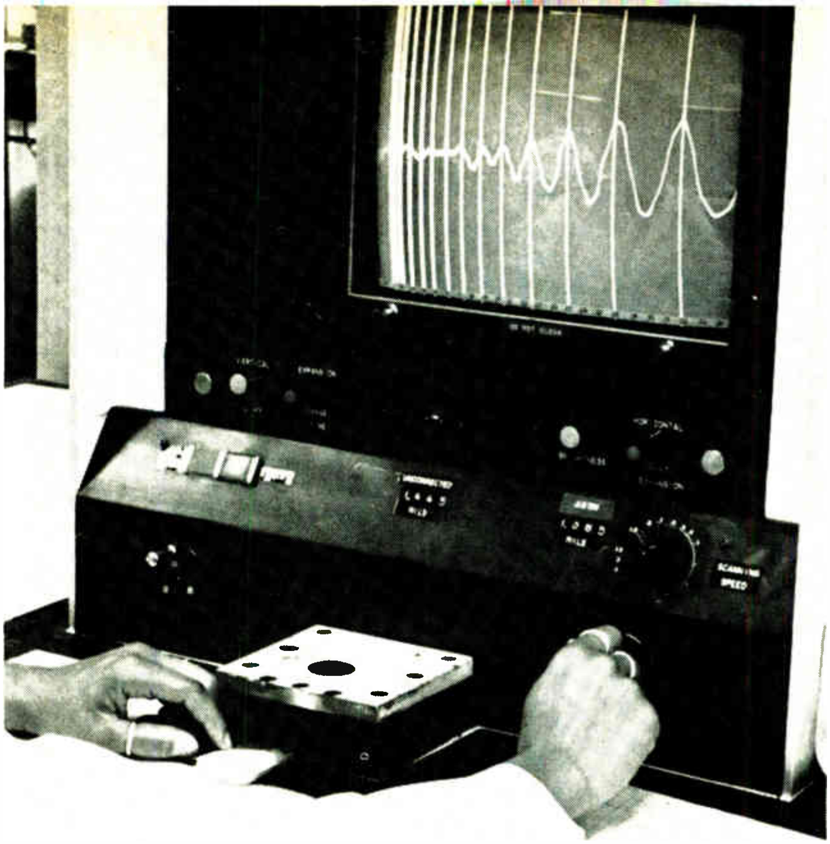
The display is a raster-scanning crt functioning as a fast-response x-y plotter. The crt has a retention time equal to two or more complete scans. As a spectrum is continually scanned, a wavelength transducer system tracks the scanning for the x axis, approximately linearly in microns. The optical-computer system monitors the movement of the spectrometer's Littrow arm and places marker lines precisely at the peak positions corresponding to the computer's thickness setting.

In the infrared range, particularly in the far infrared, radiant energy can be detected only from thermal effects that involve appreciable response-time delays. Because the radiant energy at far infrared wavelengths is weak, some noise-filtering circuitry is necessary in the detection and readout system. This introduces additional time and phase lags.

Monsanto's system, however, balances out all time and phase lags from any source.

When the total lag in the detection and readout system is a small fraction of a fringe cycle, the lag appears on the display as either a slight spreading or mismatch of fringe waveforms from the bidirectional scan. Viewing the superimposition of alternate scans, the operator balances the offset waveforms and positions marker lines at the center of the split.

When similar fringe-peak waveforms are repeated at a constant interval apart, phase lags larger than the fringe width are also balanced and compensated. This results in scanning speeds exceeding detector response.



One-handed measurement. Operator automatically measures film thickness as the marker lines are aligned with the fringe peaks in the displayed waveform.

The total time delay of the detector and readout system is 25 milliseconds on the display screen. For any given wafer, the scanning speed is set so that the interference fringes occur at 50 milliseconds per cycle and the phase lag is exactly 180°. The fringes on the opposite directions are shifted and the spectrums are again superimposed, but with an apparent peak-to-valley phase inversion.

The trace is reinverted electronically on the display, bottom of page 104. At the top is the spectrum of a typical epitaxial film about 0.5 mil thick as it would appear in real time. Marker lines are centered on the peak positions where the infrared-beam energy is highest; numbers indicate the fringe orders.

The spectrum is shifted a half order to the right on the outward scan, and a half order to the left on the reverse scan. Fringe peaks fall at the same position on the x axis for the two shifted scans; valleys, however, differ by one order.

Electronic inversion

On the crt display, the two spectrums are superimposed with the y signal electronically inverted so that the fringe valleys, which occur at the normal peak positions, appear as peaks. At the true wavelength position for an "nth" order, what actually is displayed is the $n+1/2$ order valley on the left-to-right scan, and the $n-1/2$ order valley on the reverse scan. When the operator adjusts the scanning speed to superimpose the peaks on the display, the correct phase relationship is precisely established so the inverted composite spectrum closely matches the true real-time spectrum. The composite is viewed and interpreted the same way as the real-time spectrum.

Since the rate of wavelength scanning is linearly related to wave number—the reciprocal of wavelength—and the display (x axis) is approximately linear in wavelength, the horizontal sweep is nonlinear in time. The sweep, then, is slow at the shorter wavelengths but fast at the longer wavelengths. Thus, the spectrum moves into an expanded time scale and the fringes are stretched out. In the return scan, the peaks are compressed. When two adjacent fringe peaks having different widths on a real-time display are shifted and superimposed in this manner, their widths become equal. This fringe-width expansion and compression occurs only on the display. The shifted fringe retain their original amplitudes, and the superimposed adjacent-order peaks are generally of different heights.

This method enables any combination of fringe-frequency and detection-time lags to be balanced out precisely and the opposite direction waveforms superimposed.

Extra references

Double-line markers are placed at the valley positions for the first several half-orders to provide more reference points for measuring very thin films. This is done because such films form only a few fringe peaks and would be difficult to resolve.

The system's measurement and display technique also makes it a useful instrument for following and measuring gradual variations in film thickness over the surface area of large specimens. In such a situation, the continually repeated cathode-ray display exhibits gradually shifting fringe-peak positions as different film areas on the specimen are scanned. The thickness of any location can be measured by simply adjusting the handwheel as required and reading the thickness from the counter dial.

Instrumentation

Sighting in on narrow light beams

Radiometer checks whether optical antenna reduces laser's beamwidth enough for long-range transmission

By Herbert B. Hallock
Grumman Aircraft Engineering Corp., Bayshore, N.Y.

Optical communications were given a big boost earlier this year when the moon-based Surveyor 7 proved the feasibility of such systems by successfully photographing a laser beam transmitted from earth—239,000 miles away. The next test will be the manned Apollo missions in which laser ranging systems placed on the moon will attempt to measure the drift of earth's continents.

But the moon isn't the end of the world for optical-communication experiments; laser techniques are also being considered for the Mars probe NASA is planning.

Because of the distances involved—for a Mars probe, a beam will have to cover between 34 million and 250 million miles—confining the radiated power to an extremely small, precisely pointed beam is difficult. Earth-to-Mars transmissions would require a beam a fraction of an arc-second wide, less than 1/3,600th of a degree. Although laser beams are narrow, they aren't this narrow. The beamwidth would have to be reduced by a telescopic-optics system that acts as an antenna.

In designing a transmitter's optics, an engineer must take into account the laser's coherent power distribution over the antenna aperture if he wants to achieve smallest possible beamwidth. This requires an exact measurement of the power distribution beginning with the laser itself. Since several optical coupling devices and a modulator lie between the laser and the output antenna, the distribution must be checked at each stage.

Studies conducted for the advanced development section at the Grumman Aircraft Engineering Corp. point to a radiometer as one of the most useful tools in designing optical antennas.

The idea is simply to measure the gain of the antenna by measuring the energy distribution in the far field. But the far fields for lasers are extremely long, making measurements in laboratories either difficult or downright impractical. For example, with an aperture diameter of 10 centimeters and a wavelength of 1 micron, the antenna's far field would be 10,000 meters, or about 6.2 miles. With a diameter of 1 meter and a wavelength of 1 micron, the antenna's far field would be 1,000 kilometers, or about 620 miles. Conventional antenna-range tunnels are only about 100 meters long. Thus, to achieve the desired far-field accuracy, the designer would have to limit aperture size to that of the laser source itself—between 3 and 10 millimeters.

Although large collimators can be developed to replace the tunnel, it's simpler to test the components with existing instrumentation.

It is necessary to maintain close control over background radiation if the laser's output measurement is to be accurate. The directional optics of the radiometer screens out the effect of laboratory lighting in the visual spectrum, and heat sources, such as personnel, in the infrared spectrum. The directional reflective optics also permit the engineer to select a collection area in the far field that isn't limited to the detector-cell area.

Another consideration is the detector. Since lasers emit coherent light beams at many different wavelengths, the detector employed must cover a broad electromagnetic spectrum. Only thermal-type detectors can do the job over a broad range. Their flatness of spectral response allows reliable calibration over the broad range by standards good only over limited wavelengths. Moreover, thermal detec-

The author

Herbert B. Hallock has been with Grumman since 1958. He heads the electro-optics laboratory in the power, optics, and displays section of the Electronics Systems Center.

tors also display excellent linearity.

Properly made thermopiles, for example, without optical filters, should be capable of single-wavelength calibration sufficient for an entire spectrum.

Through a looking glass

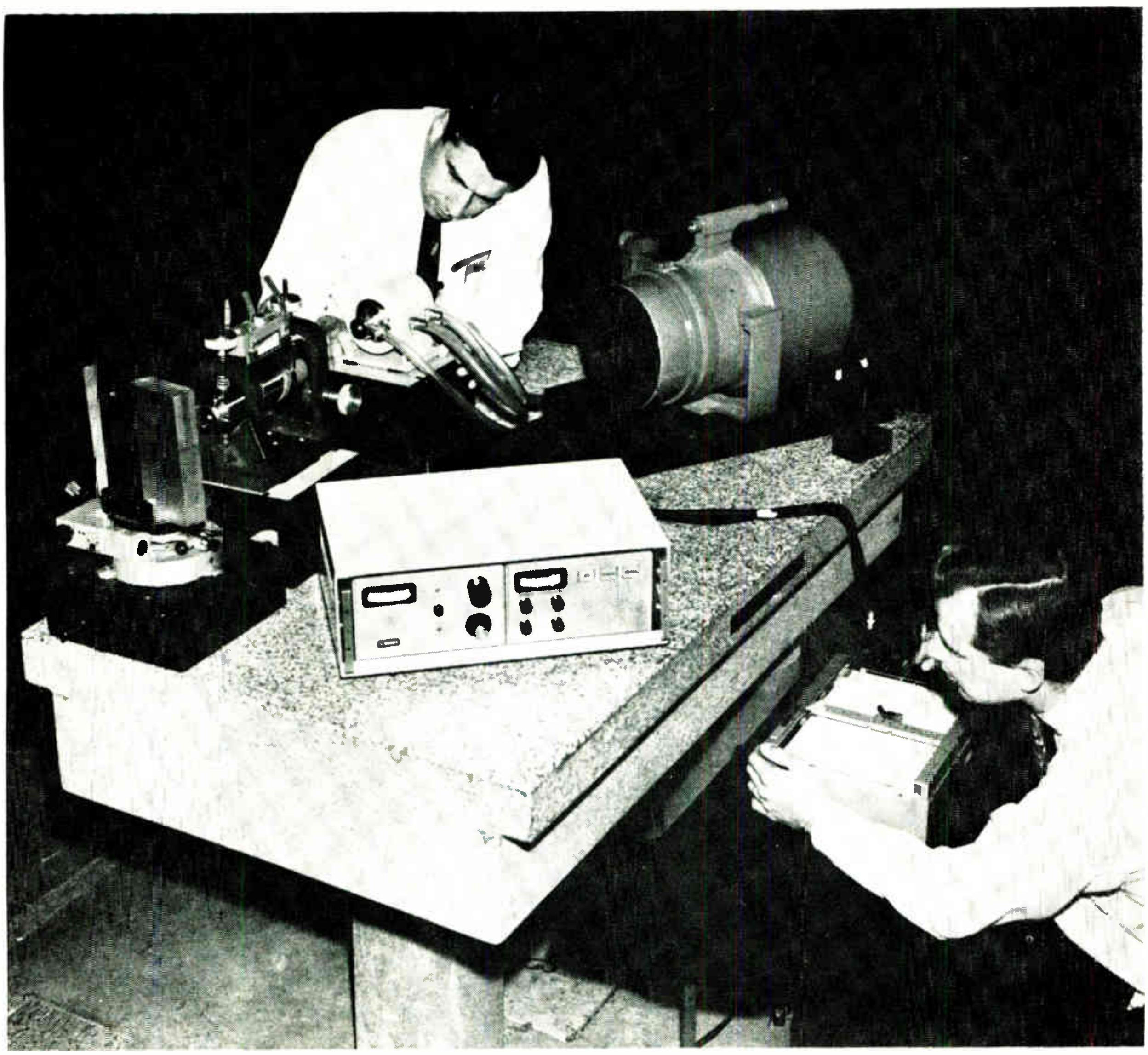
To evaluate the optical system's laser, modulator, and other components, the engineer employs a mirror mounted on a small, extremely accurate rotary table that is equipped with a potentiometer readout. The table, whose zero point is set to coincide with the center of the laser beam, is rotated and the laser output values are recorded. When automatic recording is used, the radiometer's output is fed directly to an x-y recorder's y axis, and an input corresponding to the rotated angle is fed to the recorder's x axis.

A 20-power telescope is used to spread the laser beam, thus increasing the resolution of the measurements. Since the source intensity is reduced by a factor of 20^2 or 400, spreading the beam also increases the detector's power-handling capabilities. Moreover, high resolution is helped by covering most of the radiometer opening, leaving only a small collecting aperture. As the table rotates, the laser beam is swept across the aperture. Corrections for optical losses in the instrumentation are made by measuring complete instrument transmission for the laser's radiation.

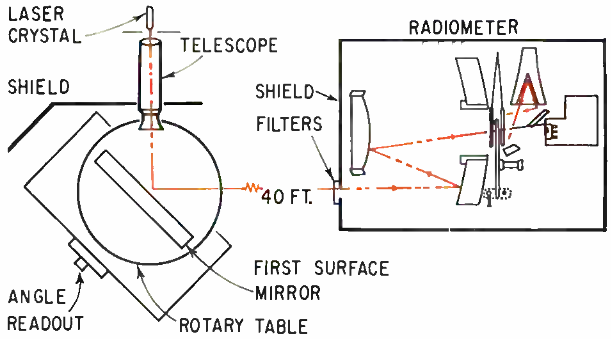
Even though the reflectance polarization and parallax are usually minor they can be avoided. Instead of a mirror, a rotary table large enough to mount the laser can be used, and measurements can be taken directly from the laser.

Achieving accuracy

The radiometer used at Grumman is the Barnes Engineering Co.'s R8T1. When Grumman's laser studies began in 1964, the spectral coverage—0.4 to 13 microns—of a thermistor bolometer with a barium-fluoride window exceeded the spectrum of the available lasers. Today, however, the laser spec-



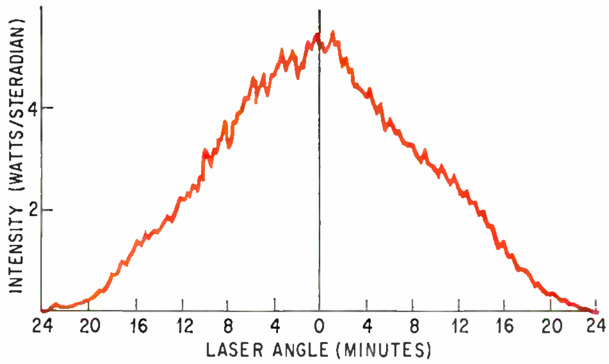
Shaping up. Members of Grumman's electro-optical engineering lab check shape of c-w ruby laser's output with Barnes R8T1 radiometer and xy recorder.

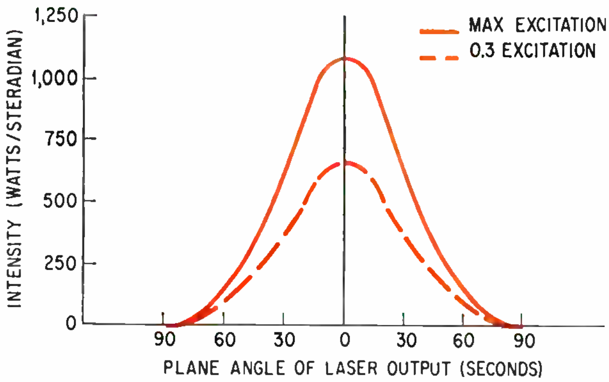


Rotary director. Angular distribution of laser output is checked with radiometer connected to an xy recorder. Mirror mounted on small rotary table directs laser beam to radiometer. The radiometer is placed about 40 feet from the mirror during the actual test.

The increasing spectrum

Laser	1964	1968
N_2 gas	Not available	3371 A (0.337 μ)
CdS semiconductor	Not available	4950 A (0.495 μ)
He-Ne gas	6328 A, 1.15 μ and 3.39 μ	No change
Nd: yag	1.06 μ	No change
Ho: yag	2.10 μ	No change
Co_2-N_2-He gas	Not available	10.6 μ
H_2O gas	27.9 μ, 118.6 μ, 337 μ	No change





The results. Power profile plotted automatically of a c-w ruby laser, at left. Done in 1966, the plot shows the broad angular distribution of early lasers. Moreover, the xy-recorder plot displays magnitude discontinuities resulting from instability in the laser's output amplitude. On the other hand, the angular distribution of a c-w helium-neon gas laser is confined to a much narrower beam. The plot of the gas laser is smooth because it is a faired curve plotted from data recorded during a test and not directly from the radiometer output.

trum has increased to a point that exceeds the transmission capabilities of available window materials —from 0.3 to 337 microns.

Also, laser power levels have progressed from the 300 to 400 milliwatts easily handled with a 20-power telescope to the 10-kilowatt level now achieved with the carbon-dioxide laser. To adequately cover today's greater spectral and power ranges, the radiometer should be equipped with a windowless thermopile for measuring continuous-wave power below 500 mw, and with a windowless-pyroelectric detector for measuring both c-w power above 500 mw and pulsed power.

For high powers, a separate detector would be far more accurate than the calibrated-attenuation optics originally planned for the thermistor bolometer. Moreover, a separate detector is much more convenient. It is possible to cope with 1,000 watts at 10.6 microns, for example, by spreading the beam with infrared-refractive optics and examining about 1/5,000th of the total power at one time. The radiometer's pyroelectric detector can be easily adapted for larger loads. With the proper electronics, this type of detector leads to accurate power distribution measurements of pulsed-laser systems.

Since the noise-equivalent power of the thermistor bolometer (2.34 x 10^{-9} watts per 2-hertz bandwidth) is better than that of a thermopile, the original test setup is still the logical choice for most lasers having a few milliwatts or less of c-w power.

By supplementing the thermal detector with faster detectors, the radiometer can also measure the laser's pulse shape and, if desired, instantaneous power levels in very-short duration pulses. Ideally, such measurements are achieved with a two-channel radiometer in which the thermal detector monitors average power or pulse energy, and a photoemissive, photoconductive, or photovoltaic detector records pulse shape. The power-level calibration of the fast detector can be referred to primary standards through the thermal detector's response. Special wideband electronics required for the fast detector would not involve the usual synchronous demodulation.

Advanced technology

Semiconductor gages make sense in most transducer applications

Capable of producing higher outputs with better sensitivity than metal strain gages, resistor and transistor devices are coming into their own as development is stepped up

By Robert M. Moore
RCA Laboratories, Princeton, N.J.

Semiconductor gages are challenging the supremacy long enjoyed by metal strain gages in transducers that sense displacement, acceleration, pressure, and force. With gage factors—voltage change per unit strain—at least 10 times better than metal devices, the challenging semiconductor resistors and transistors produce higher outputs and better sensitivity.

Insufficient development has been the semiconductor gage's major hangup. But this is fast being overcome.

Unlike the resistor gage, which behaves like a variable linear resistor, the transistor gage behaves like a constant-current source in parallel with a large resistance.

Basic resistive gage

Metal strain gages are usually incorporated in bridge circuits to convert the resistive change of the gage into a usable output voltage. For bridge applications, the figure of merit is represented by the gage factor, G, which is defined as

$$G = \frac{\Delta R/R}{S} \qquad (1)$$

where ΔR is a change in resistance, R is the nominal resistance, and S is the applied strain—elongation per unit length.

The advent of the semiconductor resistor gage makes bridge circuits impractical for single-gage applications because of the device's sensitivity and large resistance changes, which lead to unacceptable nonlinearities. For example, a strain of 10^{-3} produces a $\Delta R/R$ of about 13%, yielding a G of 130, and a bridge-output nonlinearity of over 6%. This would be critical for a resistor gage, but not for wire strain gages; $\Delta R/R$ rarely exceeds 0.5% for wire gages at 10^{-3} strain levels.

To take advantage of the resistor gage's large resistance variation and still obtain an output voltage that is linearly related to ΔR, an engineer turns to a constant-current system. For a first approximation, consider an ideal current supply and voltage detector. The voltage change ΔE due to the resistance variation ΔR is then

$$\Delta E = I\Delta R = IGR \qquad (2)$$

Here, the device's full resistance variation is used and the output's linearity is still maintained.

At first glance, it appears that ΔE can be increased to any desired value by merely increasing I. However, there are some limiting factors, the most important of which is that a large current leads to excessive ohmic heating. Resistance changes caused by temperature rise can lead to burnout. Typically, resistor gages have a power dissipation limit of about 0.1 watt. With a nominal resistance of 350 ohms, such a power-dissipation level limits gage current to approximately 17 milliamperes.

A constant-current circuit is essential when a

The author

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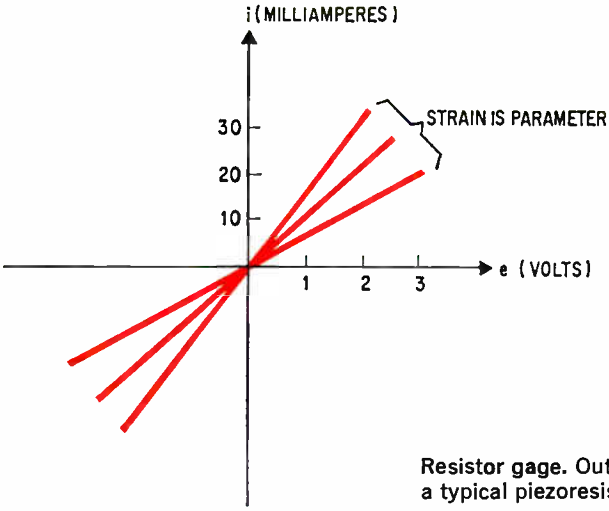
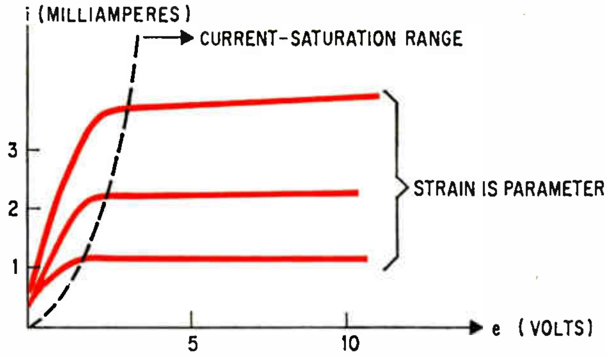




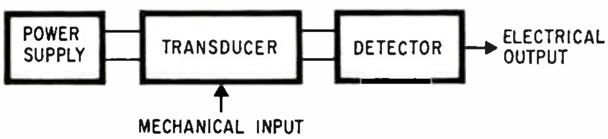
Transistor gage. Output characteristics of a semiconductor gage are similar to that of a transistor.

Resistor gage. Output characteristics for a typical piezoresistive gage are linear.

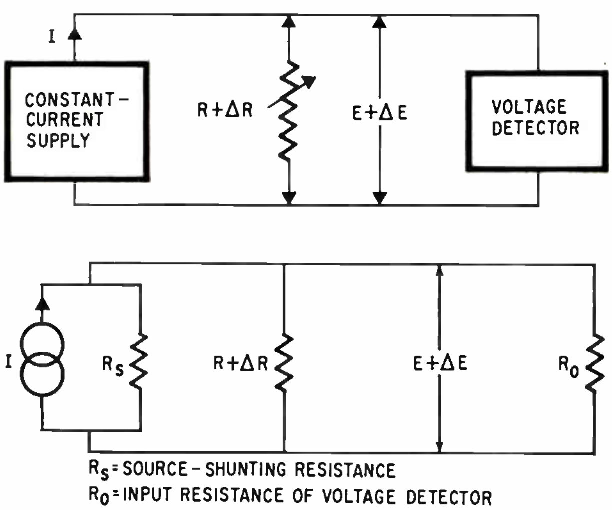
single-gage application is considered, but a bridge circuit can still be used for some two- and four-gage applications.

Supply and load

By inserting a constant-current source shunted by a resistance R_s for the supply and a resistance R_o for the voltage detector, the engineer obtains a realistic representation of a single-gage system. With an equivalent circuit, the engineer can evaluate the loading and supply-regulation effects. Voltage change ΔE is



Transducer system. Applying a mechanical input to a transducer results in an electrical output signal.



Constant current. Piezoresistive gage, top, is represented by its equivalent circuit in a constant-current system. Voltage change, ΔE, depends on the values of R_s, R_o and R.

$$\Delta E = I\Delta R\left[\left(\frac{R_p}{R_p+R}\right)^2\left(\frac{1}{1+\Delta R/(R_p+R)}\right)\right] \quad (3)$$

where

$$R_p = \frac{R_s\, R_o}{R_s + R_o}$$

The loading due to R_s and R_o has a two-fold effect—R_p of the first term in this equation tends to reduce ΔE, and R_p in the second term leads to a nonlinearity of ΔE with ΔR. For a transducer application, the nonlinearity must be reduced to a negligible magnitude. This requires

$$R_p + R \gg \Delta R \quad (4a)$$

or, since ΔR can be an appreciable fraction, 10% or more of R, the equation can be written as

$$R_p \gg R \quad (4b)$$

Equation 3 can then be reduced to

$$\Delta E \cong I\,\Delta R = IGR$$

Thus, equation 2's approximation is valid as long as the parallel combination of R_s and R_o is much greater than R. This is necessary for output linearity and maximum output voltage change.

To understand the effect of poor current regulation, consider I changing by an amount ΔI, and gage resistance remaining unchanged. Then, the spurious voltage change is

$$\Delta E' = \Delta IR$$

provided that the loading effect is negligible. Thus the resolution of the constant-current system is limited to the detection of gage-resistance changes such that $\Delta E = \Delta E'$, or

$$I\,\Delta R = \Delta IR$$

and the smallest ΔR that could be detected is

$$\Delta R_{min} = R\,\Delta I/I \quad (5a)$$

which can also be expressed by

$$\Delta R/R = \Delta I/I \tag{5b}$$

or, inserting equation 1, this can be reduced to

$$S_{min} = \Delta I/GI \tag{6}$$

where S_{min} is the minimum detectable strain. Hence, current-supply regulation directly determines the resolution of resistor-gage transducer system.

To estimate the required current-supply stabilization, consider an arbitrary resolution standard of 1 x 10^{-6} strain—1 microstrain. For a gage factor of 100, equation 6 yields

$$\Delta I/I = 10^{-4} = 0.01\% \tag{7}$$

as the required supply regulation. Thus, the current supply must not have variations larger than 1 microamp if it supplies 10 milliamps to the gage. This regulation must hold when the strain gage is varying by as much as 10% in either direction.

Voltage detector

Since the voltage-detector circuit must have a high input impedance relative to the nominal resistance—typically in the range of 100 to 1,000 ohms—a simple amplifier stage is sufficient. If a junction-transistor stage is used, an emitter follower or similar circuit would be required to yield a voltage gain near unity.

If a field effect transistor were used, a grounded-source configuration would suffice. The output would be a change in the drain current Δi_D, expressed by

$$\Delta i_D = g_m \Delta E \tag{8}$$

where g_m is the transconductance of the FET.

Basic transistor gage

In general, all transistor gages—junction and field effect—have the same type of output characteristics. Where they differ, however, are in scale factors for the current and voltage axes.

Consider a system that relies on a transistor gage to couple a constant voltage supply to a current detector. The basic figure of merit for the gage is current-strain sensitivity, K, defined as

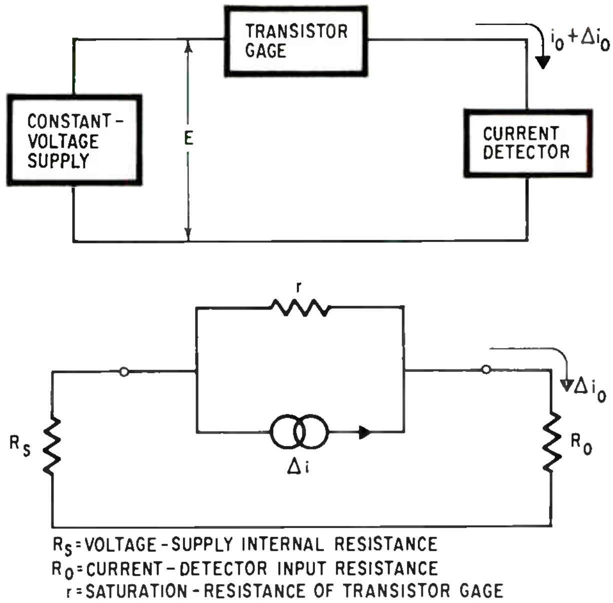
$$K = \Delta i/S \tag{9}$$

where Δi is the change in output current for a constant output voltage, and S is the applied strain. As a first approximation, for an ideal voltage supply and current detector, the change in current, Δi_o, in the detector is equal to the change in gage current, or

$$\Delta i_o = \Delta i = KS \tag{10}$$

indicating that the system uses the device's full current variation.

Unlike the resistor-gage system in which the voltage E is dependent on the supply current I, the transistor system's voltage is independent of the current change. Thus, E doesn't appear in this equation.



Constant voltage. Semiconductor gage, top, is represented by its equivalent circuit in a constant-voltage system. Current change Δi_o, depends on the values or r, R_s and R_o.

Supply and load

To analyze the properties of the constant-voltage transistor-gage system, it is necessary to represent the basic sections by an electrical circuit. In the schematic, it is assumed that the gage is operated around a quiescent point in the current-saturation region.

Assuming that the supply voltage is constant, the current change for the equivalent circuit can be given by

$$\Delta i_o = \Delta i \frac{r}{r + R_s + R_o}. \tag{11}$$

Here, the factor involving $R_s + R_o$ tends to reduce the output current change to a fraction of Δi. This effect is similar to reducing the output voltage in the resistor gage. However, unlike the resistor system, this system has no nonlinear terms due to the loading by $R_s + R_o$. Thus, if R_o's value isn't negligible compared with r, the transistor gage's loading won't degrade the system's linearity. This, of course, differs from the resistor system, which has a nonlinear output under equivalent loading conditions.

The effect of poor voltage regulation can be evaluated from a modified equivalent circuit that includes a ΔE but doesn't include a current generator in parallel with r. Thus the engineer can compute the changes in output current caused by the fluctuations in voltage.

The spurious current change is

$$\Delta i'_o = \frac{\Delta E}{r + R_s + R_o} \tag{12}$$

and the resolution of the system is limited to the detection of strain-induced current variations such

Strain-gage properties

Gage	Required power-supply stability	Output	System sensitivity	State of development	Properties
Semiconductor resistor (piezoresistance effect)	0.01%	Low series impedance, voltage source	350 volts/unit strain 3.5 amps/unit strain	Commercially available	Compatible with conventional metal strain gage circuitry
Thin-film FET (piezoelectric effect)	10%	High parallel impedance, current source	2.2×10^4 volts/unit strain 480 amps/unit strain	Experimental	Compatible with low-input impedance amplifiers and signal conditioners
Silicon npn planar transistor	Unknown	High parallel impedance, current source	4 volts/gram	Commercially available	Same as FET

that $\Delta i_o = \Delta i'_o$. With equations 11 and 12, this becomes

$$\Delta_i \frac{r}{r + r_s + R_o} = \frac{\Delta E}{r + R_s + R_o}$$

$$\Delta i_{min} = \Delta E / r \qquad (13)$$

is the smallest resolvable strain-induced current change.

Using equation 10, this can be expressed as

$$S_{min} = \frac{1}{K}\frac{\Delta E}{r} = \frac{1}{K}\frac{E}{r}\frac{\Delta E}{E} \qquad (14)$$

where S_{min} is the minimum detectable strain. S_{min} is dependent on the supply regulation, the effect of which is modified by the factor, E/r. Such a modification doesn't occur in the resistor-gage circuit.

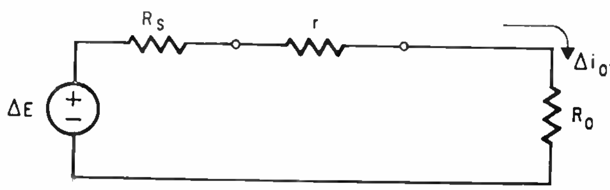
A numerical estimate of the required voltage-supply regulation is easily obtained. With a desired resolution of 1 microstrain, typical values for a thin-film field effect transistor gage are $K = 2.4$ amps/unit strain, $E = 2.5$ volts, and $r = 10^5$ ohms. Inserting these values in equation 14, yields the required regulation

$$\Delta E / E = 10^{-1} = 10\% \qquad (15)$$

Thus the transistor can stand a 10% change in its supply, a far cry from the resistor's 0.01%.

With a transistor gage, an additional factor affects bias source for the third electrode. Any variation here appears as a spurious output. For a field effect gage, this current change, $\Delta i'$, is

$$\Delta i' = g_m \Delta E_g = g_m E_g \frac{\Delta E}{E_g} \qquad (16)$$



Voltage regulation. Transistor-gage circuit is converted into a voltage-source representation for evaluating the effects of poor voltage regulation.

where E_g is the gate-bias voltage, and ΔEg is its fluctuation. The minimum detectable strain-induced current change is $\Delta i = \Delta i'$. With equation 10,

$$S_{min} = \frac{g_m E_g}{K}\frac{\Delta E_g}{E_g} \qquad (17)$$

as the minimum detectable strain.

To obtain an estimate of the required regulation, the engineer selects 1 microstrain as the desired resolution, and assigns 2 volts for gate-bias voltage and 10^4 micromhos for the transconductance. The required gate-bias source regulation, using equation 17 is

$$\frac{\Delta E_g}{E_g} = 10^{-4} = 0.01\% \qquad (18)$$

This requirement is the same as that for a resistor system's current supply. Although the resistor system must have this regulation figure when supplying an appreciable power into a load that can vary by 20% to 30% at frequencies from d-c to 50 kilohertz, the transistor's gate-bias source need only have this regulation when supplying negligible power to a constant, high-impedance load.

With insulated-gate field-effect units that operate at zero gate bias, the bias-stability problem can be avoided. For example, a thin-film transistor gage can be fabricated as a depletion type unit in which zero gate bias would yield a current saturation region at reasonable output levels of current and volttage; the gate can be connected directly to the source. All the engineer need consider is the output voltage supply regulation.

Present research is primarily aimed at improving thin-film properties for amplifying devices. To achieve this, it is necessary to increase the values of r and g_m. Although an increase in r tends to reduce the voltage-supply regulation requirements, an increase in g_m leads to an increase in the required gate-bias source regulation. Since gate-bias sources aren't needed for devices that operate at zero-gate bias, increasing g_m won't affect them. Thus, research along these lines will more than likely lead

Continued on page 116

In this corner, a challenger . . .

Resistive semiconductor strain gages have been on the market for several years, but transistor gages have made an appearance only recently. One piezoelectric transistor, a silicon npn planar device called the Pitran, is made by Stow Laboratories in Stow, Mass.

The Pitran's emitter-base junction is mechanically coupled to a diaphragm located at the top of a TO-46 can, which has a nominal diameter of 0.187 inch. When a pressure or point force is applied to the diaphragm, a large, reversible change is produced—an unamplified linear output of at least 20% of the supply voltage.

The device is operated as a conventional transistor, but a mechanical variable can be introduced to modulate the output. Besides providing a linear output voltage, the transistor amplifies or switches other electrical signals. Moreover, the device can be used as the active element in an oscillator for frequency-modulated or pulse-width-modulated outputs. Typical industrial applications include differential pressure transducers, accelerometers, flow meters, level gages, electronic scales, and high-intensity microphones.

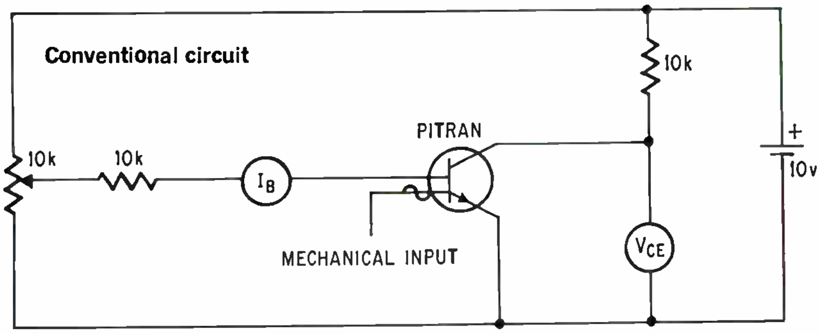
Each Pitran is calibrated for sensitivity, temperature coefficient, and over-range performance.

Bias circuit. A linear d-c output that is proportional to the mechanical input signal stems from the transistor's common-emitter configuration. The Pitran's output voltage ranges up to 20% of the power supply voltage. For factor calibration, a 10-volt power supply and 10-kilohm resistors are used. With a 50-volt supply and 50-kilohm resistors, a 50-volt linear output results.

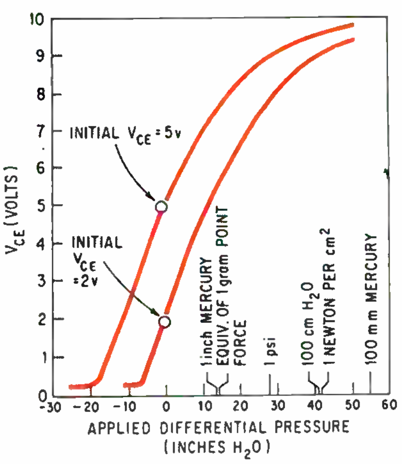
For a-c biasing, a bypassed emitter resistor is added to the d-c circuit; resistor and capacitor values determine the cutoff frequency which is lower than the d-c. This approach is similar to the one commonly used to stabilize a conventional a-c amplifier stage for wide-temperature operation.

Differential amplifier. When two semiconductor gaps are combined, the Pitran circuit becomes a differential amplifier. The output can be nulled with an adjustable resistor, and temperature compensation can be achieved with matched temperature coefficient gages. As a differential amplifier, the linear output voltage can be up to 20% of the sum of supply voltages.

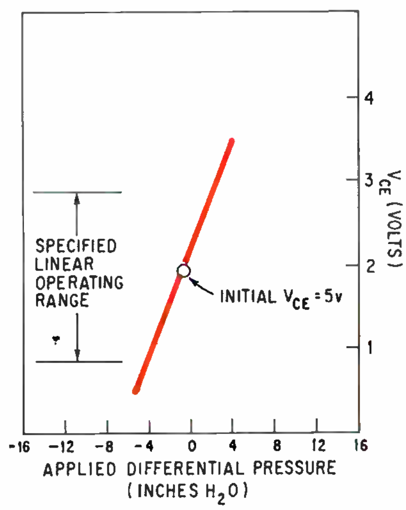
A pwm output is readily achieved with simple multivibrator circuits that operate at almost any given clock frequency and supply voltage. The output pulse width versus input pressure can be made linear over a range of ±10% of the quiescent pulse width. This mode is particularly

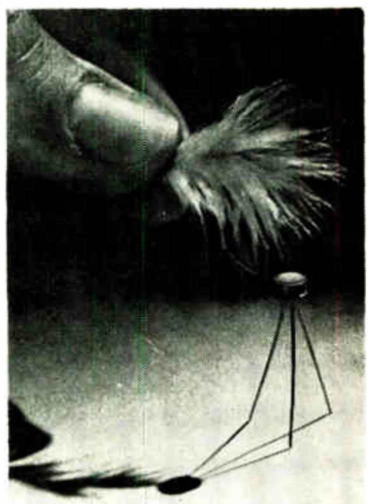


Typical over range performance

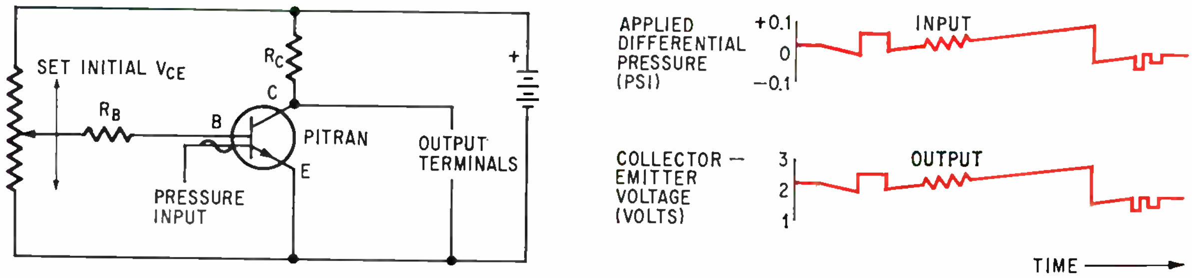


Typical calibration

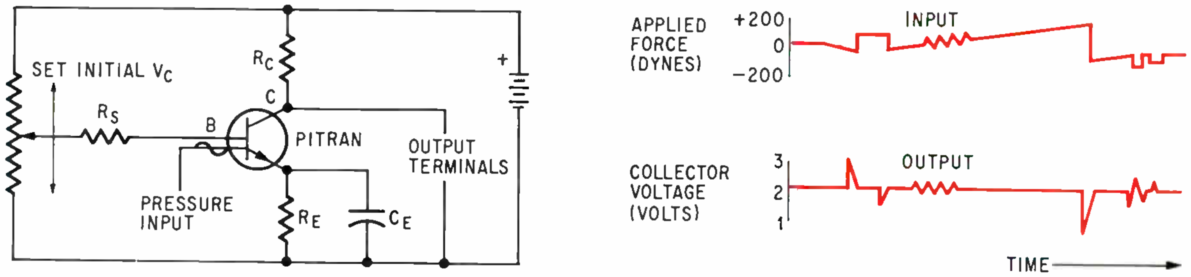




Applying pressure. Transistor-strain gage responds to any pressure, even that of a feather. Equivalent circuit and response curves are typical for this type of device.



D-c bias. Output response follows the input signal exactly for small temperature variation.



Wide temperature. Adding an emitter resistor R_E enables circuit to operate over wide temperature range. Capacitor, C_E, shunts R_E assuring the gain for a-c operation to be the same as for the d-c bias circuit.

attractive for telemetry or input to digital computers because the pwm is easily connected to pulse-code modulation.

Accelerometers. Although Pitrans will directly connect only low-level forces and pressures, they can be modified to effectively connect acceleration, weight, flow, rate, and the like. Some experimental accelerometers were built, including one in which a 0.05-gram seismic mass was bonded with epoxy to the center of the diaphragm of the Pitran and to a second parallel diaphragm that was welded to the top of the case. The entire assembly weighed ½ gram.

Fluidics. Semiconductor gages are also useful in fluidics, whereby fluid-stream interaction is used to create control and logic functions. Recently developed fluidic devices include operational amplifiers and AND gates as small as 0.05-inch square, and logic elements.

One of the more perplexing problems of this new field has been the inability to accurately determine the dynamic characteristics of such logic systems. Logic levels are usually at pressures of a few inches of water, and flow rates are extremely low. Changes in state may occur in less than a millisecond. The conventional low-range pressure transducer isn't capable of distortion-free response to such fast transients. Moreover, the high pneumatic-output impedance of the fluidic circuit combined with the large volume displacement of the diaphragm in a conventional transducer often causes malfunction of the system being monitored.

Semiconductor gages, however are far more appealing for such applications. The Pitran, for example, when used in a simple bias circuit has a 2-volt linear output that's available directly at the transistor terminals. Rise times of 30 microseconds can be followed faithfully, with negligible overshoot and phase distortion.

Unlike conventional transducers, the Stow device has a high resonance frequency and a low displacement that create ideal conditions in the fluidics/electronics interface. In addition, this type of gage permits simultaneous monitoring of several points in large fluidic systems.

Where small pressure switches are necessary, particularly in applications requiring communication with actuators or central data-processing systems, semiconductor gaps are ideal; they have no moving parts or electromechanical contacts.

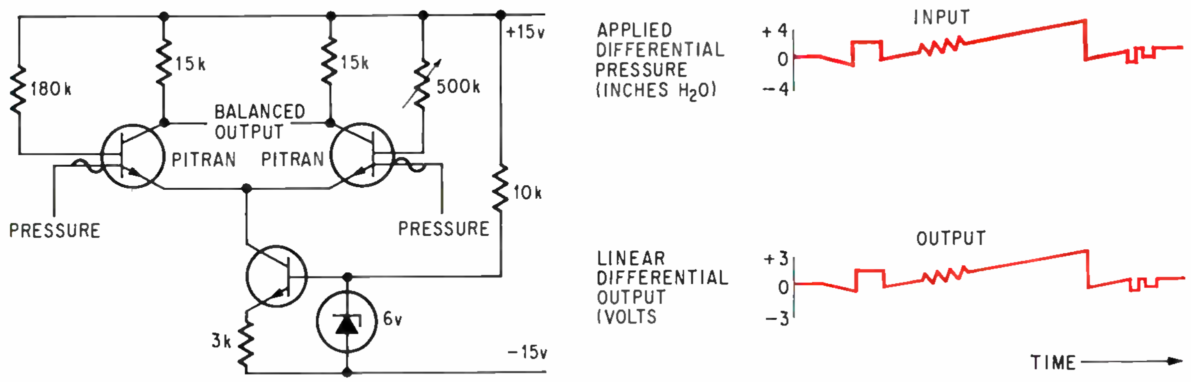
Electronic scales. In force-transmittal-and-balancing systems which require damping to both improve accuracy and prevent overshoot, hydraulic damping has proved too slow. Dynamic braking systems responding to velocity or acceleration are sometimes used, but they tend to be too costly. Semiconductor gages are much more suitable.

Since the transistor diaphragm requires only a few microinches of displacement to yield outputs of 1 volt or more, a rigid and stable weighing platform with a strain-sensing element can be substituted for the commonly used delicate scale-balancing system. The output drives a direct-reading meter or a recorder; oscillations are rapid and damped out so quickly that the weight readout can be nearly instantaneous. A hydraulic force-transmittal system can be used with the gage to achieve the same advantages.

Because of a relatively high thermal zero-shift, the transistor gage isn't suitable for high-precision applications requiring long-term zero stability. Here, the wire strain gage has the edge. But if occasional zero corrections can be made, the transistor gage could replace the wire device.

Microphones. Seismic exploration common in the continuing ticularly attractive because its high, fundamental mechanical-resonance frequency, small size, and low damping factor give it a broad, smooth frequency response—flat (±1 decibel) from d-c to better than 30 kilohertz. Used in an above-ground microphone, the Pitran has a lower amplitude limit of between 75 technique is severely limited by the manometer's inability to respond to rapid fluctuations in pressure, and by its inherent reading inaccuracies.

Although electronic pressure transducers have been used, test engineers found these devices too costly; each channel requires its own amplifier. Thus, water



Differential amplifier. Differences between two applied pressures appears as output. High input impedance results from a constant current source.

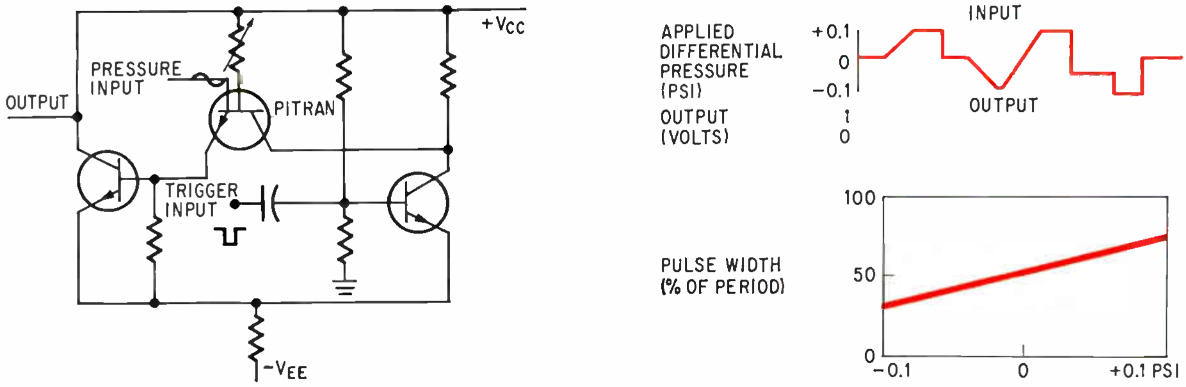
search for oil and mineral deposits, is another likely area for semiconductor gages. Transducers—microphones and accelerometers—are placed at various points around an explosive charge to pick up the blast's sound patterns at various underground layers. From these patterns, experienced geologists can determine what minerals are present and whether an oil formation exists.

For such transducer applications, the transistor gage is particularly attractive and 95 db, and an upper limit between 145 and 165 db. At full scale, the gage produces outputs of at least 1 volt without external amplification—more than enough to drive most recorders.

Wind tunnels. In laboratories that investigate aircraft aerodynamics under both subsonic and supersonic flight conditions, wind tunnels are commonplace.

Low-level bidirectional pressures in the tunnels are recorded with cameras and monitored with water manometers. But this manometers are still used despite their limitations.

Semiconductor gages can effectively fill the bill; the on-line cost per channel is less than a third that of the conventional transducer and its amplifier. The transistor gage's high mechanical-resonance frequency allows accurate measurement of dynamic pressures resulting from turbulent flow, and its 1-volt output—typical for a 4-inch water pressure input—is sufficient to feed many recorders directly.



Pulse-width modulation. A variable pulse-modulated output results for a varying applied differential pressure. Input/output characteristics are linear for applied pressure.

to new depletion-type devices for transducers.

Keyed to impedance

Transistor-gate systems can operate into low-impedance and high-impedance loads. The type of current detectors used depends on the load.

When the system is designed so that both R_s and R_o are negligible compared with r, the maximum available current variation, $\Delta i_o = \Delta i = KS$, is seen by the detector. Since r is typically 10^5 ohms, a simple current-amplifier stage is sufficient to obtain a detector input impedance such that $R_o << r$. Thus, either a grounded-emitter or grounded-base configuration is sufficient for a junction-transistor stage, and a grounded gate for a FET stage.

A grounded-base junction transistor stage, or grounded gate for a FET, results in a current gain near unity, making the stage analogous to an emitter follower for a resistor system. These analogous techniques cannot be compared exactly, because the output variable for the transistor is current, and the output for the resistor is voltage.

If a grounded-emitter stage were used for the transistor system, the output would be a change in collector current of

$$\Delta i_c = \beta \Delta i_o \tag{19}$$

where β is the forward-current ratio of the transistor. Here, the output sensitivity can be compared with that of the resistor system, which uses a FET voltage-detector stage. For this case, it is assumed that the system output is a current source driving a low-impedance load. The FET detector is necessary for the resistor system. Hence, the drain current equals transconductance times voltage change.

However, the ΔE of the resistor circuit depends on the I of the current supply, whereas the Δi_o of the transistor circuit isn't directly dependent on the E of the voltage supply. Thus a quantitative comparison can only be made on the basis of typical values. Theoretical values chosen for the resistor system are: I = 10 ma, R = 350 ohms, G = 100, and $g_m = 10^4$ micromhos $= 10^{-2}$ mhos. Thus equation 8 yields

$$\frac{\Delta i_o}{S} = g_m \frac{\Delta E}{S} = g_m IGR$$

$$= 3.5 \text{ amps/unit strain} \tag{20}$$

as current sensitivity.

For the transistor system, the theoretical values are K = 2.4 amps/unit strain, and $\beta = 200$. Using these values, equation 19 yields

$$\frac{\Delta i_o}{S} = \beta K = 480 \text{ amps/unit strain} \tag{21}$$

as current sensitivity.

Thus the ratio of current-strain sensitivities, in favor of the transistor system, is

$$\frac{\Delta i_o/S}{\Delta i_o/S} = \frac{480}{3.5} = 137.1 \tag{22}$$

But this result is based only on the available signal levels and doesn't include the possible effects of noise levels in the two device types.

To complete the comparison, the engineer must also consider an application in which the system output is a voltage source driving a high-impedance load. For such an application, both the resistor gage and the transistor gage are operated into detector stages consisting of emitter-follower amplifiers. Here, the resistor system is favored.

All that is necessary for evaluating system sensitivity is comparing the signal voltages available at the amplifier inputs.

For the transistor system, this signal voltage is obtained by inserting a resistor in parallel with the emitter-follower input and using the gage's output current to develop the input voltage for the amplifier stage. Assuming that the voltage-supply impedance R_s is negligible, the signal voltage per unit strain can be obtained from equations 9 and 11 as

$$\frac{\Delta E_o}{S} = \frac{rR_o}{r + R_o} K \tag{23}$$

In principle, this signal voltage can be maximized to rK by simply choosing $R_o >> r$. However, there are several limiting factors affecting R_o.

For one, the emitter follower has a finite input impedance; for another, too large a value of R_o would require an excessive supply voltage to drive the required quiescent current through R_o. This is shown with typical values for a quiescent operating point in which i_o = total drain-source current = 0.5ma, and e_o = total drain-source voltage = 2.5 volts.

When a matching load of $R_o = 10^5$ ohms is used, the voltage drop across R_o is 50 volts. Thus, a total supply voltage of 52.5 volts is required. To reduce this, the engineer would select a typical value of R_o = 10 kilohms. This leads to a total supply voltage of 7.5 volts, which would be compatible with the transistor supply voltages usually required for the associated amplifier stage.

With R_o = 10 kilohms, K = 2.4 amps/per unit strain, and $r = 10^5$ ohms, equation 23 yields

$$\Delta E_o/S = 2.2 \times 10^4 \text{ volts/unit strain} \tag{24}$$

Similarly, with I = 10 ma, R = 350 ohms, and G = 100 for the resistor system, equation 2 yields

$$\Delta E/S = IGR = 350 \text{ volts/unit strain} \tag{25}$$

Thus, the voltage sensitivity of the transistor circuit exceeds that of the resistor circuit by almost two orders of magnitude, even though this application inherently discriminates against the transistor gage.

Bibliography

P. Pohl, "Signal conditioning for semiconductors," ISA Journal, Vol. 9, No. 6, June 1962, p. 33.

H. Berstein, "Variable resistivity semiconductor amplifier phonograph pickup," U.S. Patent 3,144,522.

C.R. Higson, "Recent advances in strain gages," Journal of Scientific Instrumentation, Vol. 41, 1964, p. 405.

R.S. Muller and J. Conragen, "Transducer action in a metal-insulator-piezoelectric-semiconductor triode," Applied Physics Letters, Vol. 6, No. 5, March 1, 1965, p. 83

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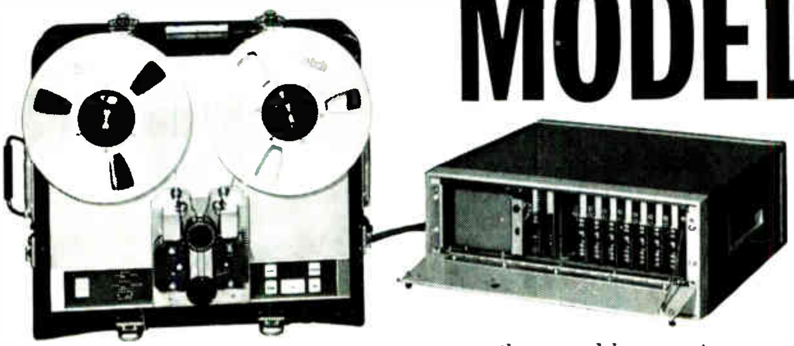

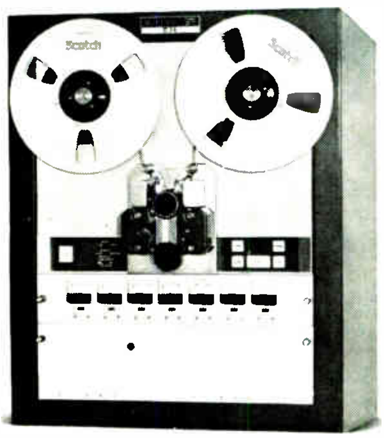

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Adder on a chip: LSI helps reduce cost of small machine

A complete 8-bit arithmetic unit on a single chip of silicon reduces need for random logic and, by subtracting without complementing, can be doubled up for words of any length

By Lee L. Boysel
Fairchild Semiconductor Division, Mountain View, Calif.

Large-scale integration becomes feasible for small, slow computers when applied to the computer's arithmetic unit. Previously the technique has been considered only for large machines with many identical circuits, because the main LSI effort has been aimed at such circuits—memories, registers, and data paths. But now small computers—for applications such as process control, data acquisition, testing, or education, where cost is a vital factor—can take advantage of LSI. Their entree is an eight-bit parallel arithmetic unit, containing 200 metal oxide semiconductor gates interconnected on a single chip of silicon.

Large-scale integration is especially valuable in an arithmetic unit, which is made of several identical parts that operate in parallel. Virtually every computer operation involves the unit, even if only to pass a number from one register to another.

However, to achieve the necessary low cost of a small, slow machine and still realize the benefits of LSI, only 10% or less of the total circuits should be random logic—circuits that perform specific functions, such as sign control, division stop, overflow error, and comparisons. Only one of each of these random logic functions, which contrast with repetitive data-flow logic functions, is required in any computer.

Previous approaches to LSI were effective on only about 25% of the system—the remaining 75% being composed of random logic, which was either unsuitable for LSI or too costly for it. But a large-scale integrated arithmetic unit and a read-only memory can reduce the random logic to well below 10% in a small machine. Working together, they perform almost all the needed functions.

With the arithmetic unit's unusual algorithm for addition and subtraction, much of the need for control by random logic was eliminated. The read-only memory approach to control cuts random logic significantly, because it can be used for combinational and sequential logic, which in turn can be applied to control functions.[1] Thus a slow, fully parallel machine can be built that is, curiously, less expensive than a serial machine, because its proportionate amount of control is substantially less. Traditionally, because parallel machines contain more circuits, they are more expensive—their cost being justified by their higher performance. Serial machines usually sacrifice speed for low cost.

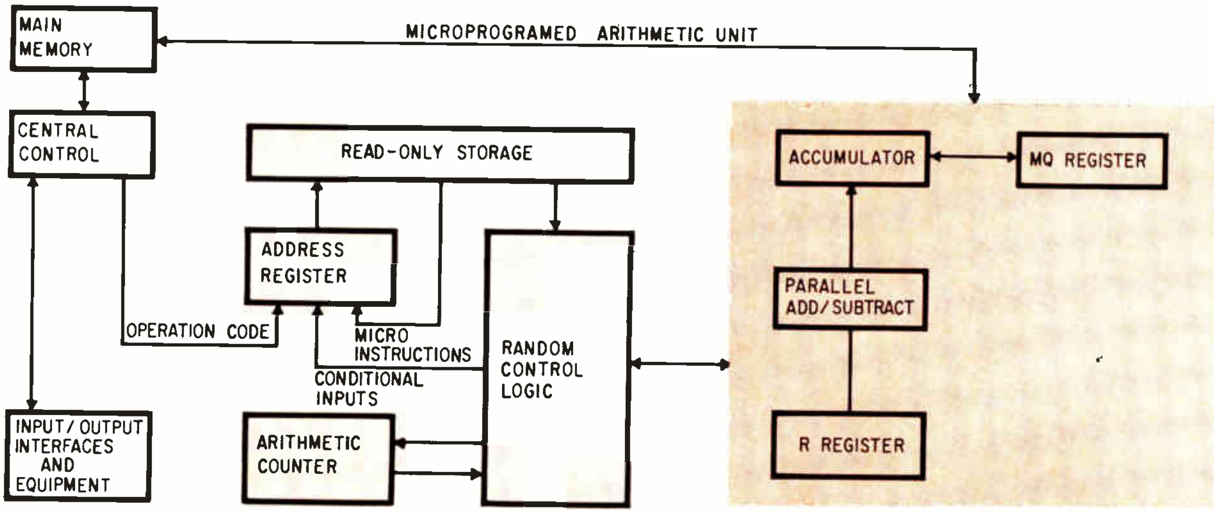
A 16-bit parallel system has been constructed with the new arithmetic unit and a monolithic read-only memory; it has only about 1% random logic.

Ideal repetition

The arithmetic unit of any computer can be designed as a series of identical blocks, each of which performs a complete arithmetic function on a single bit. Several blocks can be fabricated inexpensively on a single chip with LSI techniques. This unit can become a subsystem of a larger system with any of several word lengths.

The author

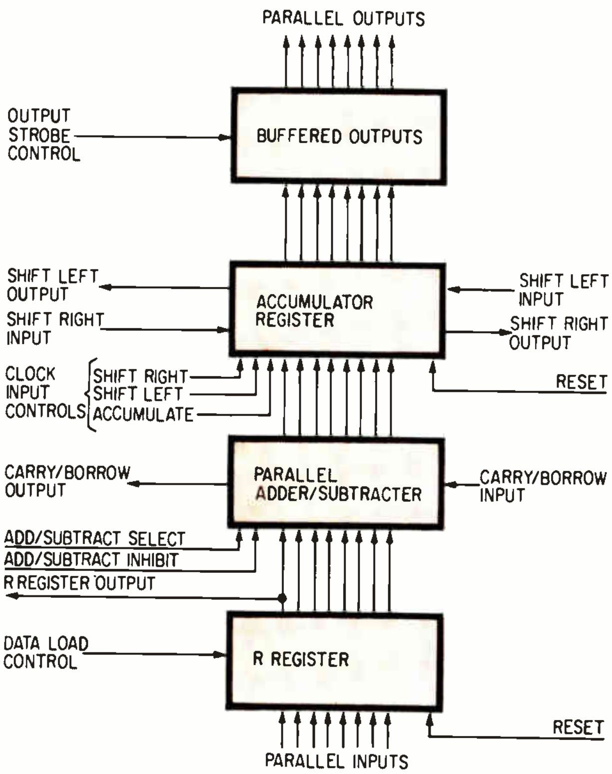
Lee L. Boysel is the supervisor of Fairchild Semiconductor's LSI-MOS subsystem section. This is his second article in Electronics; last year he described Fairchild's monolithic read-only memory.



Typical small computer. Its design requires only a monolithic arithmetic unit (dark tint), monolithic read-only memory (light tint), small amount of random control logic, and conventional input/output and memory hardware.

A computer organization that includes a fully parallel arithmetic unit can be used in either small or large machines. This organization, whose block diagram is shown above, also includes a fixed-program subroutine and conditional input control capability. It has a minimum number of random gates.

Most control functions are executed by large MOS read-only storage, using currently available hardware.[2] The standard operations include addition, subtraction, multiplication, and division, extracting square roots, and doing simple logic manipulations.



Four-in-one. Monolithic arithmetic unit comprises input register, adder-subtracter, accumulator, and output buffer, all for eight bits in parallel, plus connections to outside world or similar adjacent units.

More complex operations include calculating logarithms and trigonometric functions, converting between binary and decimal, doing floating-point arithmetic, and setting up subroutines for solving complex mathematical functions.

In action, the central control unit simultaneously enters an operation code into part of the arithmetic unit's instruction address register and calls required operands from the main memory. This causes the read-only memory to begin a micro-programed sequence—a sequence of microinstructions that control the flow of data into and out of the arithmetic unit, and manipulate it during multiple-step operations such as multiplication and division.

During each cycle, the read-only memory feeds the next microinstruction address back to part of its own address register and supplies a control word to the decoder. The decoder converts these microinstructions into signals that control the sequence.

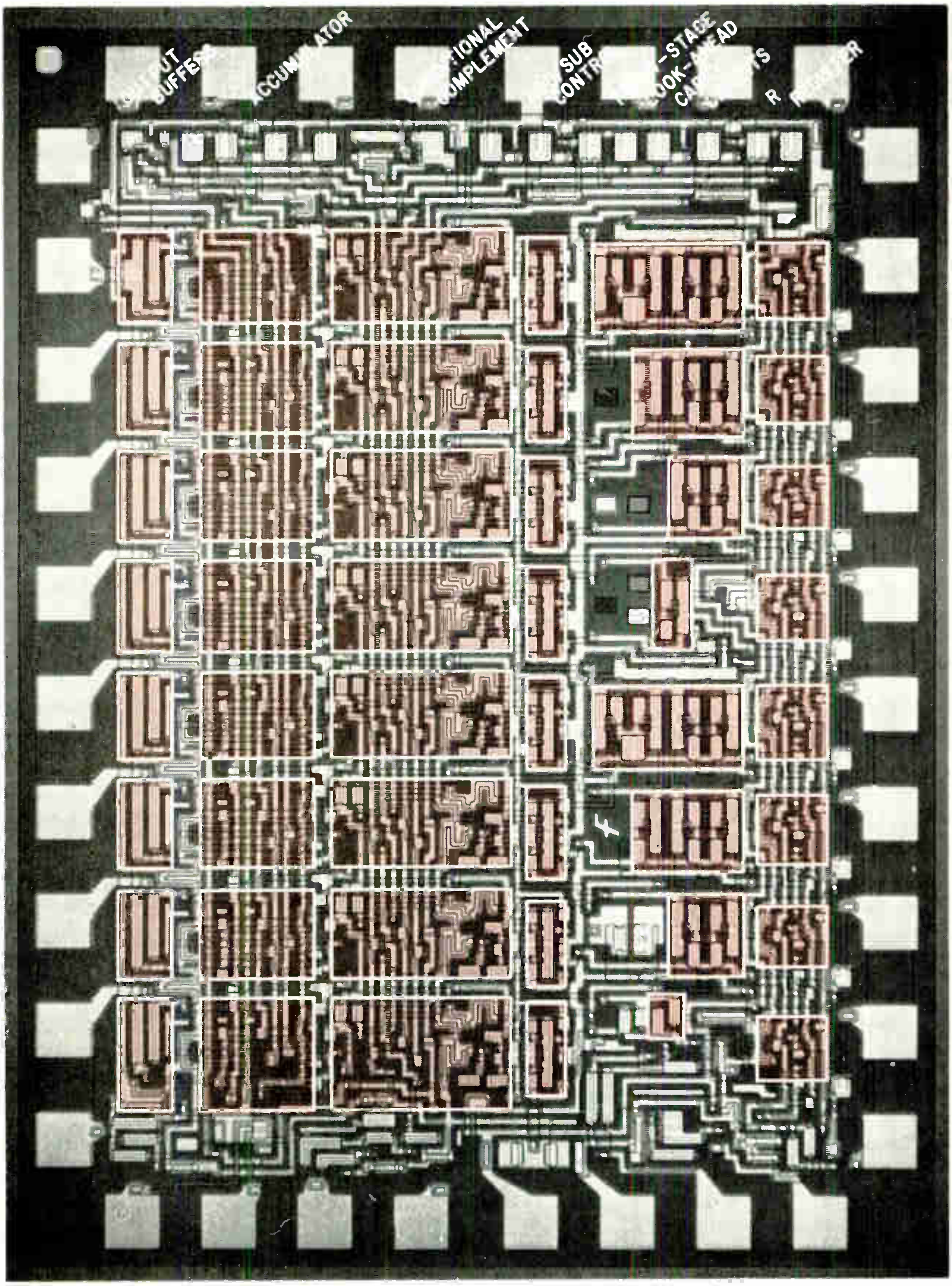
During these sequences, events may occur that require modifications. For this, conditional branch or jump operations may be implemented by including conditional inputs as part of the address register input. Thus, when a data-dependent decision is made—divide stop, for example—the microprogram address is modified by the conditional inputs and the program jumps automatically to another subroutine that takes appropriate action. After that operation is completed, control returns to the central unit and the result is sent to the memory.

While the arithmetic unit is functioning, the central control section is free to operate on the main memory, input-output terminals, or other arithmetic units, thereby effectively increasing machine speed.

Four sliced sections

An eight-bit integrated MOS arithmetic unit, measuring 86 by 116 mils and mounted in a 36-pin dual-in-line package, will be introduced soon by Fairchild Semiconductor under the designation 3800. The unit combines four major sections on one chip: an input register, an adder-subtracter, an ac-

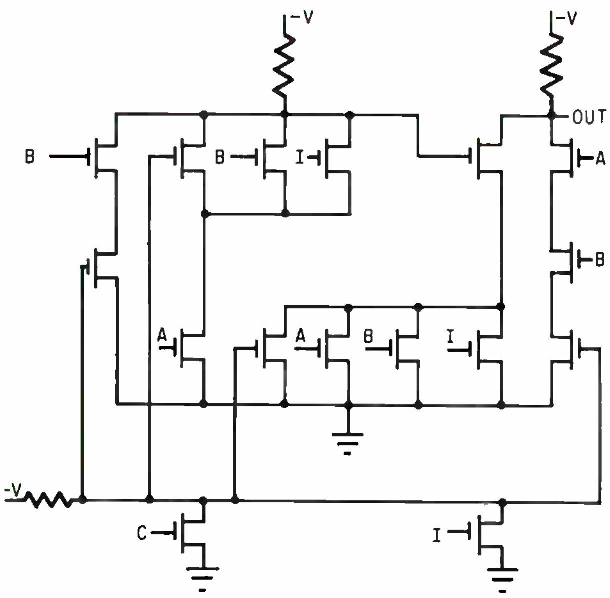
Largest production IC



Tightly packed. This silicon chip is a metal oxide semiconductor arithmetic unit with 200 gates, capable of processing eight bits at once, in an area only 86 by 116 mils. The carry-borrow look-ahead logic consists of two groups of ten circuits, each of which generates a cumulative carry or borrow for four bits at a time. All other circuitry on the chip forms eight identical parallel channels.

Add-subtract truth table

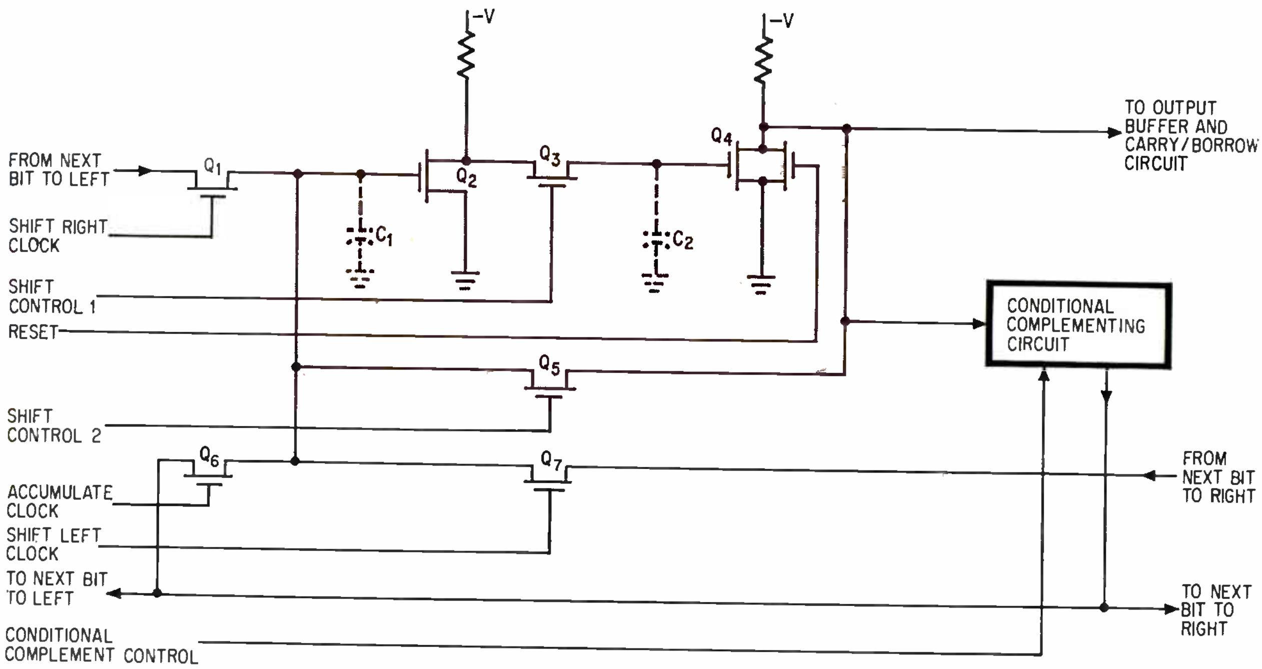
Accumulator	Addend-subtrahend	Input carry or borrow	Output carry	Sum	Output borrow	Difference
0	0	0	0	0	0	0
0	0	1	1	1	1	1
0	0	0	0	1	1	1
0	1	1	1	0	1	0
1	0	0	0	1	0	1
1	0	1	1	0	0	0
1	1	0	1	0	0	0
1	1	1	1	1	1	1



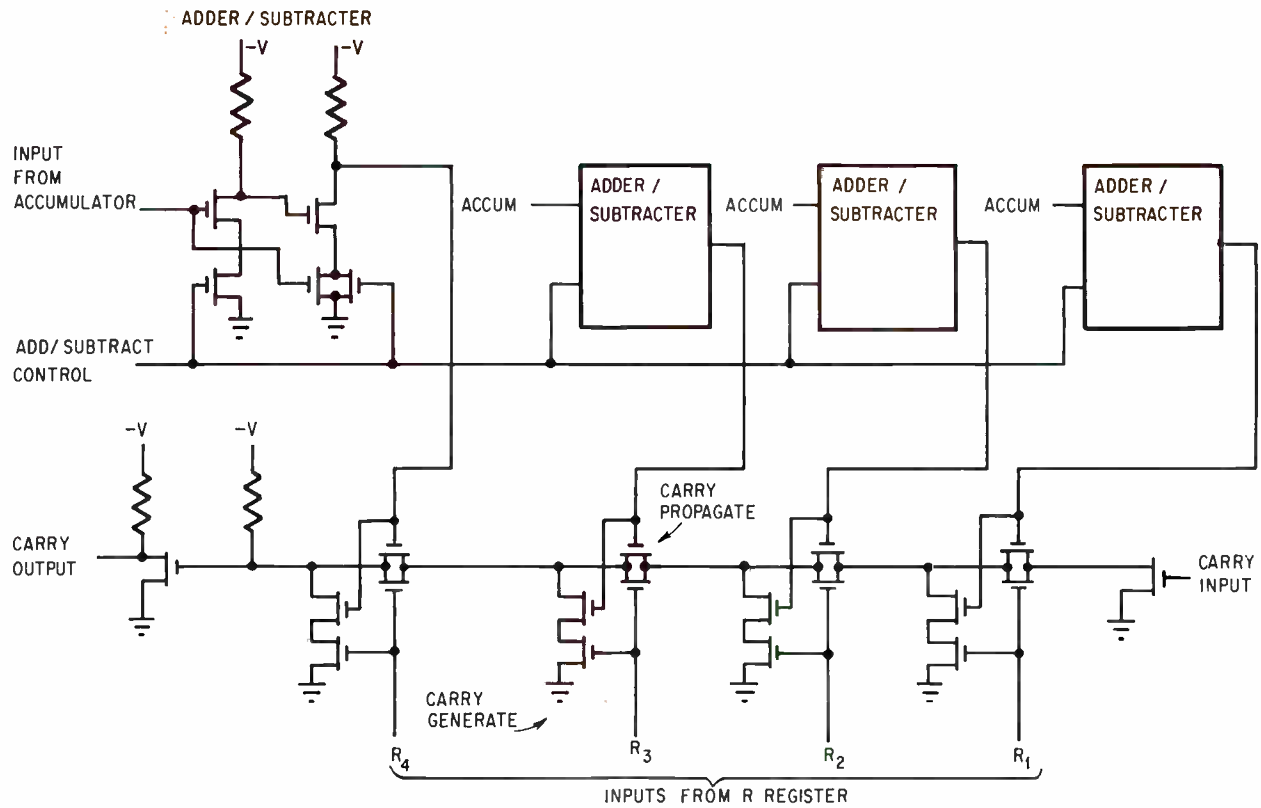
Iffy inverter. Conditional complementing circuit inverts the accumulator output if the input register and the carry bits are different and if the inhibit signal is off.

cumulator register, and an output buffer. All are made from p-channel enhancement-type MOS transistors. The four sections are shown on page 120.

- The R register temporarily stores operands for arithmetical operations. All eight positions may be loaded, bypassed, or reset at once. The leftmost bit is available for sign control.
- The parallel adder performs both addition and subtraction on either positive or negative numbers directly, without complementation. The eight-bit circuit can both accept and generate carries and borrows where more than eight bits must be processed. Look-ahead carry circuits reduce the worst-case time to carry through eight stages to approximately 2 μsec.
- The accumulator register shifts either right or left and accumulates partial sums. This shift-and-add capability much improves multiplication and division times.
- All outputs are push-pull MOS buffers. Each stage has one MOS device connected to the power supply line to pull the output up, and another connected to ground to pull it down.



Shift mechanics. Accmulator bit position contains cross-connected MOS NOR gates, shifting controls, and conditional complementing circuit that controls output for adding or subtracting. Stray capacitance in cross-connected gates retains stored data temporarily during shifting.



Add or subtract. Carry look-ahead circuit generates a carry at any bit position if both the accumulator and the input register contain a 1, and propagates an input carry if either is 1. Borrows are similarly treated during subtraction, when the accumulator bit is inverted.

Difference in subtracting

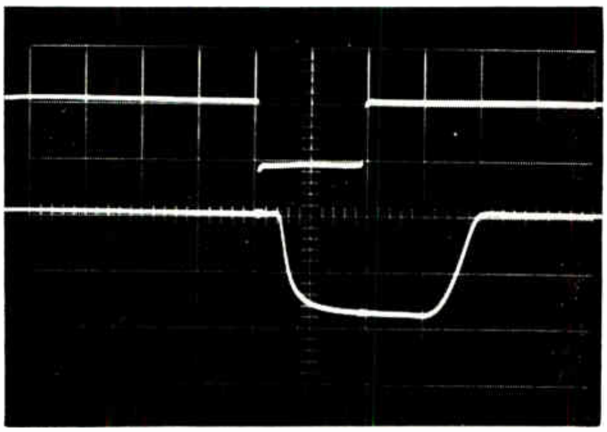
An eight-bit design was chosen for the arithmetic unit because it was easily manufactured and because it was a submultiple of frequently used word lengths such as 8, 16 or 24 bits. However, this standard block must also be usable in machines with lengths such as 12, 15, 18 or 20 bits. So the conventional subtraction algorithm was not suitable.

Ordinarily, arithmetic units subtract by a process called complement-add. First, the subtrahend—the number to be subtracted—is complemented, which involves inverting all 0 bits by 1 bits and vice versa, and adding the number 1 to the inverted number. The complemented subtrahend is added to the minuend—the number from which the subtrahend was to be subtracted. That gives the difference, except when another 1 may have to be added to the result, depending on whether an overflow carry from the left-hand end of the complement-add has occurred. This extra operation—called end-around-carry—is impossible in a standard accumulator used in systems of different word lengths, because either end of the accumulator may or may not be at the corresponding end of the system.

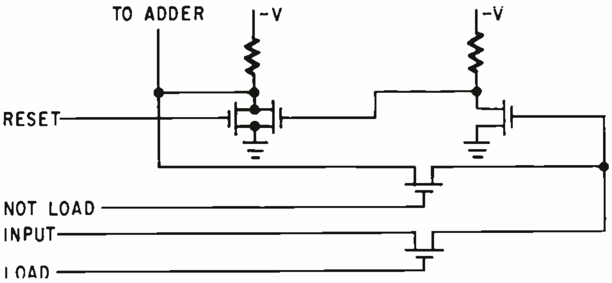
So direct subtraction circuits were included in the 3800, eliminating complementing and end-around-carry, and making the circuit a truly variable-word-length device. This additional circuitry, combined with look-ahead carry circuits to increase operating speed, made the logic techniques used with conventional bipolar circuits inapplicable to the MOS circuit. An unusual method of adding, subtracting and shifting was therefore chosen to fit the MOS technology, making possible a substantial reduction in the number of needed devices.

Logically similar

The same logic can generate either the sum or difference in the adder-subtracter without modifica-



Brief delay. Propagation delay for worst-case conditions is only about two microseconds, when both the accumulator and the input register contain zeros and a borrow signal is applied to the right-hand bit. The upper trace is the borrow input, and the lower trace is the output borrow at the left-hand bit. Scales are 10 v/div. vertically and 1 μsec/div. horizontally.



Pieces of eight. Input register position contains a pair of cross-connected transistors, loading controls, and provision for reset. The arithmetic unit contains eight of these circuits.

tion. An output to the next bit to the left—carry or borrow—can be generated by the same logic modified only by inverting the accumulator input during a subtraction.

The accumulator always contains one of the two numbers involved. An addend or subtrahend in the R register is combined with the contents of the accumulator. The sum or difference then modifies the previous contents bit by bit.

When adding, the conditional complementing circuit complements a particular bit of the accumulator if either the corresponding bit of the addend or the carry from the next bit to the right is 1, but not if both are 1. The same is true in subtraction, except that the carry signal is called a borrow. This is shown in the truth table, top of page 122, where the bits in the columns headed Sum and Difference are the same.

The table also shows that a carry to the next stage is generated if both the accumulator and the addend have a 1 in a particular bit position; and an input carry is not propagated beyond that position if both bits are 0. Otherwise, the output carry equals the input carry. On the other hand, a borrow is generated at any position if the accumulator bit is 0 and the subtrahend is 1, and an incoming borrow is killed if the accumulator is 1 and the subtrahend is 0. Otherwise, the output borrow equals the incoming borrow.

Circuit design

The accumulator register is a standard one whose contents can be shifted left or right. In either shifting mode, a particular bit can be complemented while being shifted. Any bit can also be complemented and restored to its original position, without disturbing the bit on either side.

In its static or d-c state, each bit of the accumulator—diagram, bottom of page 122—is represented by transistors Q_2 and Q_4, connected as a pair of NOR gates. The logic transistors are coupled through shift-control transistors, both of which are turned on by negative levels on their gates, forming a flip-flop under d-c conditions. The three clock-input transistors are turned off in the stable condition.

When a shift left is to occur, first the shift-control transistors are turned off and the state of the flip-flop retained temporarily by the charge on the stray capacitance of one side of the flip-flop. Secondly, a shift-left signal connects the next stage on the right to the stray capacitance on the other side of the flip-flop. Next, the shift-left signal is turned off and the shift-control transistors are turned on again, transferring the stored charges into the flip-flop. The previous output of the next stage to the right now appears on the output stage, having been inverted twice. Shift-right operations are similar.

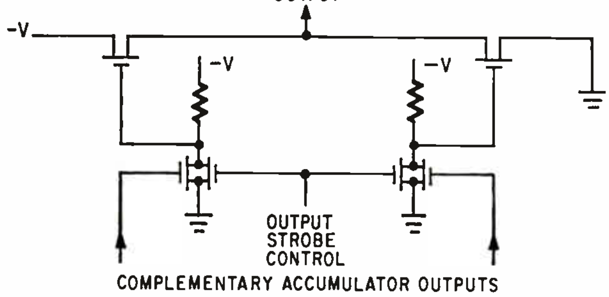
Connections to the output buffer are from the drain and gate of one side of the flip-flop. This maintains the old output value at the buffer while a new bit is shifting in. The alternative—connections from the drains of both sides—would render the output uncertain during the shift.

The unusual feature of this register is its conditional complementing circuit for each bit output. It is a function of the second operand and the input carry to each stage. The complete conditional toggle circuit, including an inhibit "I" for conventional shifting operations, is shown on page 122, center.

A four-bit binary look-ahead carry circuit, as on page 123, top, minimizes the time for addition carries to propagate through a parallel arithmetic unit, but adds little circuitry. Each of the four stages generates a carry if both the corresponding accumulator and R register bits are 1, and propagates an input carry if either bit is 1. The total carry propagation delay through the carry circuits of an eight-bit accumulator slice is about two microseconds, as in the oscilloscope photos on page 123.

A complementing circuit functionally identical to the one described, but controlled by the bit line and the add-subtract control line, appears in one of the four positions of the carry look-ahead diagrams.

The remaining circuits are straightforward. A single-input flip-flop is used in the R register as shown above; the output buffer has a simple push-pull drive, as shown at left. The strobe control for the output admits data to a common parallel bus system without adding gating or propagation delays.

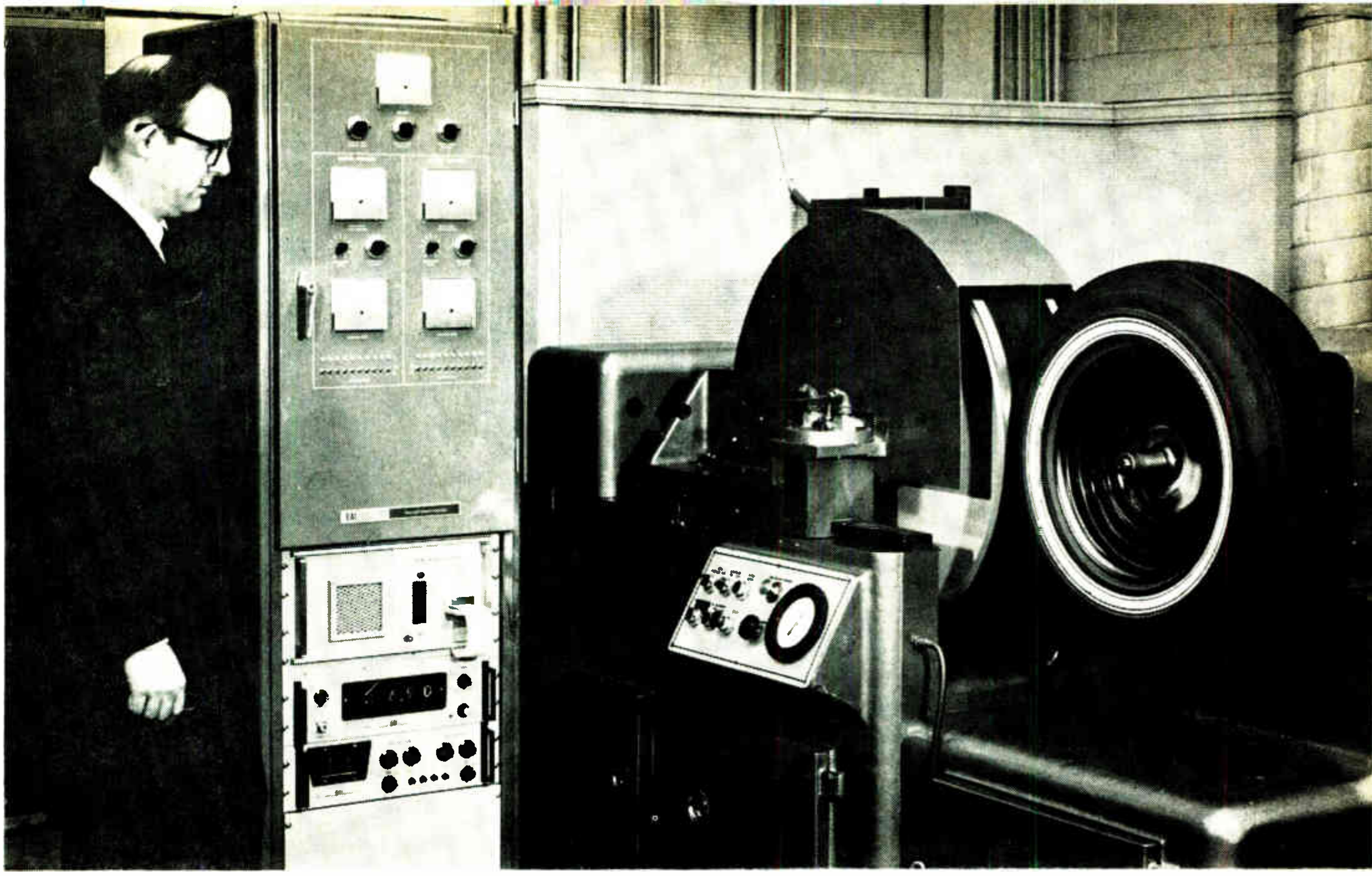


Plus and minus. Output buffer connects both positive- and negative-going signals to proper references, and has a strobe input to disconnect both levels.

References

1. John L. Nichols, "Construction of complex sequential circuits with read-only memories," Electronics, June 12, 1967, p. 111.

2. Lee L. Boysel, "Memory on a chip: a step toward large-scale integration," Electronics, Feb. 6, 1967, p. 92.



Industrial electronics

Sorting out the tires

Nonuniformities that can cause a car to shake on a smooth road are detected by analog computer systems in the production plants; besides grading the tires, newer systems may even correct imbalances

By James T. Maguire and Allen J. Schnabolk
Electronic Associates Inc., West Long Branch, N.J.

Back in the days of bumpy roads, an automobile tire's eccentricities—caused by hard and soft spots in the rubber—didn't matter much; but on today's smooth, high-speed highways, the tire can be the key factor to a smooth ride. To deliver that smooth ride on the first trip down the highway, the auto and tire industries are applying analog computation to the study of tire uniformity.

Development engineers at major car companies were the first to use special-purpose laboratory-type computers to study the effects of tire uniformity on different kinds of cars traveling at different speeds on different road surfaces, and to determine load-force variations and tire harmonics. Tolerances established on the basis of this data were then translated into specifications and passed along to the tire makers.

Over the past two years, the major U.S. tire firms have installed over 100 tire testers in their factories to inspect and grade their products; about

60 of these employ computers from Electronic Associates Inc. [Electronics, Feb. 19, p. 50.] These computers are essentially the same as those used in auto makers' labs [the photo on page 125 shows the one at the Buick Motor division of the General Motors Corp.], but are beefed up to withstand plant environments and include some additional automatic features.

Some of the newer systems not only detect nonuniformities, but calculate and mark the locations of the high-force points on tires. Under development are servocontrols that will grind these spots to achieve a dynamic balance in the tire.

Shakeout

The kind of ride a tire can provide depends on the peak-to-peak variations in radial and lateral forces. The radial force variation is particularly important; when it's wide, the axle is displaced up and down each time the tire revolves and the tire behaves as if it were slightly off center.

Because it's most noticeable on smooth roads at higher speeds, this phenomenon is called smooth-road shake. The radial eccentricity creates a vibration similar to that caused by an unbalanced tire and wheel assembly, and this vibration sets up a resonance with the car's suspension system at speeds of about 55 to 65 miles an hour.

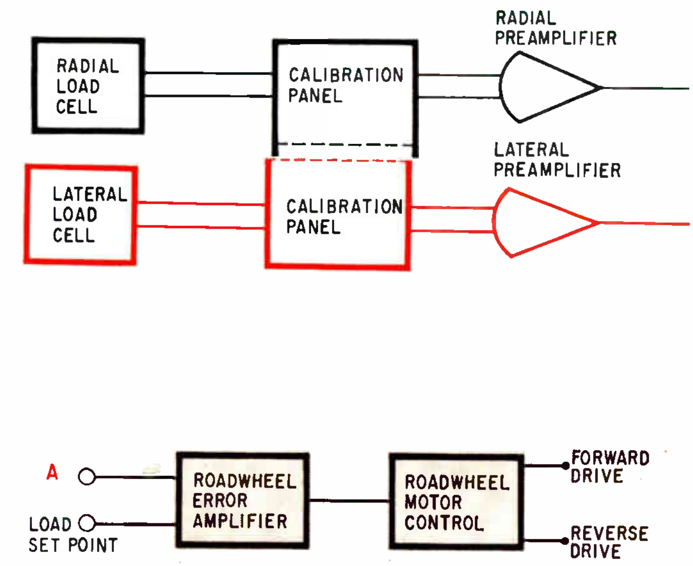
As a tire rotates at a constant speed, the force variations can be represented by a complex periodic waveform; smooth-road shake is responsive to the waveform's first harmonic, or fundamental. The first harmonic, in turn, is sensitive to tire inflation pressure and to tire load. In lab tests with tires under 1,000-pound loads—one quarter the approximate total weight of a car with passengers—it was found that a pressure boost of 1 pound per square inch causes an increase of about 1 pound in first harmonic, while an increase in load force to 1,100 pounds decreases the first harmonic by about half a pound. The peak-to-peak variation caused by the first harmonic ranges from 3 to 60 pounds about the normal value.

Treadmill

In the inspection system, the tire is first centered, secured, and automatically inflated. A rotating roadwheel is then positioned to put a load of up to 2,000 pounds on the tire, flexing it. After several revolutions, the load is reduced to the standard test level of 1,000 pounds.

The fully automatic instrumentation and computer system sequences the testing cycle, makes decisions, and then comes up with an evaluation of the tire.

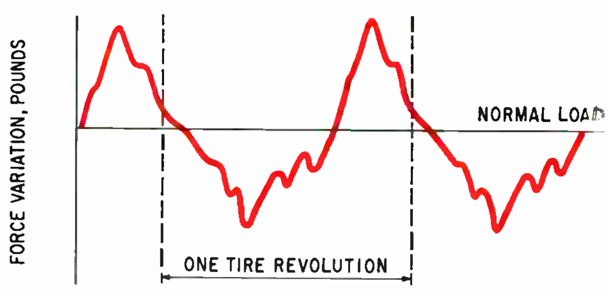
Radial and lateral forces are sensed at the end of the roadwheel shaft by a pair of load cells, each of which detects the forces applied in the two perpendicular directions. Electrically, the load cells form two conventional 350-ohm strain-gage bridges that operate on a supply of 15 volts d-c and produce a full-scale output of 2 millivolts per volt. Thus, with a 1,000-pound load, the load-cell pair produces a total output of 30 millivolts d-c, which is boosted by an amplifier in the computer to 10 volts.



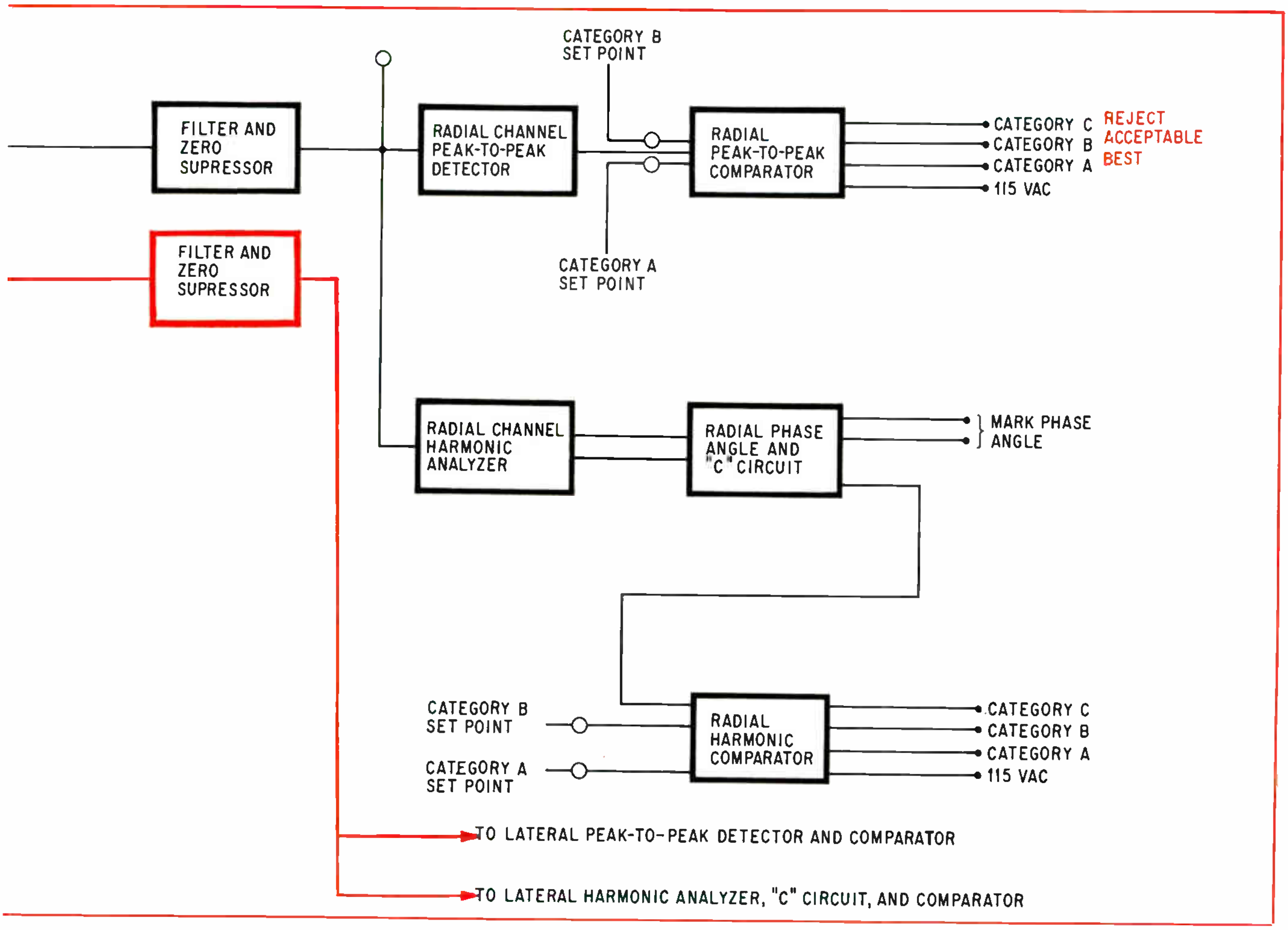
Making the grade. Computer programs the test, monitors the test cycle, and then classifies tires on the basis of the determined peak-to-peak and harmonic force. Outputs trigger logic to mark grades and location of high-force spots on acceptable tires.

The system's analog computer has separate channels for radial and lateral force signals. Both operate in substantially the same way except that the high-spot phase angle is computed only for the radial direction.

To increase over-all sensitivity, a differential amplifier algebraically subtracts (or zero-suppresses) the tire-load set point from the instantaneous sum of the tire load and force variations during one revolution of the tire. The resulting



Complex waveform. Hard and soft spots in the rubber and other materials of the tire cause variations in the load force as the tire rotates.



net force variation then goes into a peak-detector circuit, one portion of which senses and stores the maximum positive peak and another the maximum negative peak. These two values are then algebraically summed in another differential amplifier, one whose positive output voltage is the value of the peak-to-peak force variation.

Report card

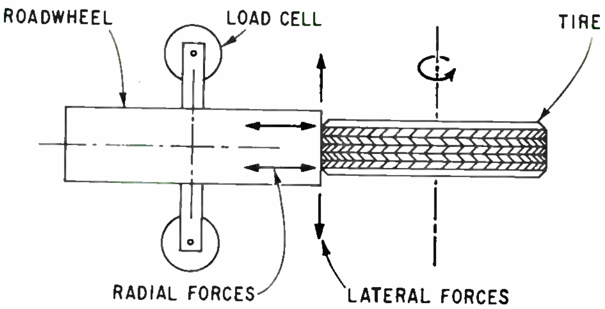
Two differential amplifiers with adjustable set points act as comparators to separate peak-to-peak force-variation levels into three categories—two "accept" (A and B) and one "reject" (C). One amplifier has an input from a set-point potentiometer adjusted to category A and another input for the peak-to-peak signal. As long as this signal does not exceed the set-point value, the tire is classed in category A.

The other differential amplifier's set point is adjusted to the category B value. Peak-to-peak signals that exceed this level are given C's.

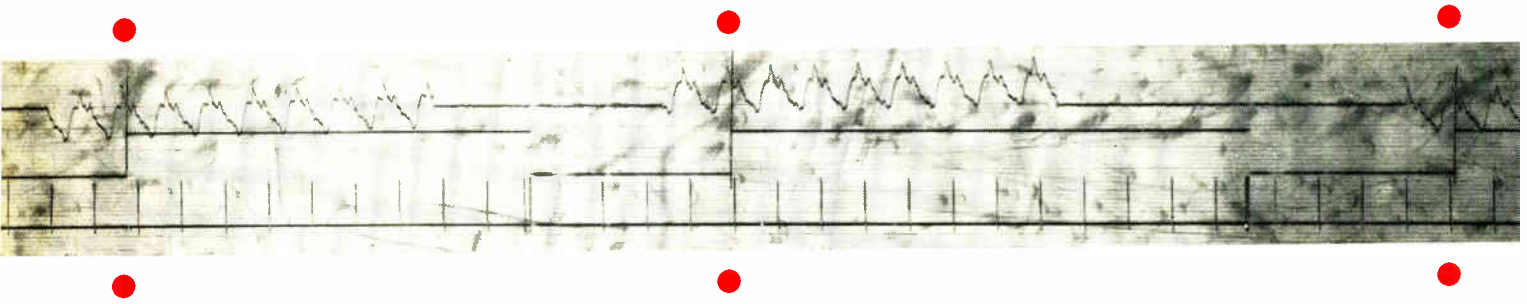
Outputs from the comparator amplifiers latch up relays whose contacts go to a logic circuit. This circuit evaluates the test results in both lateral and radial classifications to determine tire grade. If accepted, the tire is then marked with its proper grade.

An unusual harmonic analyzer is the most recent addition to the Electronics Associates computer. The fundamental is computed in both lateral and radial directions, and the output from the radial channel is used to locate and mark on the tire the high spot causing the peak value of the harmonic's amplitude.

As the tire rotates at a constant speed—generally one revolution per second—it produces the complex periodic waveform f(t). The harmonic-analysis circuits compute the amplitude of the waveform's fundamental, and the rotation angle, or phase angle, between the start of the harmonic-measure-



Road simulator. Load cells connected to roadwheel measure radial and lateral force variations.



Independent. Harmonic analysis circuit yields consistent results. When a single tire is examined three times in three different orientations in the testing machine, the record shows that the color dots indicating a high-force spot occur at the same point, or angle, on the complex waveform. These high-spot signals operate the tire-testing machine's marking device.

ment test cycle and the detection of maximum amplitude.

Hitting the high spots

The complex waveform is represented by the well-known Fourier expansion:

$$f(t) = \frac{A_0}{2} + \sum_{n=1}^{n=\infty} C_n \cos(n\omega t + \phi_n)$$

where

$$C_n = \sqrt{A_n^2 + B_n^2}$$

$$\phi_n = \arctan\left(-\frac{B_n}{A_n}\right)$$

$$A_n = \frac{1}{\pi}\int_0^{2\pi} f(t)\cos n\omega t\, dt$$

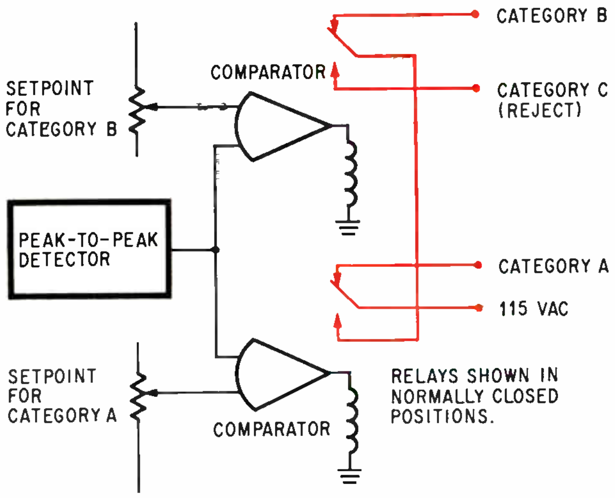
$$B_n = \frac{1}{\pi}\int_0^{2\pi} f(t)\sin n\omega t\, dt$$

t = time measured from a reference point

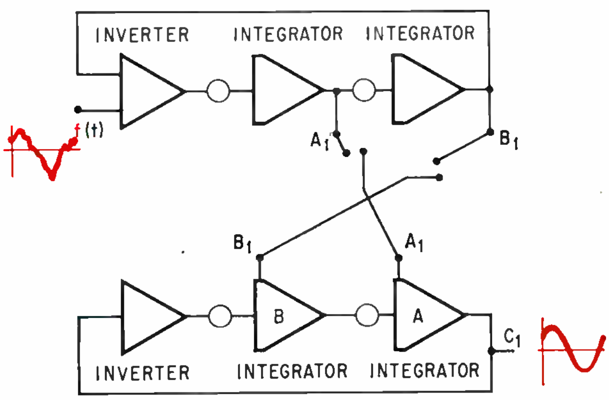
The first harmonic is determined by C_1 and ϕ_1, whose values are found by computing coefficients A_1 and B_1 at the same time the radial peak-to-peak measurements are made during the first revolution of the tire. To get A_1 and B_1, the force-variation signal is introduced into a closed-loop sine-wave oscillator made up of an inverter and two integrators. The oscillator's frequency is pretuned to equal that of the tire rotation. One integrator yields A_1 and the other B_1 after a single revolution.

These signals serve as initial conditions for integrators in another sine-wave oscillator, one whose loop is closed by a signal at the start of a second revolution. The amplitude of this second oscillator, which also operates at the frequency of tire rotation, is C_1.

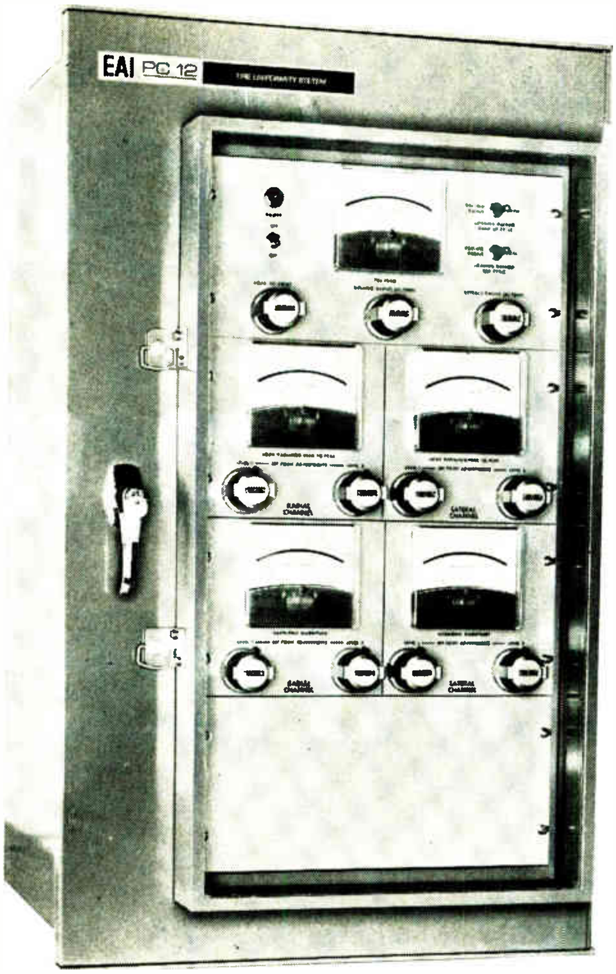
The output of integrator A is exactly in phase with the fundamental component of the complex force variation waveform, and the output of integrator B is 90° out of phase. As one output reaches its maximum value, therefore, the other is crossing zero, a crossing that can be sensed electronically. The time at which one output reaches its peak and the other crosses zero corresponds to the phase angle. At that instant of coincidence, a relay



Flunking out. Amplitude of peak-to-peak force variation is compared with set points. When the signal exceeds category B level, both relays are energized and the tire is rejected.



Smoothing the wave. Complex waveform enters the upper closed-loop oscillator, which cleans up the signal to compute first harmonic's sine and cosine amplitudes. These values become the constant initial conditions for integrators in lower oscillator, whose amplitude and phase angle equal those of the first harmonic.



Dial-a-test. After operator sets up test conditions and accept-reject values, analog computer takes over.

operates the angle-marking circuit to indicate the high spot on the tire.

The computer calculates fundamental peak-to-peak force variations to within 1 pound in both the radial and lateral channels, and locates the high spot of the radial fundamental component to within 3°. The record of three test runs, facing page, on the same tire shows the ability of the radial harmonic circuit to repeatedly find the high spot, and also indicates that the force-variation waveform is the same no matter how the tire is oriented in the testing machine.

When a tire's high-force spot is matched to a wheel's low spot, each maximum variation acts in an opposite direction. The net reduction of peak-to-peak fundamental force is impressive. For example, one group of unmatched assemblies had a first harmonic radial force variation ranging from 18 pounds to 59 pounds, with 86% above 25 pounds and 72% above 35 pounds. But in matched assemblies, one group showed a range of 6 pounds to 24 pounds, with 80% below 18 pounds.

Close shave

In a more direct approach now being developed, high-force spots on category B tires are ground by servopositioned wheels during the test cycle to reduce the force variation to an acceptable value.

The peak-to-peak force variations are measured around the tire, and equivalent voltages are sent to one input of a comparator. The other input is a set point, say 20 pounds. When a peak-to-peak force exceeds the set point, the comparator output latches up a relay that energizes the grinder control circuit, which also consists of a comparator. This second comparator is set at a desired peak-to-peak level, say 10 pounds. The set point of the first comparator is then adjusted to this same value to keep the circuit active.

The force variation signal, f(t), which might range from +15 to −15 pounds, is locked to a peak so that its range runs from 0 to 30 pounds. This signal then goes to the other input of the second comparator.

As long as the force-variation signal exceeds 10 pounds, the second comparator produces a signal to a high-power servo loop that forces grinding wheels against the tire. For mechanical reasons, the grinding wheels are 150° away from the measurement location. The grinding pulse is thus delayed by an amount of time equivalent to 150° of rotation before it activates the servocontrol loop.

Tests show that this grinding can reduce a 50-pound peak-to-peak force variation to 10 pounds in about 20 tire rotations, or about 20 seconds.

The production-type tire uniformity computer is built of standard analog modules. However, some special circuits had to be designed to make the instrumentation and computer system work reliably in the plant environment. For example, tests indicated the tire-testing machine set up mechanical resonances that appeared as noise on the load cells' outputs. This noise had a range of frequencies that could interfere with the measurement signals. A special filter was installed to attenuate the noise. The filter has a 16-hertz bandwidth and a 60-db-per-decade rolloff characteristic. The bandwidth is 16 times that of the tire rotational speed.

The authors

James T. Maguire started working on tire uniformity projects in 1965, as an original member of the team. He holds a master's degree in electrical engineering from Newark College of Engineering.

Allan J. Schnabolk came to EAI in 1959, working as a student engineer while attending Drexel Institute of Technology on the co-op plan. He, too, has been developing tire uniformity computers since 1965.

Economation: AMP's taper pin interface wiring technique

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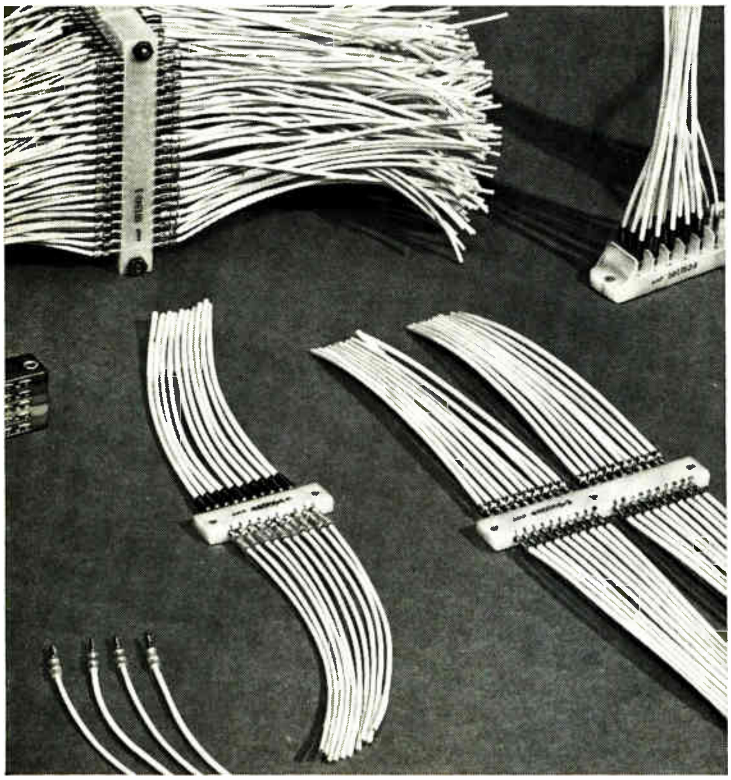

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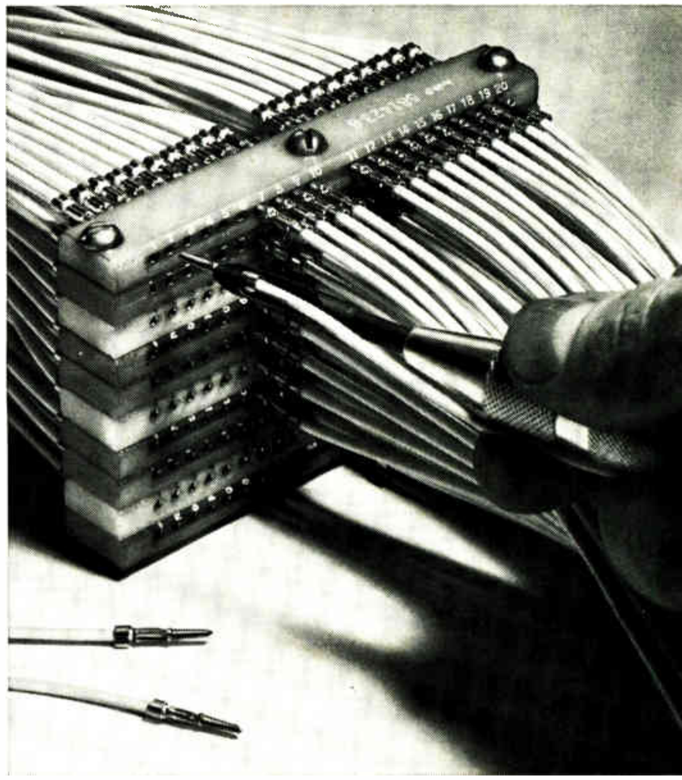

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Circle 131 on reader service card

Opinion

Cameras that wink can produce 3-D tv

If two monochrome cameras spaced like human eyes were to alternately scan a scene, and if their outputs were processed as red and blue signals, viewers wearing filter specs would get that illusion of depth

By M. G. Maxwell

Kriesler Australasia Pty. Ltd. New South Wales, Australia

Three-dimensional television has been the goal of a considerable amount of research during recent years. Many proposals have been advanced, but all have proven impractical.

An object must be viewed from two different angles to appear three-dimensional. There must therefore be two separate channels of communication—one for each eye—between the televised scene and the viewer. The greater the isolation between the communication paths to the eyes, the more pronounced will be the illusion of depth. Perhaps the best way to achieve this isolation is to put the left and right channels' information into a time-sequential form that can be transmitted by a single medium.

Such isolation can be provided by combining the technologies of monochrome picture transmission and color-television reception. Slightly modified monochrome cameras can generate separate left and right video signals for viewing on an unmodified standard color receiver.

The scheme would be relatively simple to implement. On the receiving end, viewers would have to wear colored spectacles, but with the exception of camera optics, existing video equipment on the transmitting end could be easily modified by tv station personnel.

Besides the obvious entertainment potential of 3-D television, important applications could also be found in such areas as air traffic control and vector electrocardiography.

Seeing red

Two monochrome cameras can be placed a few inches apart from each other to achieve the angular displacement of an image in a televised scene. The output of one camera, say the right, is modulated only during even fields while the other's output is modulated during odd fields. In this way, the left and right views of the televised scene are transmitted and viewed on alternate scans.

To achieve the illusion of 3-D, though, some arrangement must be made so that the viewer's right eye sees only the even fields and the left sees only the odds, or vice versa. Color television offers a practical and simple solution here. For when the red dots of the picture tube are viewed through a red filter of the same hue saturation, they will appear almost white; similarly, the blue dots appear almost white when observed through a blue filter. On the other hand, if the red dots are viewed through a blue filter, or vice versa, the dots will appear almost black.

Now if the blue and green guns of a standard color tv receiver are turned off momentarily while the red gun stays on to scan a beam across the cathode ray tube, the trace will appear essentially white if it is observed through a red lens or will be hardly visible if observed through a blue lens. If the red and blue guns are set up to scan alternate

The author

Before joining Kriesler, where he is now an instrumentation engineer, Maxwell G. Maxwell was a studio equipment engineer with the Television Corp. of New South Wales. He also worked at the British Broadcasting Corp. in London for 11 years, and is the holder of six Australian and foreign patents.

fields, and the picture tube is observed through a pair of spectacles with red and blue filters for lenses, one eye will see a blue field and the other a red.

With a vertical frequency of 60 scans per second, the eye will see a raster at a rate of 30 scans per second. Each eye, then, sees a picture every 1/30th of a second—not an intolerable flicker since the scene is being viewed with both eyes, and one compensates for the other. For the viewer, the alternating scenes will appear as one continuous picture with all gaps filled in.

The two monochrome tv cameras would take inputs from points spaced 2½ inches apart to represent the normal spacing of the human eyes. The video output of the left camera would be fed to the color matrix that normally receives a color input signal representing red objects in the televised scene. In this instance, the red input is being fed a black-and-white signal. Once out of the matrix, though, the signal can be regarded as containing color information from a red object, and this deception can be carried all the way through to the grid of the red gun. Similarly, the right camera video output is processed to activate the blue gun of the picture tube.

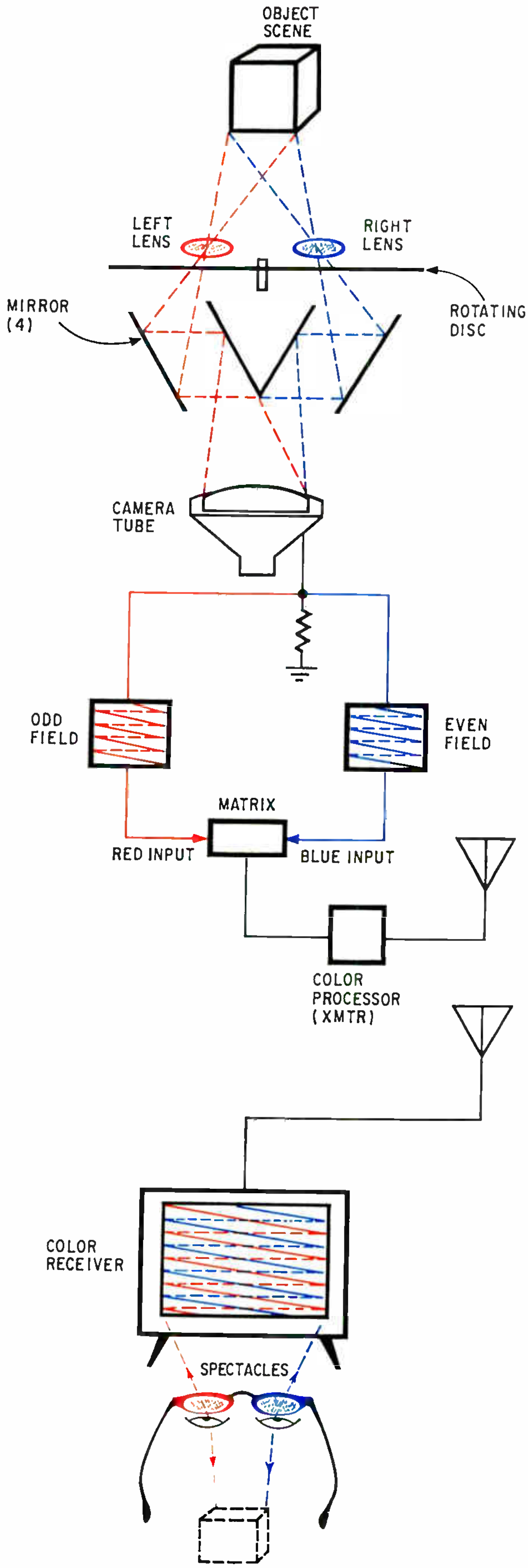
In the regular tv matrix, 30% of the red signal, 59% of the green, and 11% of the blue are combined to yield the luminance, or brightness, signal. Here there is no green signal, but luminance is achieved by equalizing the red and blue signals in the matrix.

In this 3-D system, then, there would be left and right cameras, a matrixing circuit, and an electronic switching circuit to alternately turn on the red and blue guns during odd and even fields. The optics of both cameras could be combined in a single unit with only one camera tube and a means of switching the left and right pictures to the camera tube during alternate fields. Four plane mirrors direct the right and left images onto the camera tube mosaic.

Mounted in the focal plane of each lens are disks with slits whose centers coincide with the focal planes of the lenses. These slits are arranged so that when one lens is opened the other is effectively closed. The size and spacing of the slits in the disk are such that each lens remains open during the vertical sync signal interval. By synchronizing the disk with the vertical sync signal, the holes in the disk can be made to expose the left lens during odd fields, and the right lens during even fields.

After the alternate switching of the odd field to the red input terminal of the matrix and the even field to the blue, the information is handled as normal color signals.

It's interesting to note that color cameras couldn't be used as pickup devices in this 3-D system because the red and blue lenses would be insensitive to objects not within their color wavelengths. Thus, portions of the scene being televised would be obscured at times. For this reason, only monochrome cameras can be used in this 3-D scheme.



Stereoscopic view. Isolation of left and right channel information, from object scene to observer, is achieved by color-coding the odd and even fields at the matrix.

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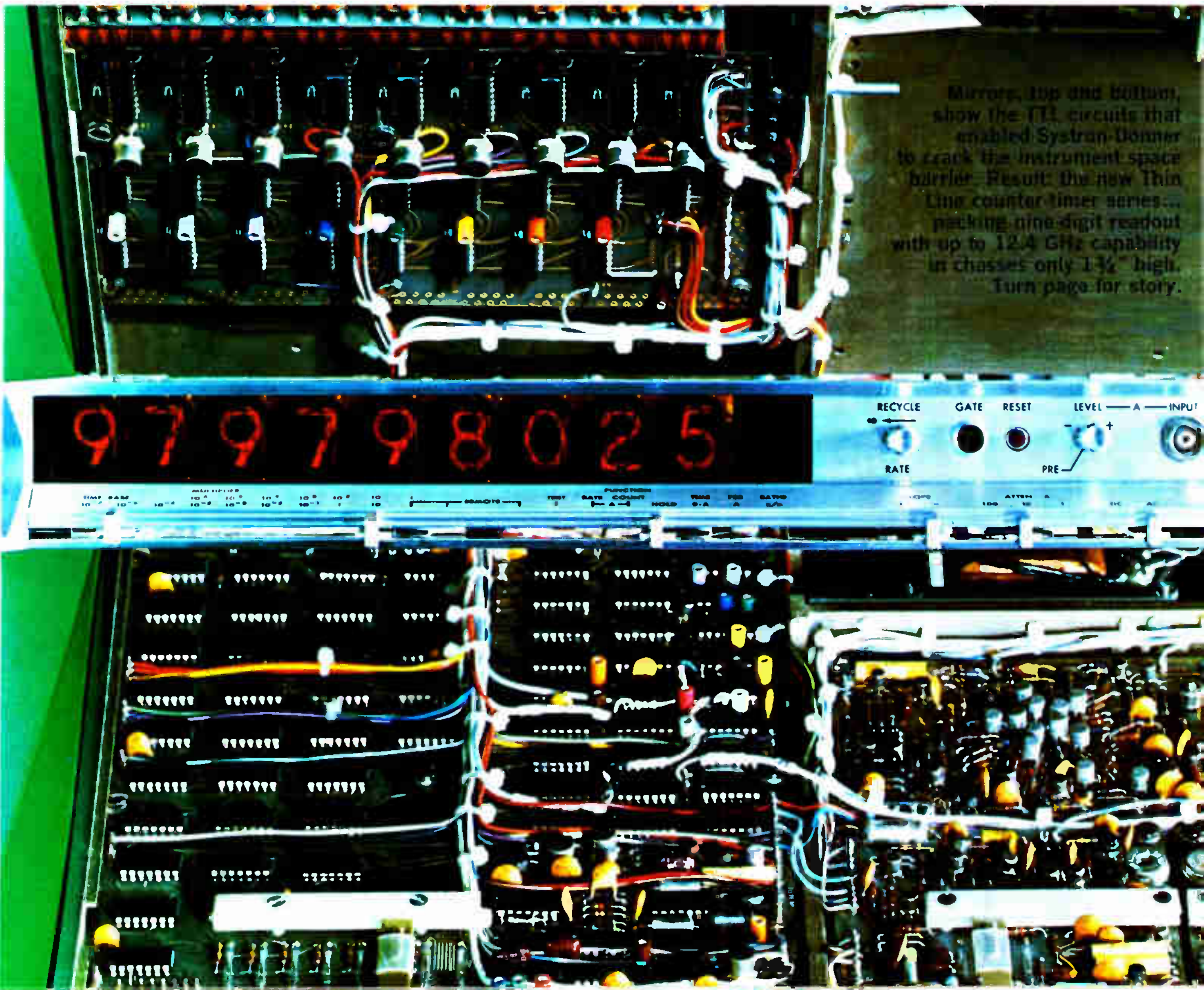
TTL Trends

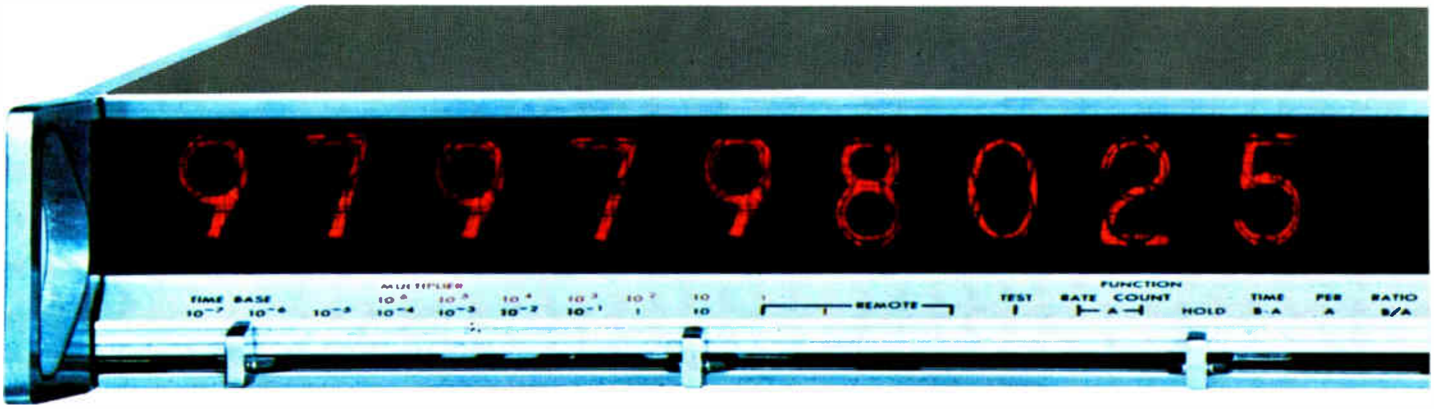
from Texas Instruments

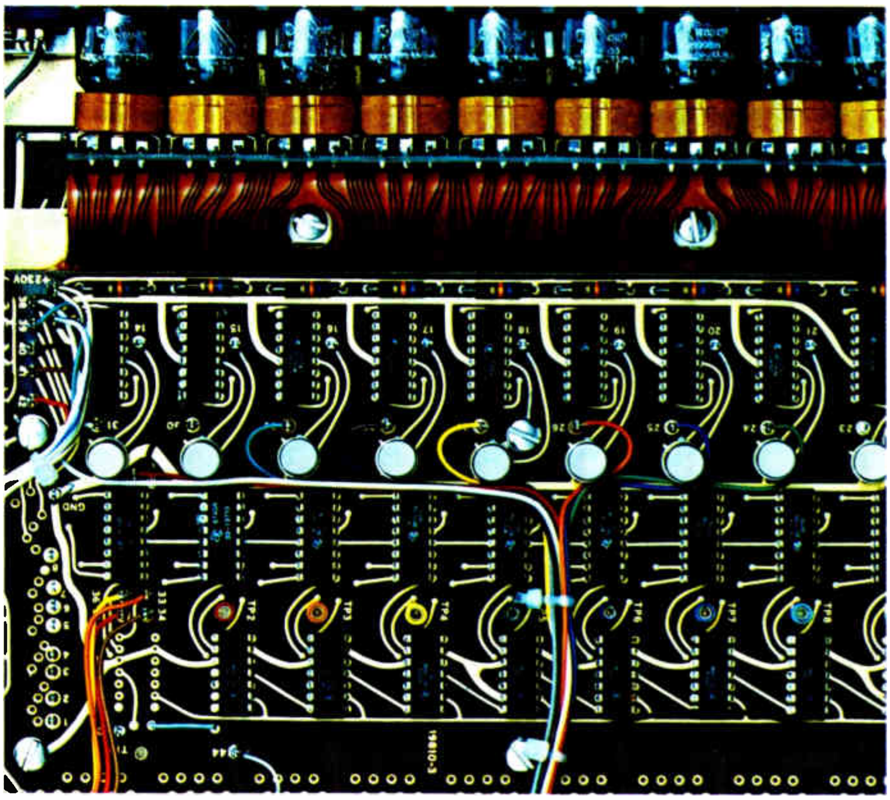


Mirrors, top and bottom, show the TTL circuits that enabled Systron-Donner to crack the instrument space barrier. Result: the new Thin Line counter-timer series... packing nine-digit readout with up to 12.4 GHz capability in chasses only 1½" high.

Turn page for story.

How TTL helped slim fat counters





Twenty-six TI Series 74 complex-function integrated circuits form the decade chain and decoder-driver section of this Systron-Donner Thin Line counter. Without circuits such as SN7441N BCD-to-decimal decoder-drivers, hundreds of separate transistors and simple integrated circuits would have been necessary to perform the required functions.

Mission impossible? It may have seemed so to project engineers at Systron-Donner Corp. They had the assignment of designing a radically new line of high-frequency counters—one that would give them a big jump on competition.

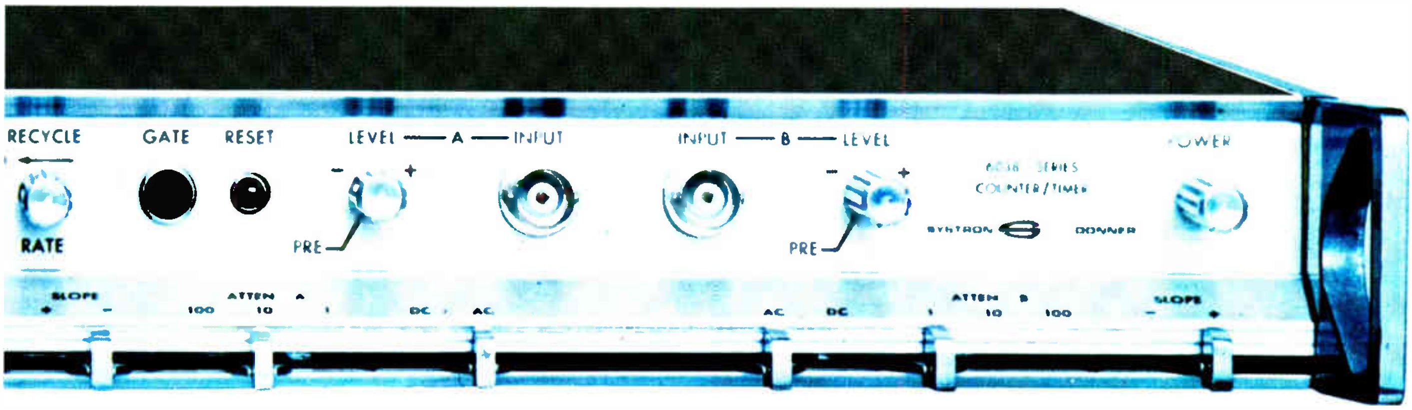
A key requirement was reduced panel height. Systron-Donner engineers wanted a *skinny* counter — one only 1¾″ high.

But, they also wanted nine-digit readout for top resolution.

Plus a 100 MHz direct counting range.

And greater freedom from repairs than ever before possible.

Integrated circuits were the obvious solution. But *which* ICs posed the tough question. Answering it triggered a two-year search that covered all major IC suppliers as well as many smaller producers. Systron-Donner's analysis included RTL and ECL logic types, in addition to TTL and DTL. Breadth of product line, depth of manufacturing facilities and competence of personnel were considered—along with price, service and performance—before the final selection was carefully made.



Texas Instruments got the nod, and its Series 74 TTL integrated circuits were selected to carry the major share of the chassis-shrinking job.

Cutting package count with complex-function ICs

Availability of complex function circuits was a prime factor in the selection of Series 74 TTL. With these advanced ICs, Systron-Donner engineers were able to make major reductions in package count – particularly in the decade-chain and related storage-readout driver section. Eight SN7490N decade counters, nine SN7475N quadruple latches and nine SN7441N BCD-to-decimal decoder-drivers replaced hundreds of simple integrated circuits and transistors. Without these TTL circuits, the new Thin Line counter design would have been virtually impossible.

Other benefits from TTL

Even where complex functions were not required, TI's Series 74 TTL line permitted significant package and space savings. For example, SN7473N dual J-K master/slave flip-flops assured high switching speeds for control binaries. A further reduction in package count resulted from use of multiple-input SN7470N J-K flip-flops.

In addition, Series 74 gates – SN7400N, SN7410N and SN7420N – provided a solid 10 MHz switching capability in those sections where such speed was desired. And the high driving capability of these gates (resulting from low output impedance) gave Systron-Donner engineers greater flexibility in wire routing and circuit board layout, without compromising switching speed.

And high noise immunity – typically 1.9 V for logical one and 1.2 V for logical zero – further simplified board layout. Series 74 ICs also permitted much faster evaluation of pilot board runs than had ever been achieved with discrete components.

Reliable, maintenance-free operation

Field experience to date indicates Systron-Donner has achieved its design goals for reliable, trouble-free service. Expectations are that the MTBF for the new Thin Line counters will far exceed that of older counters using discrete components. This improved reliability is due, in large measure, to the reduction in package count and even greater reduction in number of soldered connectors made possible by the Series 74 TTL logic family from Texas Instruments.

Planning for tomorrow

By using industry's most modern logic family, Systron-Donner has also provided for future design opportunities – at minimum cost, time and effort.

TI's growing family of TTL complex functions has provided Systron-Donner a link with the MSI and LSI semiconductor circuits of tomorrow. Why not also put this advanced IC line to work for you?

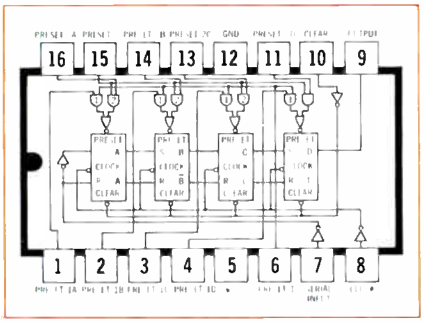
Three of the most recent additions to the TI complex function line of shift registers are featured on the next page. They typify the increasing versatility and complexity that has characterized the evolution of TI's family of TTL circuits. One of these ICs may be just the ticket for breaking that design logjam of yours.

TEXAS INSTRUMENTS
INCORPORATED

3 new shift registers expand industry's broadest logic line

These complex-function TTL shift registers are far more than basic registers. Applications include shift counters, Johnson and ring counters, and shift-register generator counters.

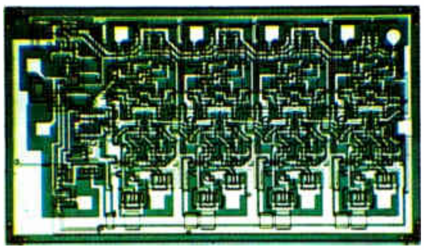
These registers incorporate additional gating as well as input and output connections, and are recommended for many storage and counting applications in addition to such shift functions as serial-to-parallel, parallel-to-serial, right-shift and left-shift operations. In all cases, substantial savings in packages, interconnections, design time and overall costs will be realized.



SN7494 4-bit shift register

This parallel entry, serial shift register includes four AND-OR-INVERT gates, four inverter drivers, and four R-S master-slave flip-flops. The result is a versatile circuit which performs right-shift operations as a serial-in, serial-out register or as a dual source parallel-to-serial converter.

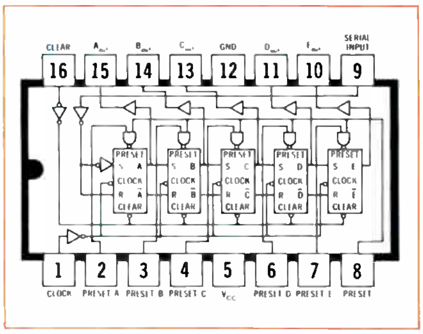
All flip-flops may be cleared simultaneously — independently of clock input. Also, the circuit has asynchronous loading capability from two strobe-controlled sources.



SN7495 4-bit shift-right, shift-left register

This parallel or serial-input shift register incorporates four AND-OR-INVERT gates, one AND-OR gate, six inverter-drivers, and four R-S master slave flip-flops.

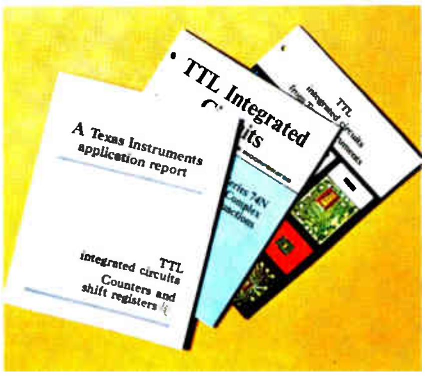
This versatile register can be used in a wide variety of applications, including serial-in, right-shift/left-shift, and parallel loading operations.



SN7496 5-bit shift register

This register consists of five R-S master/slave flip-flops, with gates and inverter drivers, connected as a shift register to perform parallel-to-serial or serial-to-parallel conversion of binary data. Since both inputs and outputs to all flip-flops are accessible, parallel-in/parallel-out and serial-in/serial-out operations may be performed.

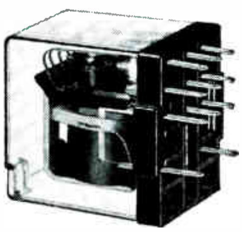
A common clear line and strobe-controlled, individual presets permit loading of any binary information into the register. Preset is independent of the state of the clock input.



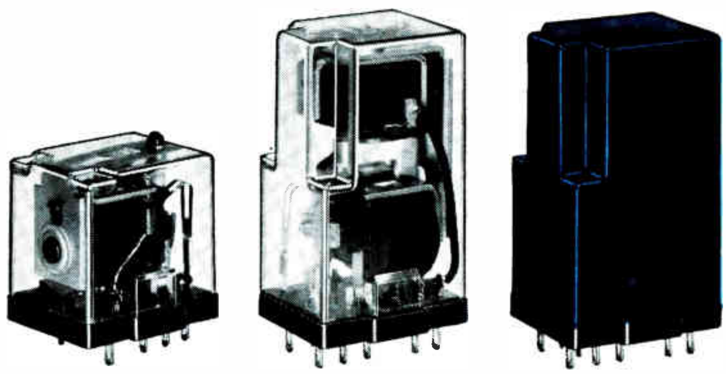
A note from you, on your company letterhead, will bring this goldmine of information . . . data sheets on these 3 new shift registers plus application information on all our 54/74 counters and shift registers . . . a data book on the entire 74 N complex-function family . . . and finally, an in-depth 48-page brochure covering all 54/74 TTL integrated circuits. Just address your letterhead request to Texas Instruments, Incorporated, MS980, P.O. Box 5012, Dallas, Texas 75222.

TEXAS INSTRUMENTS
INCORPORATED

popularity has gone to its head



the versatile Series 1220 relay has grown a manual reset an electrical reset and a solid state time delay.



Now the Series 1220 10 amp relay is modular. All four versions give you the three ways to connect and four ways to mount that made the basic 1220 relay a runaway favorite in its class.

Now when you need a manual or electrical reset or a time delay, you can count on the same performance characteristics that led you to choose the basic 1220. No need to fool around with relays that use radio-type plugs or mount only one way.

The basic 1220 is available DPDT or 3PDT, AC or DC. The new members in the family are all DPDT, AC or DC. All of them feature our new "Uni-Guard" one piece switch that eliminates internal solder connections for reduced contact circuit resistance (and reduced price, too). Get the specs on all four Series 1220 relays for your file today. Write Guardian Electric Manufacturing Company, 1550 West Carroll Avenue, Chicago, Illinois 60607.

GUARDIAN® ELECTRIC

Circle 141 on reader service card →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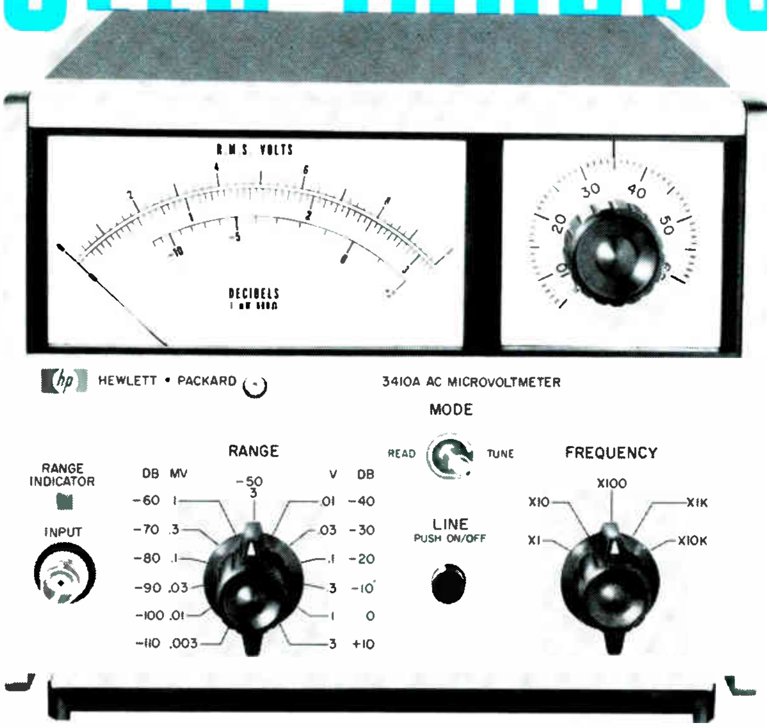
STACKPOLE
ELECTRONIC COMPONENTS DIVISION

[redacted] **Assignment:**

AC MICROVOLTMETER SEES THROUGH NOISE!



New hp 3410A Measures 300 nanovolts Buried in Noise

New hp Model 3410A AC Microvoltmeter measures low level repetitive signals obscured by noise—3 μV to 3 V full scale—accuracy ±3%. RMS noise voltages up to 20 dB above full scale *do not affect* readings. Sensitivity, low cost and ease of operation are the 3410A's contribution.

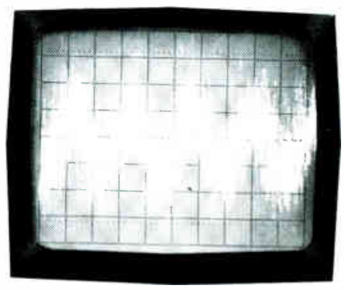
This new microvoltmeter uses an hp designed phase-locked synchronous detector to separate effects of noise from signal. The detector is an electronic gate controlled by an oscillator phase-locked to the input signal. No external reference is required to lock to the input signal. Simply adjust front panel tuning control within 1% of signal frequency and phase-lock circuits *lock-on and track* input signal with ±5% variation in the 5 Hz to 600 kHz frequency range. Phase-lock circuits track 0.5%/sec change in signal frequency without a change in voltmeter accuracy. Input impedance is 10 MΩ shunted by 20 pF.

The new Model 3410A has two outputs on the rear panel. One is a dc recorder output for monitoring long term drifting ac voltage amplitudes. The other is an output for driving an electronic counter to make precise frequency measurements.

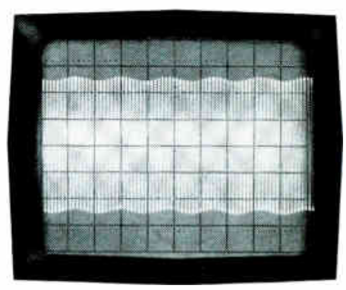
For full specifications on the new hp Model 3410A AC Voltmeter, call your hp field engineer. Or, write to Hewlett-Packard, Palo Alto, California 94304. Europe: 54 Route des Acacias, Geneva. Price: hp Model 3410A, $800.00.

097/11

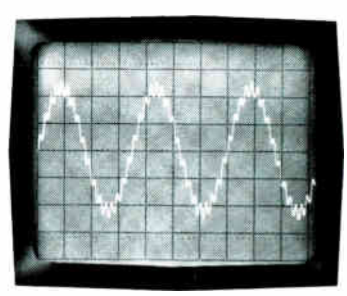
HEWLETT hp PACKARD
An extra measure of quality



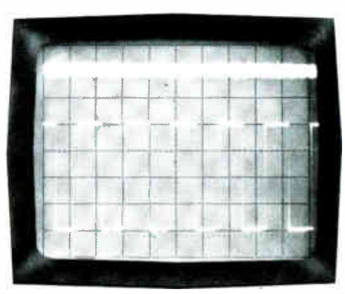
Measure 1 μV, 500 kHz signal out of 40 dB noise.



Measure 10 mV, 5 Hz amplitude modulating 1 V, 400 Hz.



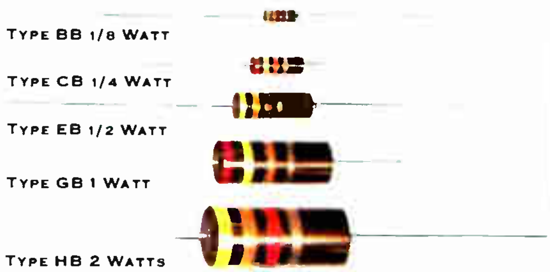
Measure 300 nanovolts, 10 kHz. signal superimposed on 10 μV, 1 kHz



Measure frequency of signal in noise up to 560 kHz by using square wave output, i.e. as a counter preamplifier.

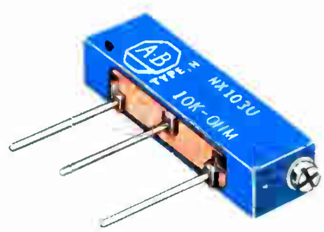
"We have learned through bitter experience that
Allen-Bradley resistors are unmatched for reliability"
Philbrick Researches

Typical Philbrick solid state operational amplifiers. The Model P65A differential operational amplifier with cover removed shows the use of Allen-Bradley hot molded fixed resistors and an Allen-Bradley Type N adjustable fixed resistor for zero balance adjustment.



A-B hot-molded fixed resistors are available in all standard resistance values and tolerances, plus values above and below standard limits, **and they meet or exceed all applicable military specifications including the new Established Reliability Specifications.**

The need for a yearly production capacity of well over a billion units is a testimonial to the uniformity and reliability of all Allen-Bradley hot molded resistors.



Type N hot molded adjustable fixed resistor rated ⅓ watt at 50°C ambient. Available with nominal resistance values from 100 ohms to 2.5 megohms with tolerances of ±10% and ±20%.

■ "Why have Allen-Bradley hot molded resistors been our first choice since the late 1940's? In a word: Reliability!" states Philbrick—the leading manufacturer of operational amplifiers. There's nothing accidental about this superiority of A-B resistors. A unique hot molding process using completely automatic machines, eliminates the "human element" and produces such uniformity from one resistor to the next—year in and year out—that long resistor performance can be accurately predicted. No instance of "catastrophic failures" has ever come to our attention.

Allen-Bradley Type N adjustable fixed resistors likewise use a solid hot molded resistance track. Adjustment is so smooth, it approaches infinite resolution—and settings remain fixed. Being noninductive, Type N controls can be used at high frequency where wire-wound units would be completely unsatisfactory.

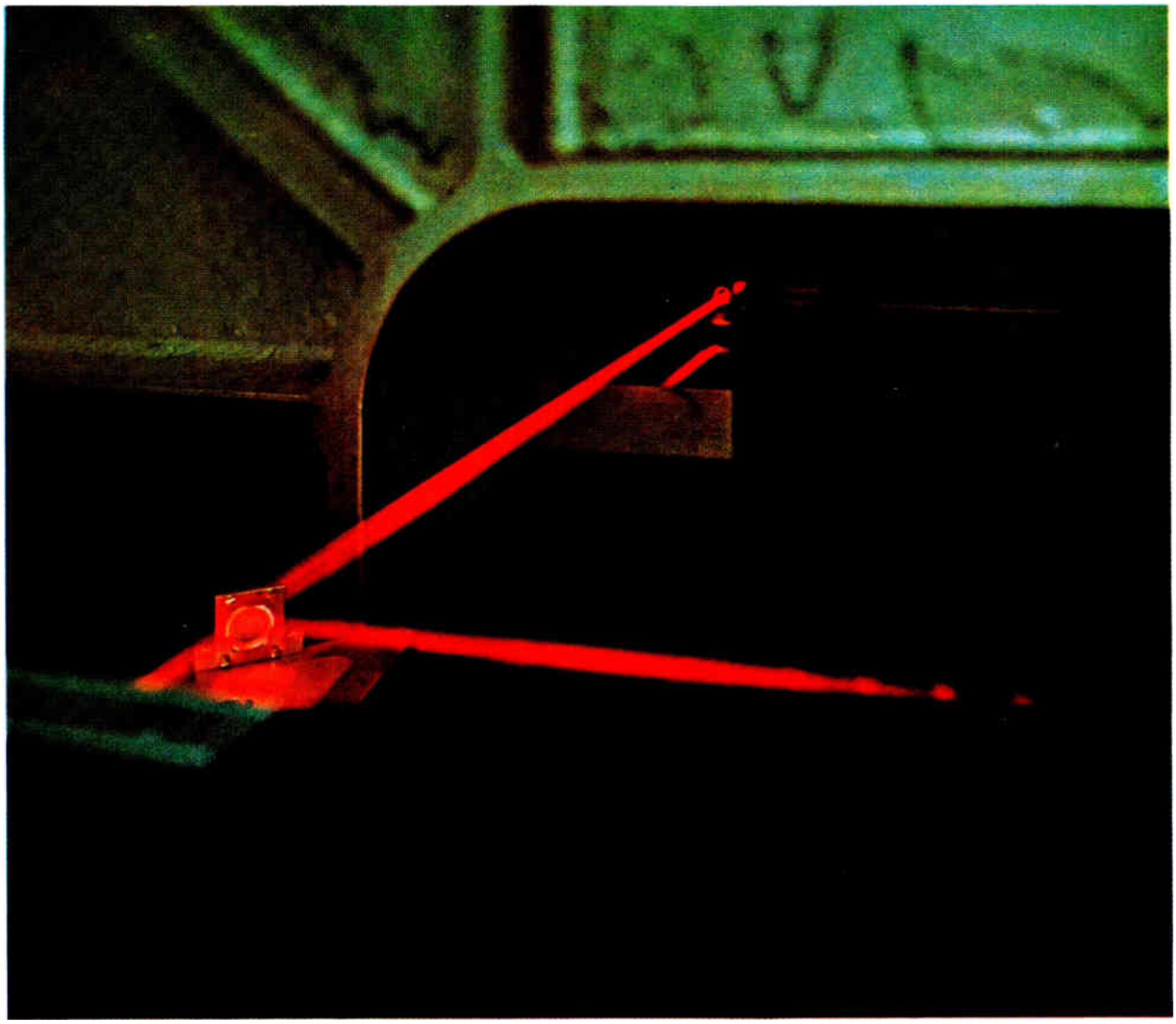
For more details on the full line of Allen-Bradley quality electronic components, please write for Publication 6024: Allen-Bradley Co., 110 W. Greenfield Ave., Milwaukee, Wis. 53204. Export Office: 630 Third Ave., New York, N.Y., U.S.A. 10017.

366E-5

Circle 145 on reader service card

A-B QUALITY

ALLEN-BRADLEY
QUALITY ELECTRONIC COMPONENTS



Only ITT has laser-controlled IC mask making.

Another reason to buy from "The Predictables."

Mask variations used to mean performance variations in Series 930 DTL. Now ITT initiative has eliminated the problem. An exclusive laser-controlled, fully automated mask making machine assures absolute repeatability of masks and of circuit performance.

ITT's machine, representing an order of magnitude improvement over older processes, holds mask registration tolerances to ± 122 silicon atoms (based on the crystal lattice constant). It is tape programmed, with memory storage capacity of 10,000 separate semiconductor devices, and it can complete a matched set of up to nine masks in as little as 10 minutes.

If you think all Series 930 DTL circuits of the same type should act the same, the solution is simple: buy them from "The Predictables." ITT predictability also extends to diodes, rectifiers, and silicon planar transistors. Ask for a quote on any or all. They are on-the-shelf at your ITT distributor. ITT Semiconductors is a division of International Telephone and Telegraph Corporation, 3301 Electronics Way, West Palm Beach, Florida.

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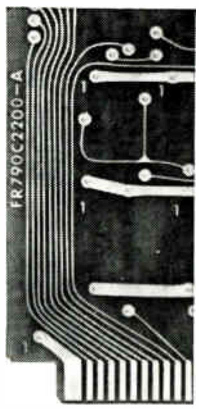
CAMBION's exclusive gold-plated 70-pin input/output is the key to your investment. It lets you bring more functions through to the outside world . . . reduces the total number of circuit connections . . . and provides for large scale integration . . . *now.*



And CAMBION's complex function logic assemblies give you more circuitry in the etch — permanently. You get more functions per card, use fewer cards and card racks and get more compact design at lower cost.

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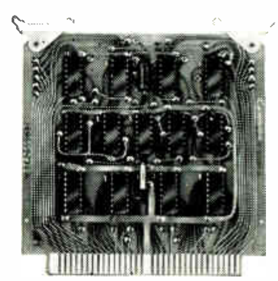

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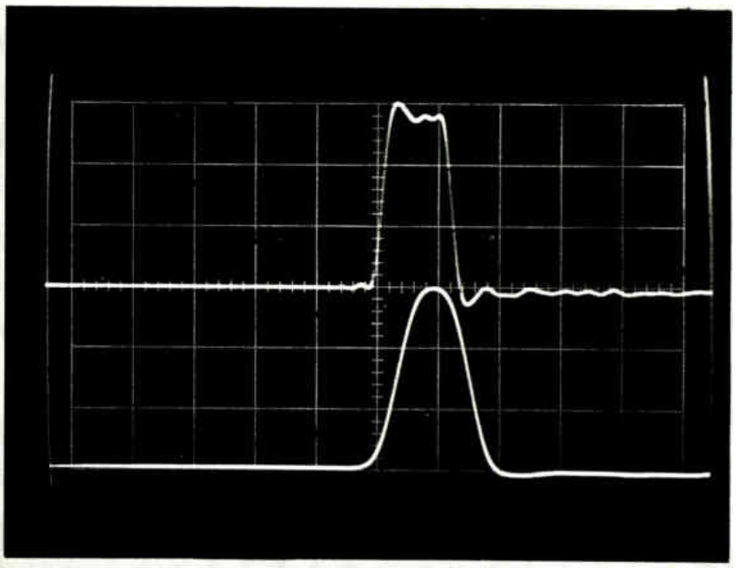
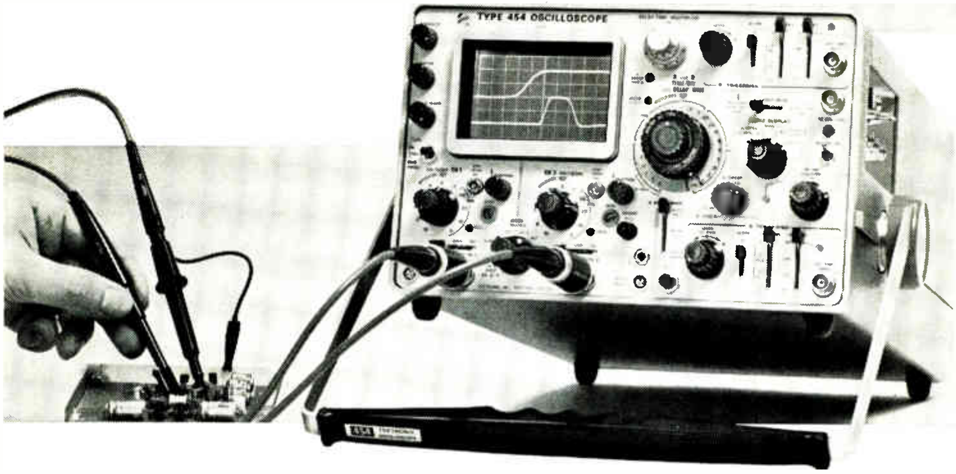
Circle 149 on reader service card

Pulse Fidelity

This double-exposure photograph shows the same 12-ns-wide pulse displayed by the Tektronix Type 454 (upper trace) and by a 7-ns, 50-MHz oscilloscope (lower trace). Note the difference in detail of the pulse characteristics displayed by the Type 454 with its 2.4-ns risetime performance.



10 ns/div



150 MHz, 2.4 ns *with or without probes*

The Tektronix Type 454 is an advanced portable oscilloscope with DC-to-150 MHz bandwidth and 2.4-ns risetime performance where you use it—at the probe tip. It is designed to solve your measurement needs with a dual-trace vertical, high performance triggering, 5-ns/div delayed sweep and solid state design. You also can make 1 mV/div single-trace measurements and 5 mV/div X-Y measurements.

The vertical system provides the following dual-trace performance, either with or without the miniature P6047 10X Attenuator Probes:

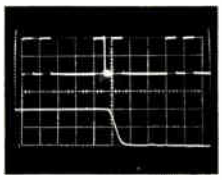
*Deflection Factor**	*Risetime*	*Bandwidth*
20 mV/div to 10V/div	2.4 ns	DC to 150 MHz
10 mV/div	3.5 ns	DC to 100 MHz
5 mV/div	5.9 ns	DC to 60 MHz

*Front panel reading. With P6047 deflection factor is 10X panel reading.

The Type 454 can trigger internally to above 150 MHz. Its calibrated sweep range is from 50 ns/div to 5 s/div, extending to 5 ns/div with the X10 magnifier on both the normal and delayed sweeps. The delayed sweep has a calibrated delay range from 1 μs to 50 seconds.

Type 454 (complete with 2 P6047 and accessories)	$2600
Rackmount Type R454 (complete with 2 P6047 and accessories)	$2685
Type 200-1 Scope-Mobile® Cart	$ 75

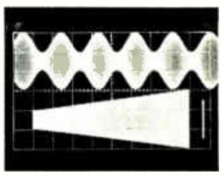
U.S. Sales Prices FOB Beaverton, Oregon



Double Exposure

5 ns/div delayed sweep

The delayed sweep is used to measure individual pulses in digital pulse trains. The Type 454 with its 1 μs-to-50 s calibrated delay time, 5-ns/div sweep speed and 2.4-ns risetime permits high resolution measurements to be made. Upper trace is 1 μs/div; lower trace is 5 ns/div.



150 MHz AM

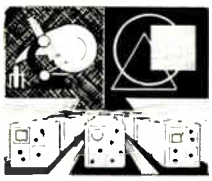
X-Y

The upper display is a 150-MHz signal that is 50% modulated by a 2 kHz signal. The lower display is an X-Y trapezoidal modulation pattern showing the 150-MHz AM signal vertically (Y) and the 2 kHz modulation signal horizontally (X). Straight vertical line is the unmodulated carrier. Multiple exposure.

For a demonstration, contact your nearby Tektronix field engineer, or write: Tektronix, Inc., P. O. Box 500, Beaverton, Oregon 97005.

TEKTRONIX

Coordinated research, design and manufacturing



. . . part of the Tektronix commitment to progress in the measurement sciences

Advanced technology

Wave of optimism for millimeter waves

Frequencies above 30 Ghz promise wider bandwidths, secure communications, and new data on molecules and space as well as relief from crowded spectrum

By William J. Bucci
Communications editor

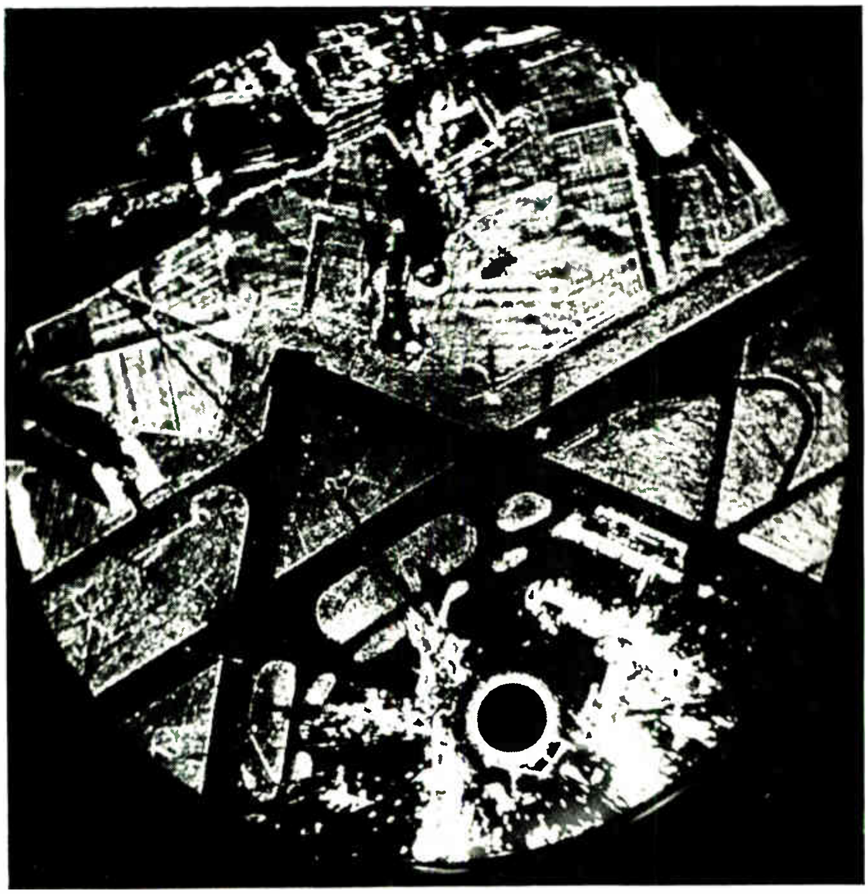
Millimeter-wave work, long a ripple in the ocean of electronics research, is rapidly becoming a ground swell that could reach tidal-wave proportions within a few years. There are a few rip currents, particularly in some components areas. But around the world, radars are beaming signals at gigahertz frequencies to the sun and moon to acquire data for space exploration. Researchers are preparing to study millimeter-wave transmission from a satellite, ground links are being installed to check on how atmosphere and weather affect propagation, and buried waveguide transmission systems are being tested. In addition, the armed forces are eyeing millimeter waves as a secure transmission medium that cannot be intercepted.

The millimeter-wave region covers frequencies from 30 Ghz to 300 Ghz. At the lower frequency, wavelength measures 10 mm; at the higher, 1 mm.

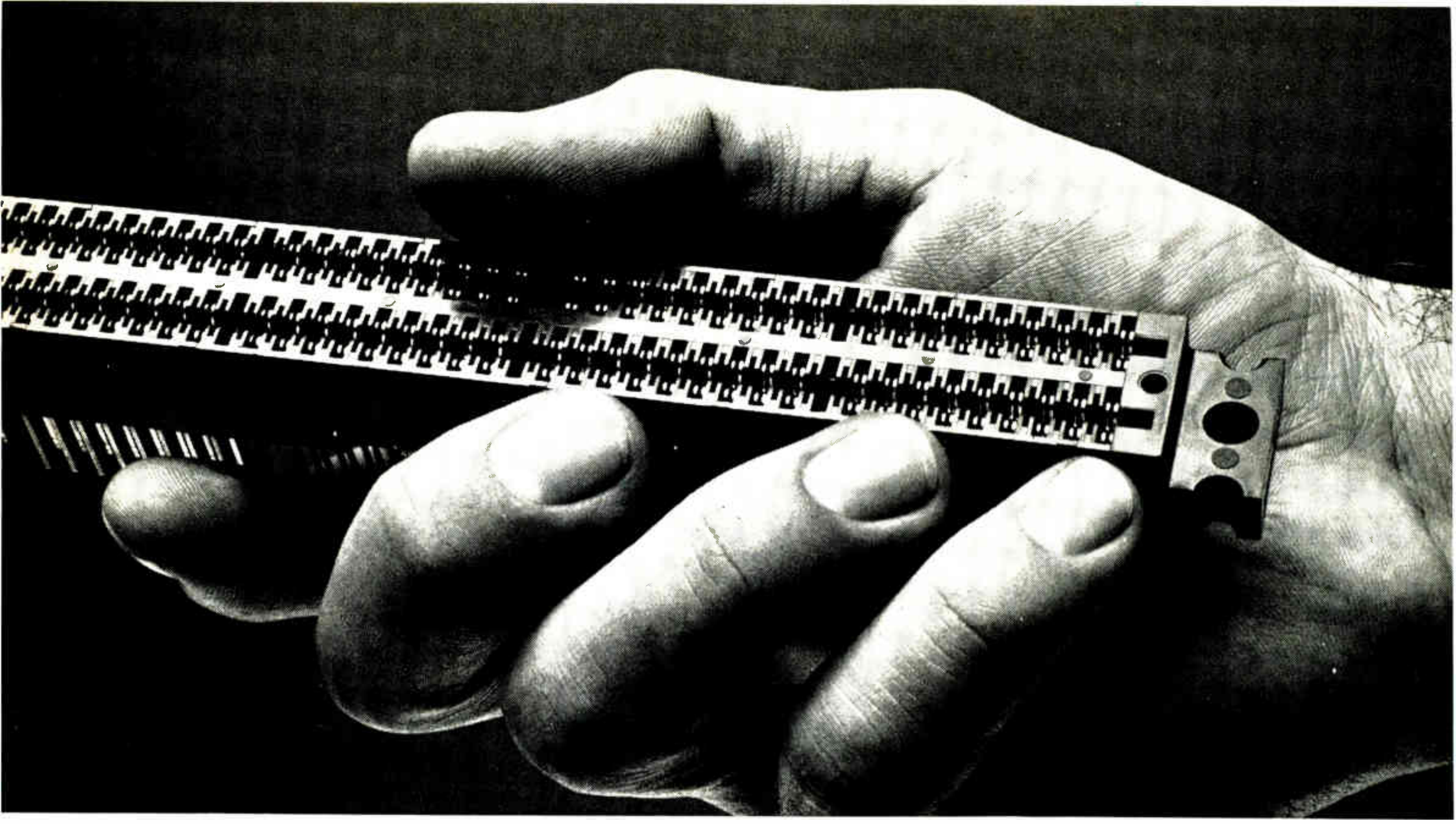
Plus factors. While many observers call relief from spectrum overcrowding the principal reason to explore millimeter waves, there are at least two other factors. Millimeter-wave systems are especially attractive in space and military applications where wide bandwidth is required. Also, it is easier to study certain materials in the millimeter-wave region than at lower frequencies.

Many companies are in the field, both on their own and with Government support. The Department of Defense boosted outlays for millimeter-wave work more than 10% to $2 million in fiscal 1968, despite a shortage of research funds resulting from U.S. commitments in Southeast Asia.

"There'll be a tremendous market for millimeter-wave systems over the next five to 10 years," says an East Coast marketing executive. "But we'll have to sell the technology as well as equipment. Some people still think everything above 30 Ghz gets clobbered by the atmosphere. So we trot out the absorption curves and show them the windows around 35 Ghz and 95



Keeping tabs. Decca surveillance radar, operating around 35 Ghz, displays both air and ground traffic at London Airport. The millimeter-wave system has proved a practical way to get high discrimination with light antenna.



Our connectors are better.

Of course, you have to pay a little less.

Everybody knows that gold makes the best electrical contact.

So we put ten times more gold at the contact area than any plater does.

But everybody knows that gold is expensive.

So, we developed a special welding process that lets us put the gold exactly where you want it. So overall, we use much less gold.

As a result, you get a better, longer-wearing, more reliable connector for less money.

Sounds simple, but it takes some doing.

It not only calls for advanced technical know-how, but also precise control of all fabricating processes. Well, at Sylvania, we leave nothing to chance—or to outside suppliers.

First, we draw our own wire for the contacts. Then we do our own coining, forming, bending, solder plating, and gold dot welding. Next, we mold our own plastics bodies to assure precise control of tolerances.

And, finally, we assemble the whole thing ourselves.

And we do it all to your specifications.

So if you want the best connector, and you don't mind paying a little less, give us a call. Sylvania Metals & Chemicals, Parts Division, Warren, Pa. 16365.

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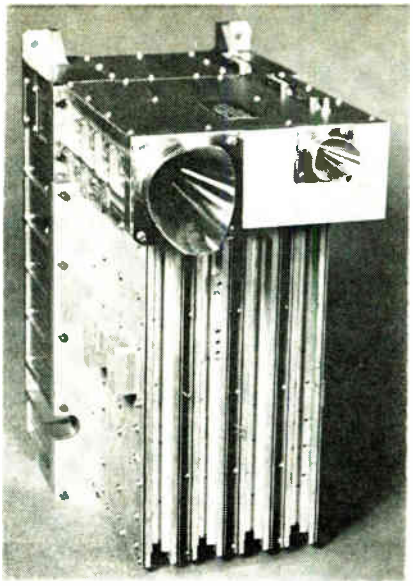


Package deal. NASA will conduct first millimeter-wave satellite experiment with this transmitter-receiver setup.

Ghz." (Windows are portions of the frequency spectrum where atmospheric absorption, or dissipation of electromagnetic energy, is low.)

I. Weakest links

While components are commercially available and the sales side is optimistic, engineers contend that a general lack of reliable, off-the-shelf parts could slow the growth anticipated for millimeter-wave systems. John Bartnik, an engineer at Sylvania Electronic Systems, a subsidiary of Sylvania Electric Products Inc., Williamsville, N.Y., put the problem this way: "Everyone's still applying conventional microwave techniques up to about 100 Ghz, and they're really skating on thin ice there. Tolerances are so minute it's very hard to produce a consistent product. Since there's been no need to make millimeter components in quantity, very little debugging has been done."

Joseph Stacey, an engineer with the Aerospace Corp., El Segundo, Calif., seconds this complaint, citing crystal mixers as the chief reliability culprits: "They don't last long, have poor temperature stability, and burn out at high powers. I can't think of any mixer at 94 Ghz that's qualified for space uses."

Some engineers even complain about components operating below 40 Ghz. Donald Worthington of the Defense Communication Agency in Washington, D.C., says: "We tried to get balanced diodes for 50-mega-bit-per-second switching and just couldn't find any. When you do buy components, you can't always believe the manufacturer's figures. We bought 12 integrated circuits and they were all bad. You can live with that in research and development but not in an operational setup."

Ante up. Throughout the field, engineers criticize the high cost of components. Says Stacey: "A simple, 94-Ghz magnetron costs $9,000 and a local oscillator to drive a receiver costs $3,000."

Millimeter-wave activity is up somewhat because of the increased availability of high-power tube sources, according to Donald Forster of the Hughes Research Laboratories, an arm of the Hughes Aircraft Co. located in Malibu, Calif. Hughes is, of course, a leading supplier of high-power devices. The company is working on about $400,000 worth of contracts having millimeter-wave applications. Among other items, the company is developing: a 10-kilowatt pulsed 100-Ghz source for the military; a 5-kw continuous-wave source for the Atomic Energy Commission; and 31-Ghz ground transmitters for the Goddard Space Flight Center's experiment on the "E" model of an Applications Technology Satellite (ATS-E).

Keep it simple. Where lower power can be tolerated in millimeter-wave systems, solid-state sources are preferred for reliability and economy. Multiplying the low frequencies from a transistor amplifier using varactor diodes has so far proved to be the most trustworthy technique. Sylvania has achieved a power output of 100 mw from 36 Ghz to 38 Ghz in this way.

Meanwhile the industry is keeping an eye on impact avalanche transit time (Impatt) oscillators, Gunn effect devices, and limited space charge accumulation (LSA) diodes, all of which promise higher power. John Copeland, a Bell Labs scientist who developed the first LSA diode, expects powers of 1 watt cw up to 200 Ghz in the near future. Now, however, materials problems make such devices iffy.

II. The millimeter underground

Perhaps the best known millimeter-wave applications center on guided-wave transmission systems. At Bell Telephone Laboratories in

. . . engineers must have a detailed knowledge of an area's rainfall . . .

Holmdel, N.J., work is being resumed on such equipment after several years hiatus. Most observers feel the prospect of commercial Picturephone service that would gobble up bandwidth is the spur.

With its work on helix waveguides done, Bell is now concentrating on solid-state power sources and repeater design. A recent report describes the design of a single channel in an experimental solid-state repeater. The system under consideration transmits 208,000 two-way voice channels or equivalent information over a band of frequencies from 40 Ghz to 100 Ghz. The pulse-code modulated signal would propagate in a low-loss mode through 2-inch helix or dielectric-lined circular waveguides. Bell calculates losses are less than three decibels per mile.

Teuton trial. Meanwhile in West Germany, Siemens AG has completed work on experimental circular waveguides operating from 20 Ghz to 90 Ghz; it has installed two systems, one near Munich, the other at Darmstadt in the Post Office Central Research Institute. The Darmstadt setup contains all the duplexers, filters, modulators, and associated gear needed to handle 260,000 channels.

Also in Darmstadt, AEG-Telefunken is installing a helix waveguide pcm system, operating in the 50 Ghz to 80 Ghz range for the Post Office. Eventually, the system will span three kilometers, transmitting more than 100,000 voice channels.

Insular item. In England—where a good many telephone users are concentrated in a small area—the British Post Office is underwriting the efforts of Standard Telecommunication Laboratories Ltd., an affiliate of the International Telephone & Telegraph Corp. to develop an experimental wideband system using glass waveguides. The system is unusual in that it transmits at very low optical frequencies, using millimeter wave propagation techniques.

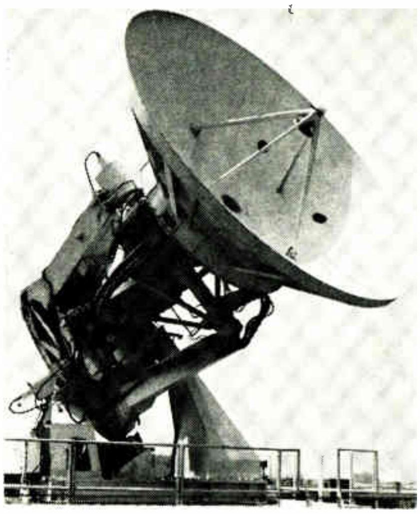
III. Rain's a pain

Ironically, waveguides are a better-charted millimeter-wave transmission medium than the atmosphere. While the regions of the frequency spectrum where atmospheric attenuation is minimal—the windows—are well known, the effects of weather on millimeter-wave transmission still remain clouded. To design effective ground-to-ground or ground-to-satellite systems, engineers must have a detailed knowledge of area rainfall, as well as how much of a downpour it takes to drown out transmissions.

To that end, Bell Labs has designed a high-speed gauge that measures the rate of rainfall in time periods as short as seconds. By spreading 96 gauges over a 13 kilometer area in New Jersey, engineers hope to get meaningful statistics on the probability of heavy rain in one part of the area concurrent with light rain in another. From such studies will come "space diversity" millimeter-wave systems that automatically switch transmission paths when the attenuation in one area exceeds that in another.

Low road. At the same time, Bell Labs is measuring the effects of rain on frequencies transmitted at 18.56 Ghz and 30 Ghz over a four-mile experimental link. Bell is considering the possibility of millimeter-wave radio links at these frequencies to help relieve future crowding of the microwave spectrum.

Farther south, the Defense Com-



Looking up. Millimeter-wave antennas are being used to predict sun spots.

munications Agency has sent 50 million bits of data a second over a 28-Ghz and 40-Ghz link from its headquarters in Arlington, Va., to the Navy Security Station in Washington, D.C. The agency's engineers have been able to operate in a frequency-hopping mode in 20-megahertz jumps, without signal fading. Tests show such a system can take on the Washington rain pattern and win 99% of the time.

Another transmission link in El Segundo, operated by the Aerospace Corp., is carrying frequencies around 55 Ghz—a range that's badly attenuated by atmospheric oxygen. Underwritten by the Air Force, this work will verify whether the atmosphere can prevent satellites that are communicating with one another from being jammed or intercepted.

In England, the Radio and Space Research Station near London Airport is measuring absorption and scintillation at 100 Ghz using a 150-meter link. Engineers there are trying to find the maximum antenna size and bandwidth that can be used in such links.

A big jump. Sylvania decided to leapfrog and market an operational transceiver with immediately practical application [Electronics, Nov. 27, 1967, p. 45]. The set has 500 Mhz of bandwidth and operates between 36 Ghz and 38 Ghz over a distance of 15 nautical miles. Tests show the unit can operate in poor weather. The solid-state tranceiver's performance characteristics, particularly the capacity to carry information in a tight beam that's difficult to intercept, convinced the Navy to make tests from one ship to another. The set puts out 100 milliwatts of continuous power and has an estimated mean time between failure of 10,000 hours.

IV. Spacious times

Early next year, the National Aeronautics and Space Administration will conduct the first millimeter-wave experiments via satellite. Varian Associates has built a 15.3-Ghz transmitter which the Martin-Marietta Corp.'s Orlando, Fla., facility has incorporated, along with its own 31.65-Ghz receiver into a 34-pound package. The equipment is earmarked for the ATS-E.

The type of phase modulation to

Circle 155 on reader service card →

be used in the ATS-E experiment guarantees that the center frequency and two sidebands transmitted will have the same amplitude. By studying the phase and amplitude relationship between the carrier and sidebands of the transmitted or received signal, NASA will be able to determine whether the 100-Mhz bandwidth sent can carry information without distortion.

The space agency has to go slowly because wider bandwidths mean higher power, more weight, and greater expense. A wider bandwidth experiment is scheduled for an upcoming NASA Nimbus weather satellite.

Dropouts. Martin also had several study contracts for other millimeter-wave experiments. One involved a 500-Mhz bandwidth study for the Apollo program, another a transmission study from 30 Ghz to 100 Ghz between satellites. Neither project was implemented.

The Bell System is interested in transmitting domestic telephone calls over satellite in the 18-Ghz and 30-Ghz range and has asked the Federal Communications Agency for permission to use these frequencies. Bell is now trying to measure millimeter radiation from the sun at 6 Ghz and 30 Ghz. High atop its Crawford Hill, N.J., facility, Bell has erected a sun tracker to continuously measure how the sun's millimeter-wave output is affected by the weather.

Looking ahead, NASA awarded Sylvania a contract to develop a 100-megawatt, 35-Ghz, transmitter that has been delivered for plasma penetration studies. At 35 Ghz, electromagnetic waves can break through the plasma sheath that surrounds vehicles entering or leaving the atmosphere—when their speed exceeds Mach 5.

Of more immediately practical interest are the millimeter-wave radars being used to perform a variety of tasks that would be all but impossible at other frequencies. At London Airport, for example, Decca Radar Ltd. has installed a 34.5-Ghz to 35.5-Ghz surveillance radar to keep tabs on both air and ground traffic. The system's specifications require that the display be bright enough for the controller to switch his gaze from the set to the runway and back without vision adjustment problems. In addition, the display must be permanent and presented in real time. An antenna revolving at 750 rpm maintains the display and keeps it from fading between sweeps. Decca went the millimeter-wave route because it's the only feasible way to get high discrimination, using a light, easily movable antenna.

Solar systems. Millimeter-wave radars are also being used to predict sun spots. The Aerospace Corp., for example, has a unit operating at 94 Ghz to observe the upper chromosphere and another at 210 Ghz to check the lower. By programing a computer to look alternately at the measurements made at both frequencies, engineers can determine how long it takes a solar flare to develop. (Flares are born in the chromosphere, the lower region of the sun's atmosphere.) At lower frequencies, only the corona (a luminous envelope surrounding the sun beyond the chromosphere) can be studied; in the optical range, only the photosphere can be checked. But Aerospace officials say that by correlating measurements made at all frequencies they should be able to pinpoint sun-spot activity, which can knock out space communications and endanger astronauts.

To acquire data, the radar makes a television-type raster scan across the sun's surface, measuring temperature gradients. Mapping the gradients day after day allows predictions to be made. The 94-Ghz radar also has made soil studies of the moon.

Lincoln Laboratories at the Massachusetts Institute of Technology is also interested in studying the lunar surface, and has a 35-Ghz radar that includes an output varactor designed and built by Sylvania and a 1.2-kw cw output klystron amplifier from Varian Associates.

V. Back at the lab

Millimeter waves have other properties that make them indispensible tools for basic lab studies. Many molecules are excited only by frequencies in the gigahertz region, either absorbing or emitting radiation. These changes provide much data on bonding energies as well as details of molecular structure. One application is the study of atmospheric conditions on other planets.

Some basic studies are being done at institutions backed by the Air Force's Office of Aerospace Research. Duke University, Durham, N.C., for example, is seeking to combine optical and microwave techniques to develop new and more versatile millimeter and submillimeter measuring instruments. University College in Galway, Ireland, is studying the rotational spectra of materials by transmitting frequencies from 70 Ghz up through the submillimeter region (around 0.5 mm). And in North Wales, University College is investigating submillimeter generators.

Highlights. Martin-Marietta is among the more active American companies in basic millimeter studies. A team headed by scientist James Gallagher has phase-locked signals up to 450 Ghz back to a low-frequency crystal. Under a contract with the Army Signal Corps, Gallagher's group has beat an 890-Ghz hydrogen-cyanide laser against the twelfth harmonic of a 70-Ghz klystron, phase-locked to a 5-Mhz frequency standard. The 30-Mhz difference frequency made it possible to look at the laser line width. The hope is eventually to phase-lock the laser back to a frequency standard, perhaps using the 30-Mhz intermediate-frequency signal as a control source. Thus, as lasers reach down into the submillimeter region, techniques are being developed to bring the stability of lower frequencies into the millimeter and optical regions.

Another group at Martin has developed a 35-Ghz radiometer capable of detecting temperature differences of 0.2° Kelvin. A high sensitivity interferometer that was used to measure absorption characteristics of the atmosphere has also been produced.

Contributions to this report were made by: Lawrence Curran in Los Angeles; Paul Dickson and Robert Skole in Washington; James Brinton in Boston; John Gosch in Bonn; and Michael Payne in London.

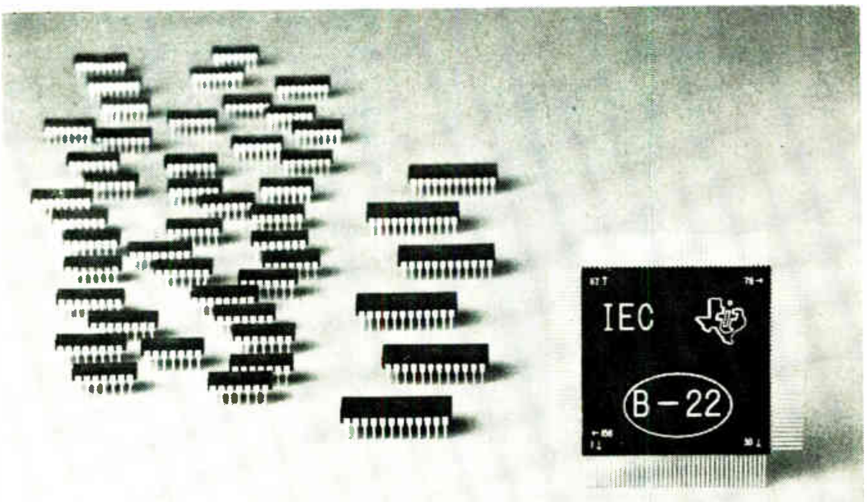
IC registration revisited

Lack of pressure from the military and stand-pat attitude of suppliers still stymies Electronic Industries Association's effort to register IC's

Despite more than two years of effort, integrated-circuit registration is still only a gleam in the eye of the Electronic Industries Association. Although officials of the trade group expected to issue type numbers for hundreds of devices when the registering program was announced in December 1965, not one with the 6N prefix for IC's has been issued [Electronics, Feb. 20, 1967, p. 217]. And now, no one at the EIA is willing to speculate when the first registration might appear.

In theory, registration represents the first step toward greater standardization of IC's. Nonstandardization, the reasoning goes, leads to higher unit costs and a fragmented market--situations that make it difficult for IC customers to develop second sources of supply. For all this, though, there's little prospect of early concerted action on either registration or standardization.

For in reality, there's surprisingly little anxiety in the industry about the lack of hard-and-fast IC standards. One reason for this is the absence of the kind of pressure the Pentagon exerted to obtain registration of discrete semiconductor devices during the 1950's.



Generation gap. Assortment of devices ranging from conventional IC's to LSI assembly is symptomatic of proliferation of designs. However, EIA's efforts to promote registration have so far proved unavailing.

I. House divided

Officially, the Defense Department has, since issuing a white paper early in 1967, maintained a position against the setting of standards for IC's (though it's also on record as favoring "the widest possible appropriate use of microelectronics in military systems"). But Pentagon officials still disagree on whether IC designs should be standardized for military applications.

On one side of the controversy are the Pentagon's businessmen who work in the Office of Technical Data and Standardization Policy, which reports to the assistant secretary of defense for installation and logistics. This agency tends to favor standardization as a means of reducing the number of goods, parts, or whatever, that must be bought by the armed forces.

A policy of standardization is practicable for buying tent pegs or toilet bowls, say officials at the Office of the Director of Defense Research and Engineering, but not for items such as integrated circuits. "You just can't apply the traditional, conservative yardsticks to this kind of technology," says a DDR&E source who, with a number of his colleagues, thinks that standardization might stifle innovation. "Mean time between failure has little relevance in the case of IC's," he says. "No one has meaningful data on how long such devices will last. How could they? Many parts have never failed. And you can't build a statistical bank without a reference point."

Apostles. Staffers at DDR&E favor throwaway modules with IC's over standardized assemblies. Replacement specs would simply spell out form, fit and function.

But if the Pentagon's businessmen haven't wholly made their point, they appear to have at least a partial victory. Officials close to both camps say it's a good bet that the Defense Department will soon begin asking contractors for more support data, especially information on how quickly component designs are obsoleted by technical advances.

Test case. Moreover, the Defense Department's IC testing standards will be published later this month. They establish procedures for uniform electrical, environmental, mechanical, and sequence checks for virtually every kind of integrated circuitry, centralizing the specifications of all the military services and the National Aeronautics and Space Administration.

As a rule, most IC vendors are less than enthusiastic about the prospect of standardization. Their customers, however, generally take an opposite position.

"I'd like very much to see some form of standardization, but it looks like it is a long way off right now," says dissenting Harry M. Luhrs, IC product marketing manager at the Semiconductor division of Sylvania Electric Products Inc.,

. . . some suppliers feel standardization of IC's would stifle innovation . . .

Woburn, Mass. "Nonstandardization deters general growth. If, for example, tests are not standardized, test equipment can't be standardized either; every new kind means new tests and new test gear—an expensive proposition."

Luhrs, however, appreciates the ironies involved in the situation: "On the one hand, buyers want standards, but on the other, they make it difficult by making their specs the standardization aims."

Luhrs feels that although the EIA people rate an "A" for their efforts in reviewing industry problems and spreading the word about specifications, "they aren't even getting to first base on IC standardization."

"Standardization of parts doesn't make much sense; new IC's are coming out too rapidly to make such a policy stick," says Lawrence Drew, of RCA's Aerospace Systems division, Burlington, Mass. "But there is useful work to be done with standardization of test requirements and specifications, definitions of parameters, and in user-vendor communications."

By any other name. Drew, who's on two EIA microelectronic devices committees, cites the 930 series of diode-transistor-logic circuits offered by a number of semiconductor houses as an example of how differences can creep into the "same" assemblies. Even though specs are almost identical, differences occur in epitaxial layer depth, line widths, geometries and pad sizes, he says. This is acceptable for those using the circuits in the middle of their operating ranges, but it isn't much help to the man on the outer regions, where the performance of the device might vary radically from vendor to vendor.

Sylvania's Luhrs agrees, remarking wryly, "you can get three or four reasonably interchangeable versions—if you aren't too critical about reliability or particularly hard-nosed about other specs."

Other voices. Ben Anixter, marketing manager for IC's at the Fairchild Semiconductor division of the Fairchild Camera & Instrument Corp., says he wants standardization, but questions whether it's physically possible. Anixter is also worried about retarding innovation: "The first resistor-transistor-logic circuits were put on 100-by-100-mil chips; they are now down to 20-mil chips. Registration would have kept us from making a change which allowed us to bring the cost down from $80 apiece to 25 cents."

Anixter says there is no pressure from systems companies: "The push from this source is to develop viable second sources."

Stuart Snyder, assistant director of engineering assurance in the research and engineering group of the Autonetics division of the North American Rockwell Corp., says standardization cannot be applied universally. He favors it where possible because "you can put more effort into assuring that you get better components." However, Snyder believes that standardization could mak IC users somewhat less flexible and receptive to new ideas.

Dialogue. "I'm for standardization where it aids communications with second sources," says Robert Roeder, senior engineer at the Hughes Aircraft Co.'s Aerospace Group, Culver City, Calif. Roeder says a lot depends on systems requirements: "We are beginning to find out that it's more economical to put more IC's into large, replaceable modules." On balance, however, because of the rapid pace of developments in IC's, Hughes has not pressed for standardization.

But Edward Keonjian, who heads the microelectronics and circuit design section at the Grumman Aircraft Engineering Corp., takes a harder line. "With over $200 million worth of IC's produced last year for thousands of systems, any talk about standardization's being premature is just plain foolish," he says. Keonjian is chairman of the Aerospace Industries Association's Users Committee, which has selected a number of digital and linear circuits for standardization.

Keonjian's assistant, Frank Rente, is concerned about standardizing the physical, rather than electrical, properties of microcircuits. "It almost seems as if IC manufacturers were deliberately trying to make it hard for the user," he says, recalling a panel session he attended at which a semiconductor marketing man said his company tries to package its new circuits differently in an effort to tie up the market.

Another proponent of standardization, Jorge Acosta, who heads the Reliability Physics Laboratory at the Raytheon Co.'s Missile Systems division, says: "Right now two manufacturers may sell gates which look alike on paper, but they may not publish schematics with their data. Thus, the engineer who buys from both does not know whether a level shift diode is at the base or the emitter of a transistor. Although the package, the pinning, and the function may be the same, drive-current typical values could differ 30% to 40%. I'd prefer worst-case specifications; 'typical' specs don't always reflect the real world."

Acosta also warns about the proliferation of terms. "Before you can test, you need to get your definitions straight. But with IC's, you find one firm calling a parameter 'minimum one input,' another company calling it 'threshold voltage' and a third taking a reverse approach and calling it 'minimum zero voltage.' You need a glossary."

Cost conscious. "Everything we do is based on costs," says Kenneth Tillmans, senior engineer at General Dynamics Corp.'s Pomona division, "We feel that eventually standardization would yield lower costs." However, he points out that rapid advances in the design of integrated circuits make nonstandardization almost imperative. "If you have two assemblies performing the same function and one uses a few nonstandard parts and the other many standard parts, which are you going to take? You'll put the cheaper one into production; we're faced with that today," he says.

II. Disintegrating demand

Semiconductor makers are more reticent in their approach to registration and standardization of IC's. Says a source at one major house: "The situation boils down to the fact that the design guys among our systems customers want state of the art and the latest changes. This is not compatible with standardization. We sell what people want to buy." This explains why EIA and other industry groups haven't suc-

. . . systems designers aren't keen on standardization . . .

ceeded in pushing standardization, he says. "Paradoxically military customers say they want standardization. But it's really only the reliability and purchasing people. The designers don't want it and they're the ones who are calling the shots."

Similarly, Allan C. Bahr, market applications manager at the Amelco Semiconductor division of Teledyne Inc., says he sees no pressure at all for registration, from users, makers or the military. The users, he says, tend to create their own drawings, and the makers won't register unless they must, because of the time and expense involved.

"Integrated circuits will be registered only when the customer demands it," Bahr says. "That will occur when he stops believing the maker's data sheets." However, Bahr sees an incipient trend that is creating some pressure for standardization: cost-consciousness is leading some designers to work with off-the-shelf devices. At best, however, this represents informal standardization.

Wrong number. One of the problems of EIA registration of IC's, says a maker, is the lack of provision for reserving registration numbers. "If tomorrow we registered eight devices that were all of one family, they would have sequential numbers," he says. "But if six months from now we came up with a ninth device in the same family, it would be impossible to get it into the same numerical sequence as its brothers. For all we know, it could be assigned a number sequentially related to an entirely different device, perhaps even made by a different company."

Another executive who doesn't think formal rules are necessary for standardization is John Ekiss, manager of circuit development at the Philco-Ford Corp.'s Microelectronics division, Blue Bell, Pa. He says: "Systems makers are pushing too far; they want us to tell them everything about a product—including proprietary information—even when that data can't possibly help them. When we're talking of standardization, what we're really saying is interchangeability."

Systems houses generally buy

from two or three vendors using common specs the systems house has developed, says Ekiss. A result is a kind of underground standardization: "We're gravitating to standardization, even if no one issues an edict, because it's a good way to do business."

Some suppliers cite their customers' propensities for tinkering as a cause of the standardization hullabaloo. And some systems companies agree. One source at a New England firm says: "Engineers pick up a spec sheet and begin tightening here and there; using a spec as a springboard is costly."

III. Pilgrim's progress

C. Everett Coon, the EIA's type administrator, says his organization is beginning to move faster on standardizing microelectronic devices. "We've had to get mutual understanding and trust between users and suppliers as never before," he explains. "It's because they are so close to each other in this area." He notes that frequently users outnumber makers on committees.

During the past year, three new EIA registration circuit formats have been issued. There are formats for semiconductor integrated logic gate circuits; semiconductor integrated linear amplifier circuits; semiconductor integrated linear amplifiers; semiconductor integrated bistable logic circuits and semiconductor integrated linear wideband, pulse and video amplifiers. Coon says these documents cover more than 95% of commercially available devices. Formats being prepared include sense amplifier/comparators, rf/if amplifiers, and voltage regulators.

Coon says that although industrial and consumer products are becoming sizable users of IC's, it will probably require a Pentagon push before registration comes about. "Then, industry and consumer goods makers will be obligated to use them," he says. "And one of these days the services may have microelectronic modules that can be used in a number of applications. This could lead to registration of the entire module," he says.

Contributions to this report were made by: James Brinton in Boston; Lawrence Curran, Bill Bell, and Darrell Maddox in Los Angeles; Walter Barney and Peter Vogel in San Francisco; Robert Skole and William Hickman in Washington; and Peter Schuyten and Howard Wolff in New York. It was compiled by Eric Aiken in New York.

Soviet computer program has as many downs as ups

Government inefficiency, technical problems, and personnel shortages slow Russia's drive to computerize virtually all sectors of its planned economy

By Howard Rausch
Moscow news bureau

The technology-conscious Russians have embraced the computer whole-heartedly. But the love affair isn't totally requited. Despite some progress, many industrial problems in the world's oldest planned economy are directly attributable to shortcomings in computer technology.

In their franker moments, Soviet specialists concede that the excellence of their design and programing is offset by uncertain reliability of components and deficiencies in peripheral equipment.

Soviet designers, for example, boast they have compiled computer programs for 80% of the nation's numerically controlled machine tools—a proportion higher than in any other country. Programs have also been developed for such complex processes as electron-beam cutting and welding. Yet a Renault engineer, helping to modernize the Moskovich auto plant in Moscow, found a serious lag in the Soviet's NC capabilities. When he inquired, the Russians blamed the slow development of computers and worse problems with peripherals.

I. Somebody goofed

Visitors to the computer center in Novosibirsk last summer found the Soviet Union's fastest computer —the BESM-6—idle, awaiting magnetic disks. None were made in the country. The center's director cheerfully dismissed the situation as "a bureaucratic oversight." Since then, extremely limited production of disks has started.

Another bureaucratic gaffe is blamed for the fact that only half of the 10 BESM-6 machines in existence late last summer were fully operative. Someone in Moscow had revised specifications for peripherals a year earlier—too late to assure delivery on time.

Government inefficiency is only part of the problem. Equally important is a serious shortage of qualified personnel.

When the vital Algol compiler for the BESM-6 was being developed at the Academy of Sciences' computer center, only 10 trained programers and analysts were available. Soviet specialists concede that number is totally inadequate.

Stood up. While waiting for peripherals, the first civilian BESM-6 was idle two years at the computing center on Vavilov Street in Moscow. Even now, the machine can handle only three problems simultaneously—well below its theoretical capacity of 10. The unused channels still need software and additional terminals.

II. Limited liability

Significantly, the factory that assembles the BESM-6 under the aegis of the Ministry of Radio Industry has no responsibility for peripherals of software. It's up to the user to develop or find his own. The situation, says computer specialist Victor M. Glushkov, "is tantamount to producing telephones without earpieces or cables and making the customer supply his own."

In the case of the idle BESM-6, the center itself prepared the executive system and Algol compiler. Other software was farmed out—the Cobol and Fortran compilers to a Kiev institute, Alpha to Novosibirsk, and Algek and two-level assembly language to two other institutes in Moscow. (Algek, used principally for economics problems,

Hung up. The Soviet Union's fastest computer, the BESM-6 was idle at the Novosibirsk center last summer for lack of magnetic disks.

and Alpha are Soviet versions of Algol.)

But few users have the authority of the Academy of Sciences computing center to order development of software. A typical customer, the Frazer machine-tool plant, had so much difficulty with software its director suggested the government bar production of computers without translators and other software.

In addition, engineers complain that one of the most widely used punch-card feeders, the BY-700, requires a fulltime operator. "It's also very hard to find out who has approved such unreliable machines as the P 80-6 and PL-20 punchers," complains one. Consumption of magnetic tapes is generally double what it should be because of poor reliability, reports another.

Service with a smile

In Russia's centrally administered economy, computer manufacturers have no responsibility for developing or producing peripheral equipment and software. As a result, the Soviets have tacitly given top priority to this aspect of work, farming it out to support organizations.

Anatoly A. Dorodnitsyn, director of the Moscow computing center, exemplifies this push. Dorodnitsyn heads a 400-man staff that includes 250 scientists and mathematicians; his agency furnishes programing service for the Academy of Sciences, and does research work in such areas as pattern and sound recognition and data transmission. In addition, the center serves an increasing number of organizations outside the Academy on what amounts to a commercial contract basis. For example, Mosavtotrans, the agency that monitors and directs the movement of Moscow's 30,000 trucks and buses, has long been a client.

Profile. The 58-year-old Dorodnitsyn is a three-time winner of Stalin Prizes, once the highest accolade a Soviet scientist could achieve. He reads English and has traveled in both the United States and Canada. Dorodnitsyn enjoys expounding mildly heretical views while puffing at a cigarette through a short amber holder. For example, largely as a result of his efforts, the computing center has not been caught up in rigidly defined five-year plans, and is given only basic directions. "A mathematician can change the plan more easily than a scientist," Dorodnitsyn explains.

Nor is Dorodnitsyn an empire builder. "I've read Parkinson's Law," he says. "The director of an institute must at least be able to understand what his collaborators are doing, and this is difficult when the organization gets too big." The computing center has added only 150 people in the past 10 years, bringing the current complement to 400. Dorodnitsyn says he hopes even this modest growth rate has leveled off.

As a rule, Soviet complainants don't identify the erring parties—presumably because they don't know who they are. Paradoxically, computer experts in this largest of centrally administered societies are generally hazy as to who has the last word on what's to be built, for whom, and to what specifications.

This comparative anonymity may be at least partly responsible for another Soviet problem. Every Russian machine seems to have a different tape or card format. And no program written for one processor seems to works on another.

For all the limitations involved in their craft, Soviet designers and programers are talented and resourceful. An American specialist who has visited most of the major Soviet computer centers says: "They're at least five years behind us in design, but they're probably ahead in getting the most out of a machine."

Foreign designers are particularly impressed with Russia's small, special-purpose computers. British experts recently reported an "impressive" Soviet attack on problems of semiautomated, high-volume production plants, adding that certain Soviet systems were better than their British counterparts. Likewise, an American specialist was "intrigued by the Russian emphasis on and accomplishments in computer-aided design."

Big step. The Kiev 67, a small machine still in development, furnishes evidence of the Soviet thrust in CAD. A comparatively untrained technician, using a light pen on a cathode-ray-tube display will be able to alter designs to generate new instructions for numerically controlled machine tools.

III. Russian dressing

Soviet designers also stress simplicity in some general-purpose machines. An example is the Promin, a single-address computer that performs 1,000 additions or 100 multiplications a second—a rather slow performance by Western standards. It automates engineering computations in scientific research and design, solving simultaneous differential equations of the third and fourth order.

The Russians are also proud of the hybrid Dnieper-2 system used

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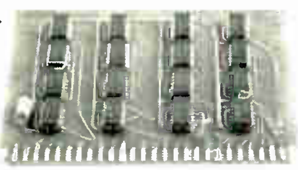

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Scientific Data Systems, Santa Monica, California

Circle 167 on reader service card

. . . Soviet planners are confident that their economy will be computerized . . .

for solving industrial problems. The system combines two digital control computers, the Dnieper-21 and Dneiper-22, with an analog machine, the MN-10M; the analog unit simulates the process being controlled. The three-or-more-machine complex permits simulation of direct digital control systems as well as multivariable and optimizing setups. The transistorized Dneiper-2 installation is compact enough for laboratory use.

Remote control. For all the bureaucratic sins, the Russians have succeeded in computerizing a good part of their lives. Every Friday morning the computer center of the Soviet Academy of Sciences sends a package of calculation across Moscow to Mosavtotrans, the agency that dispatches and routes the city's 30,000 buses and trucks. From these figures, planners schedule every trip for the next week.

And at a television plant in Lvov, a Minsk 22 computer makes production-control decisions for management; it also prescribes distribution of materials, the duration of workshop shifts, and the speed of the major conveyor.

IV. Model society

Using computers, Soviet laboratories are modeling everything mathematically—with the possible exception of miniskirts. Perhaps the most ambitious undertaking is Novosibirsk's effort to compile programs for determining probable effects of catalysis in chemical processing. This system would replace or supplement the present hit-or-miss approach.

There are also programs for controlling critical-path techniques in big construction projects, receiving processing weather data from satellites, prospecting for minerals, predicting when and where certain fish will be most abundant, and forecasting river flow three years in advance.

Hinterlands. To increase construction efficiency in outlying areas, a Laboratory of Mathematical Methods and Computing Machinery has been created, equipped with a Minsk 22 and a Promin computer. This agency is charged with formulating a theoretical basis for optimizing designs for rural construction. The mandate covers everything from delivery of equipment to creation of a master capital-construction plan.

Among the newer national efforts, is an attempt to computerize the Soviet fertilizer industry. A Minsk 22 is being used to process information on production of 28 kinds of plant food and to supply data to such interested parties as industrial ministries and the governments of member republics.

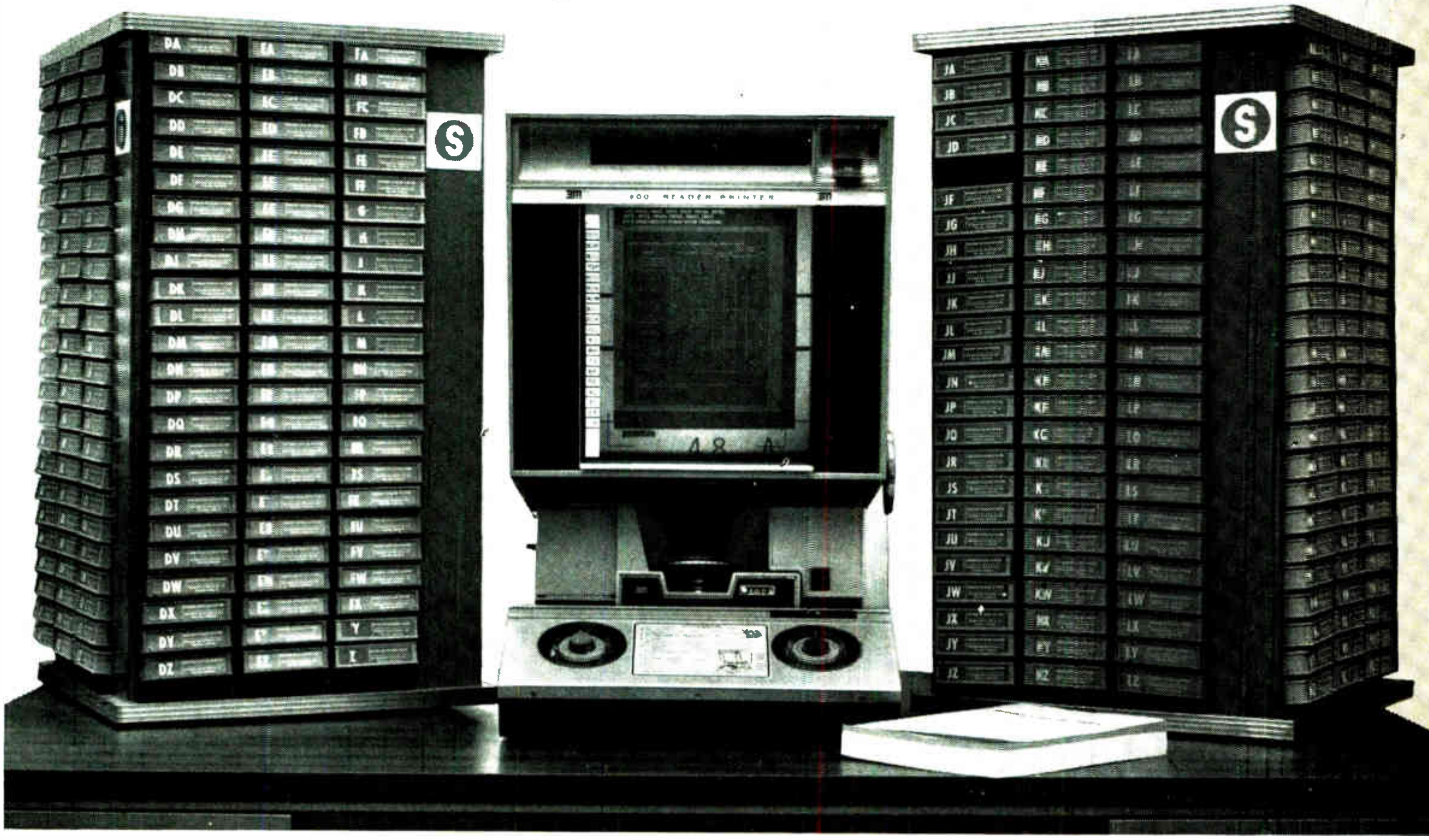
The Minsk 22 will correct obviously defective data automatically, then arrange the information, calculate the derived values and deviations from daily and monthly plans, and do other calculations.

Retail outlet. One of the first commercial computer applications is at GUM, the big department store on Moscow's Red Square. A Minsk 22 has been installed to process sales and inventory data.

Each price tag now contains a section of punched holes; it also performs what Soviet officialdom optimistically calls "market forecasting." However, while the computer seems able to keep track of sales fluctuations, it is still unable to adequately gauge demand in a scarcity economy where nearly any quality item can be sold.

Taking a flier. A year ago, Aeroflot—the state airline monopoly—announced installation of a computerized reservation system. It is still impossible, however, to book a domestic flight more than 10 days in advance, to do it at any time by phone, or to receive a confirmed reservation before the day of the flight.

But Soviet planners are confident the economy will eventually be computerized. Recently they introduced a classification system in which every product will receive a 10-digit index number for data processing. (Despite the wide varieties of format, most Soviet computers can handle 10-bit words.) The system will lead, Russians say, to a central inventory of every product anywhere in the country.

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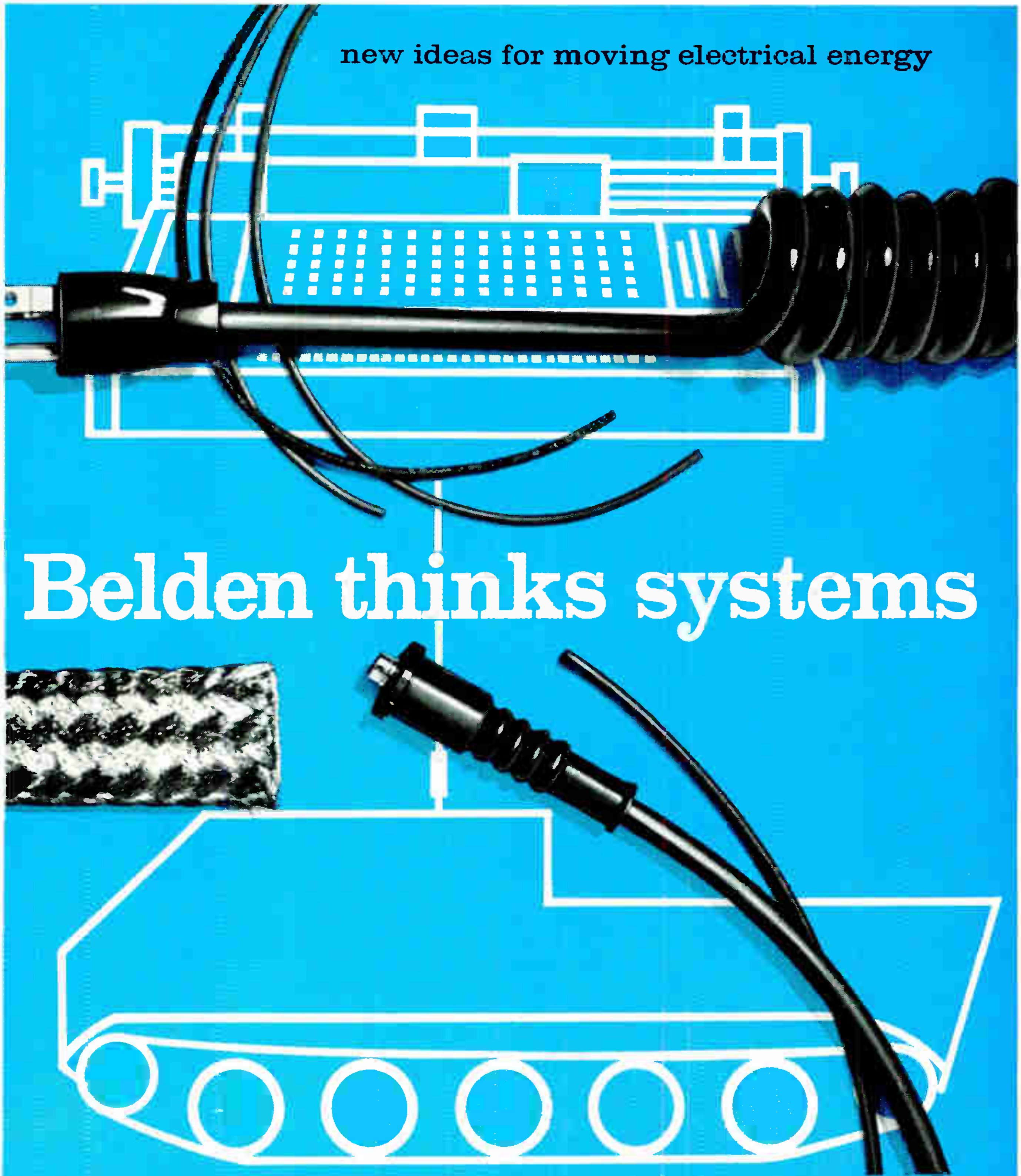
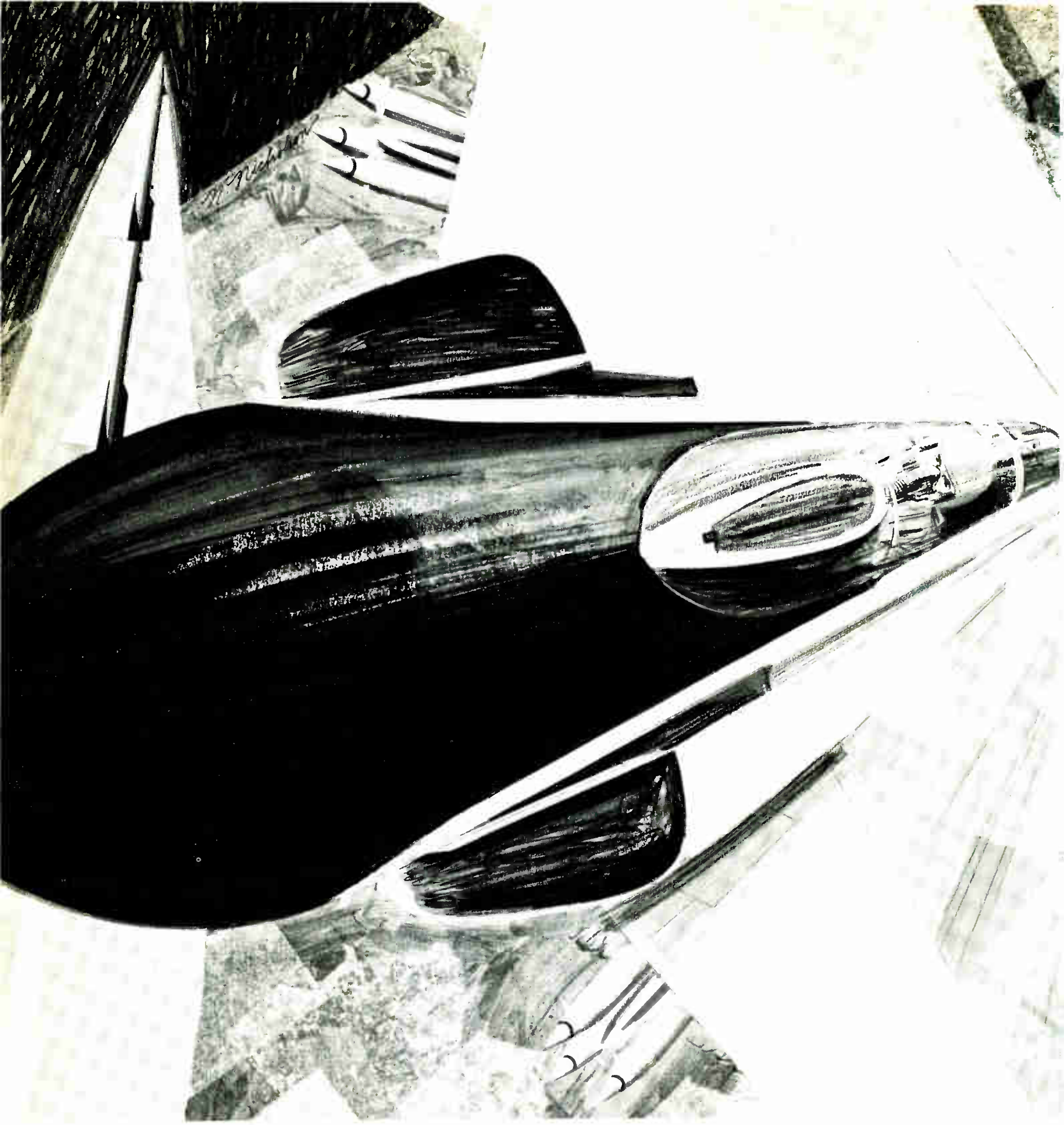


link each component, they can help simplify designs, enhance reliability, save internal space, even reduce assembly costs. That's worth investigating, isn't it? Then get together with the wire men who think systems. You can reach them at the place that makes all kinds of wire for all kinds of systems—Belden Corporation, P.O. Box 5070-A, Chicago, Illinois 60680.

G-3-7



New Products

New semiconductors

MOS bandwagon starts rolling

Industry leaders producing metal-oxide-semiconductor integrated circuits as improved reliability, high packing density attract equipment designers

By Walter Barney
Manager, San Francisco Bureau

Some of the giants of the industry are making it clear this week in their IEEE exhibits that they'll be beating the drums for metal-oxide-semiconductor integrated circuits, until recently a small-house specialty.

- General Electric introduced a frequency divider, first of a series of basic IC's.
- RCA showed a line of complementary circuits, its favorite approach.
- Texas Instruments entered a half-dozen me-too circuits, the start of a catalog product line.
- Westinghouse demonstrated "a capability."

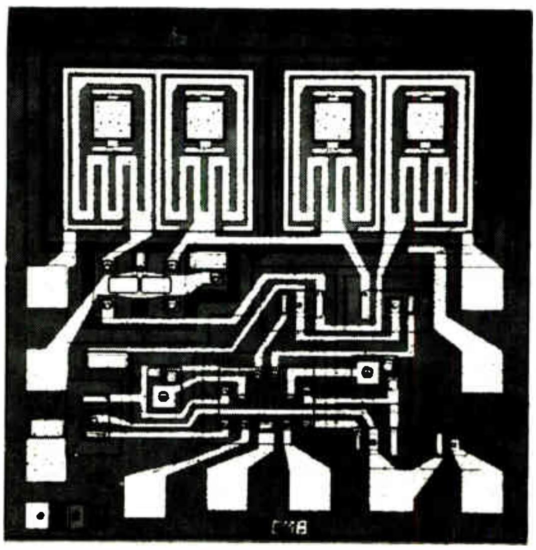
Apparently convinced that bipolar techniques are firmly established and it is now time to turn to MOS, the big three in semiconductors—Fairchild, TI, and Motorola—are moving from custom work to standard products [Electronics, Jan. 8, p. 11]. And both GE and RCA, late starters in digital IC's, are making MOS the principal products of their lines.

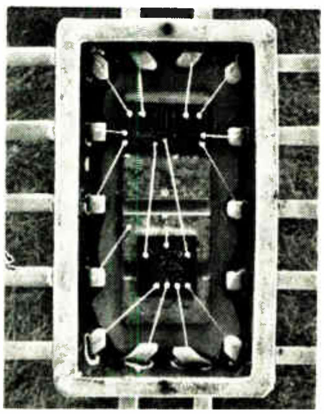
Meanwhile, the small group of companies which pioneered the technology has worked diligently to overcome the resistance generated by an oversell a few years ago. Their efforts are beginning to pay off.

Two at start. Three years ago, General Micro-Electronics Inc. and the General Instrument Corp. were the only significant names in MOS IC's. Today there are nearly a score of suppliers. General Instrument and the company that swallowed General Micro-Electronics, the Philco-Ford Corp., are churning out a respectable 35,000 circuits a month. After a couple of static years at the $5 million to $6 million level, total MOS sales reached $10 million last year; most suppliers expect them to double this year and to double again in 1969. More significant, by the end of this year, for the first time, the bulk of the sales dollar is expected to go for hardware, rather than engineering and design. And where once the military was the sole support of MOS companies, industrial users are now beginning to design MOS into a variety of equipment.

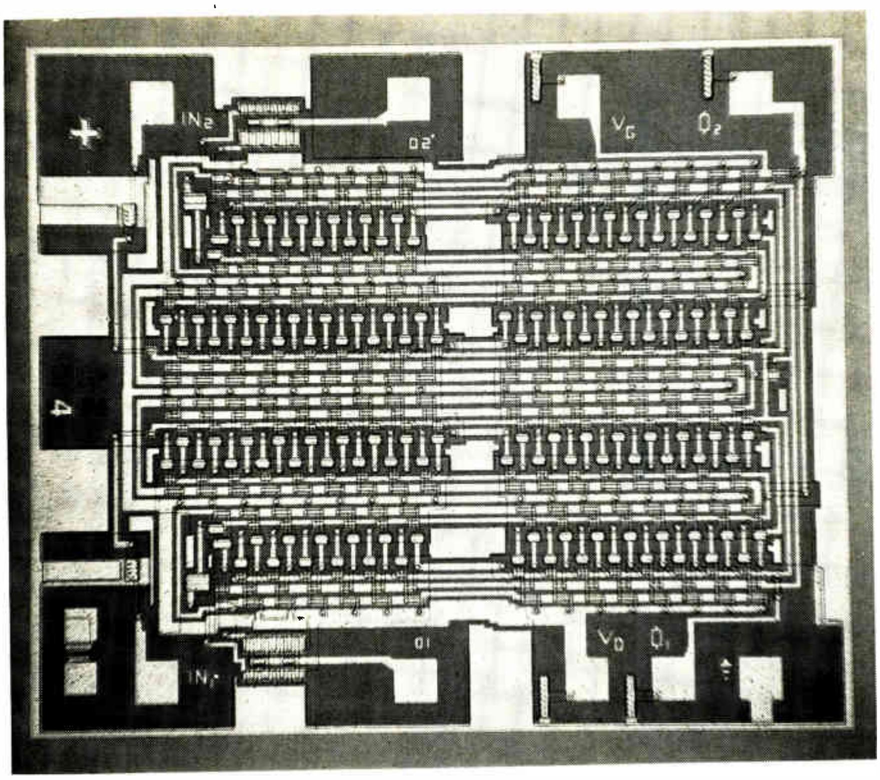
Most MOS manufacturers believe that the devices are ready for use in computer peripheral equipment, calculators, radars, process controllers, multiplexers, and memories, including scratchpads, read-only memories for computer subroutines, and circulating types that act as delay lines.

Dense but slow. The advantages of MOS are its high packing density, low cost, and low power requirements. One disadvantage, the slow





Wed. Siliconix' monolithic marriage of bipolar, MOS (left) costs less, is more reliable than earlier hybrid.



Double shift. Typical of the recent MOS integrated circuits is this dual 32-bit static shift register from TI. It operates between d-c and 1 Mhz.

speed of the devices, has not been nearly as great a handicap as the users' concern about MOS reliability. The thick oxide process popularized by General Instrument and in general use throughout the industry for several years is given some credit for improvements in yield; but most manufacturers say that it is a better understanding of the process, and of the nature and effect of impurities in the oxide, that is the real reason for the higher yields.

Whatever the cause, manufacturers are now sufficiently secure about the process to be candid about past difficulties; they have moved ahead to develop markets. With the appearance of these markets has come the entry of the big three. Since last fall, the Semiconductor division of the Fairchild Camera & Instrument Corp. has introduced two MOS IC's a month. Motorola made its debut with two circuits designed for electronic organs, and TI showed its first shift registers, logic units, switches, and amplifiers at the IEEE show.

I. Who's buying?

For many years, the chief supporter of MOS has been the National Security Agency. NSA is believed to have accounted for as much as 20% of the MOS market in 1965; in 1966 and 1967 its share was between 10% and 20% and, even this year, when the market is beginning to take off, its share may be as much as 10%.

Through Texas Instruments and Honeywell Inc., NSA is now letting classified contracts for the next generation of R-13 equipment for cryptographic communications. It's believed that NSA wants low-cost, reliable devices to make telephone communications secure; clearly, there would have to be a lot of equipment, probably one system or device per phone.

About 75% of MOS sales today are in custom or special contract work. One of the few production lines of any size is Philco's for the Victor Calculator; this single product accounts for half of Philco's output. But Don Richard, an old Philco hand who became marketing director of American Microsystems, Inc., last fall, says that more than half a dozen programs, about evenly divided between military and industrial, will begin using MOS hardware in the last half of this year.

Richard will not identify these programs; MOS manufacturers are, if anything, more secretive about their customers than the rest of the semiconductor industry. Some programs, however, are known. A sampling:

- Wright-Patterson Air Force Base has let contracts, worth $3 million, to Philco, TI, and RCA, for development of large-scale arrays for navigational computers. The Air Force wants a machine costing under $20,000. The C-5A transport plane, being developed by the Lockheed-Georgia Co., will use MOS circuits in multiplexing signals in its Madar (malfunction detection, analysis, and recording) system. (The Boeing Co. will also use MOS for multiplexing the entertainment system signals in the 747 superjet.) MOS will be used for switching in the F-111, the Phoenix missile, the Navy's Standard missile, the anti-radiation missile, and the SAM-D. The Harry Diamond Fuze Laboratories, the Picatinny Arsenal, and Honeywell's Ordnance division will use MOS shift registers as delay lines in fuzes.
- The Whittaker Corp., and the Ground Systems division of the Hughes Aircraft Co., are using MOS in radar "defruiters," which eliminate spurious signals. The technique is to store one signal and compare it with the next.
- The Lockheed Missiles and Space Corp. is designing MOS arrays into an advanced guidance package.
- On the industrial and commercial side, Philco will deliver circuits to a Japanese calculator maker, and the National Cash Register Co. has an extensive developmental program in large-scale integration, under which MOS arrays are being evaluated.

The computer terminal and peripheral field is rich in potential, and every MOS maker expects it to be a sizable market. Under a directive from corporate headquarters, the Santa Clara, Calif. facility of Philco's Microelectronics division, where MOS work is centered, is currently engaged in a program to provide more support for the company's nearby Western Development Laboratories, and its Space and Reentry Systems division. One specific area of work is on MOS memories that refresh the displays at remote computer terminals.

Down memory lane. Since the MOS transistor is either on or off, it is admirably suited for memory functions; the main question for the designer is how to address the memory. The 1,024-bit read-only memory, recently introduced by Philco,

Shifting by 10's

Why do shift registers, the nearest things to a standard MOS circuit, come in decimal sizes for sale to an industry thoroughly committed to the binary system? One answer is that delay requirements seem to be independent of methods of counting; another is that the standard may have been set by that most famous of MOS systems, the Victor calculator [Electronics, Mar. 6, 1967, p. 231; Oct. 30, 1967, p. 26].

The calculator used six dual 48-bit shift registers, explains one person familiar with its history, and that circuit was proprietary to Victor. The easiest way for the manufacturer (General Micro-Electronics) to turn it into a standard product was to add four devices and produce a dual 50-bit register. The system of decimal increments stuck; Philco, American Microsystems Inc., and General Instrument now make the dual 50.

Some binary registers are available, and more are in the offing.

has eight parallel series of 128 bits each, addressed by a 2 by 5 matrix. A random access memory would need a 5 by 5 matrix to address any bit of a 32 by 32 array; Philco saved chip area on the address matrix at the expense of flexibility since the user is bound to an 8-bit word if he wants to make most efficient use of the circuit.

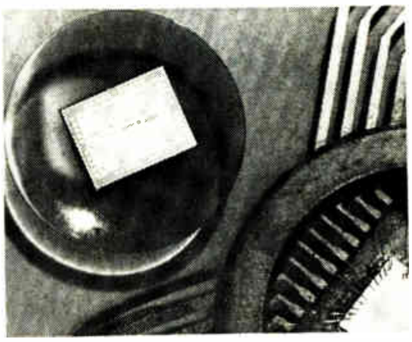
The National Semiconductor Corp. will introduce soon a 256-bit read-only memory, with all decoders and counters on the chip, that will have fully random access. In effect, it will have 256 one-bit words, and the user will buy one chip for each bit in his own word. This read-only memory market, says product marketing manager Floyd Kvamme, will be mostly in computer subroutines, such as the square root process, or for reading out constants. National has also found solid customer interest in using subroutines as control logic in test equipment, instead of hand-wired NOR gates. "Fixed-program logic will be done with MOS," Kvamme says.

Scratchpad memories, which must be fully addressable since information is written into them, are useful suppliments to core memory. Here MOS's slow speed may be a disadvantage but the greater number of devices per chip can offset that difficulty wherever speed is not a primary need. American Microsystems Inc. has developed a 32-bit scratchpad, for a military customer, that has 1.8-microsecond access time and operates at a bipolar-compatible 1.9-volt threshold voltage. It will drive two high-current TTL gates. The company has a 256-bit scratchpad under development.

Shift registers have been the nearest thing to a standard MOS product, and if users could have agreed on a preferred bit-length, prices might have dropped even further than they have. As it is, prices of the popular 100-bit shift register have dropped from $50 to $75 a year ago, to prices that range from $10 to $20, and will continue to fall. The trade-off here is in number of pads versus chip space; the more places the user can tap in, the more flexible the device—but the more pads, the more wasted real estate.

Packed. The biggest register currently available is probably the 426-bit device developed for the military by AMI. At six devices per bit of delay, plus extra output circuitry, there are about 2,700 transistors on the chip.

Shift registers make excellent delay lines, and the only argument is over price. National's Kvamme shrugs the argument off and compares National's MM902 100-bit shift register to the SN7473, a TTL dual flip-flop. The MM902 is on a 63 by 67-mil chip, he points out, comes in an 8-lead TO-5 can, and costs $14.80 in lots of 100. The SN7473, on a 64 by 67-mil chip, is twice as difficult to test, comes in a 14-lead dual inline package—and costs $4.00 in quantities of 100. "There's no reason why the 902 won't be that cheap eventually," Kvamme says. One factor that will hasten that day is plastic packaging; many firms are currently working on passivation techniques to make it possible. General Instrument is believed to be developing a new passivation process at its Salt Lake City laboratory.



Packed. Digital differential analyzer from Autonetics is 125 x 100 mils.

One of the chief arguments against IC memories has been their volatility—the fact that all stored information will be lost if the system accidentally loses power. (By sequencing down the voltages slowly, and in the proper order, core memories can be designed to retain data when power is lost.) But the problem may be illusory. Donald T. Valentine, National's marketing manager, says that the systems companies are not worried about volatility since they recycle memories after loss of power. At Westinghouse, engineers are trying to build nonvolatile memories using nitride films instead of oxide.

II. Through thick and thin

For simple circuits, MOS yields are now comparable to those for bipolar circuits; yields have increased by as much as 10 times in the past year. Closer control of the thickness and purity of the oxide has been the chief factor in boosting yields, says Autonetics' Arthur Lowell, assistant general manager of the North American Rockwell division's research and engineering operation.

Almost everyone uses some form of the thick-oxide process—National Semiconductor is a prominent exception—which reduces pin-holing by making the oxide over the p regions thick, while leaving a thin layer over the channel so that it can be inverted with small gate voltages. Typically, the oxide over the source and drain is 10 times as thick as the 1,000-angstrom oxide over the gate. There are several ways to achieve these differing thicknesses: GI, for example, grows a thin layer of oxide, etches through to form the p regions, then deposits a thick layer of oxide over everything. Philco begins with the thick deposited layer, etches down to the silicon surface, then grows a thin layer of oxide.

Common to both approaches is the fact that the gate oxide is

. . . better process control means increased yields . . .

grown. The big problem, according to Jerry Farrell, manager of MOS production at National, was to achieve what he calls an oxide with "integrity." The move to thick oxide was intended to minimize flaws or latent failure mechanisms—"but that is like taking aspirins," he says. "We want to grow a truly amorphous oxide, with no concentrations or high stress points." Moreover, says Farrell, the thick oxide process tends to make the dopants pile up over the p regions.

Grown oxides are clearly superior in this respect, as Philco learned the hard way. In its original process, which had embarrassingly low yields, the company was depositing a thick layer, etching away 1,000 angstroms over the p regions, then etching right down to the silicon over these regions—the theory being that the gate area, having started 1,000 angstroms thicker, would still have its thin layer when the rest of the oxide was etched away. But the etchant tended to go right through this layer as well, since the deposited oxide was not controllable. The change in process, which took place early in 1967, increased yields and enabled Philco to cut prices in half last September.

Whatever the process, the key to yield increases has been improved process control. AMI has designed superclean facilities; National has put a great deal of emphasis on testing at various stages during the process, obtaining curves that tell where failures occur and why.

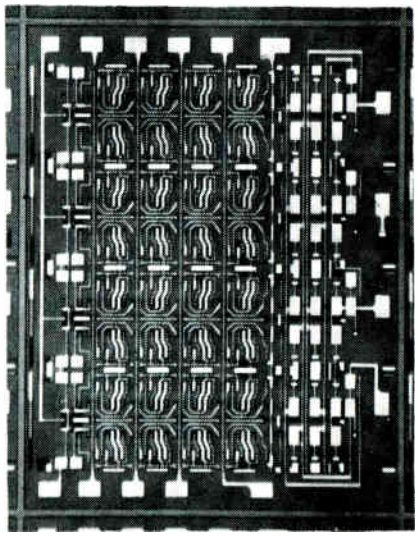
III. New tricks

With improved processes, and with the greater understanding of how MOS devices function, has come an improvement in reliability that has been reflected in user acceptance. During a study for the Lockheed Electronics Co., Siliconix Inc. disposed of three traditional difficulties in building reliable MOS devices. They were ion migration in the oxide, leading to large swings in threshold voltages, sneak leakage paths between source and drain caused by ions in the oxide, and oxide puncture caused by electrostatic voltages.

Siliconix found that using phos-


128
NORTH

phorus-impregnated oxides, and covering the gate oxide with metal immediately after it is formed, a step also taken by GI, stabilized threshold voltages. Changing geometries, in one case, so that the source is a dot, completely encircled by a circular gate, eliminated sneak leakage; and building zener diodes in parallel with each gate, so that charges are shunted to the substrate before the voltage is large enough to puncture the oxide, re-



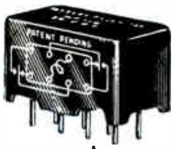
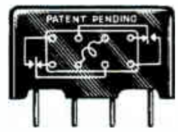
Remember. The 32-bit MOS memory from Westinghouse is a complementary device.

duced electrostatic puncture. National met the latter problem by switching to 100 silicon, which has a lower pn junction breakdown between gate and base material than does 111 silicon; the pn junction can thus protect the gate oxide.

With the process under control, the manufacturers have begun to get fancy. It is already no trick to build devices that operate at voltages low enough to interface directly with bipolar circuits, a desirable step because all-MOS systems are rare. The next move is to build both types of circuits on the same chip. Bipolar manufacturers are using MOS field effect transistors as the input stage to linear amplifiers; in this respect, the MOS device is peripheral to the circuit function.

New breed. The first circuit in which the bipolar elements will serve the MOS function is probably a chip made by Siliconix [Electronics, Mar. 4, p. 25]. That company introduced a hybrid series of MOS analog gates and bipolar drivers about a year ago; it is now replac-

Circle 181 on reader service card→

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

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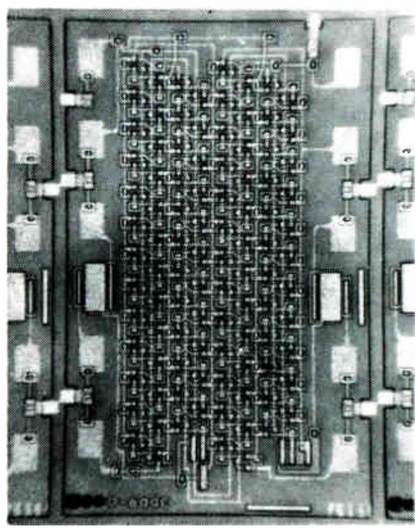
ing that two-chip package with a direct plug-in replacement containing npn and pnp transistors, p-channel MOS FET's, zeners, and resistors, on a single chip. It has also developed an integrator with 8 MOS transistors and 2 npn's.

One difficulty in marrying the technologies was that, typically, MOS is built on an n-type substrate and bipolar on a p-type substrate, with an epitaxial layer. Siliconix had to build both types of devices on the layer, and had to make certain compromises in the bipolar elements to accommodate the MOS. Nevertheless, says chief engineer and vice president Arthur Evans, the chip can be a direct replacement for the hybrid version except if special parameters are needed.

The process, Evans adds, is a general one that is applicable to other bipolar-MOS applications. The driver/switch circuit is useful in multiplexing, an area where Siliconix may have a head start on other producers.

The other state-of-the-art development is in complementary MOS IC's, which offer big gains in power savings and speed, plus bonuses in fanout and noise immunity. Here the drumbeater is RCA, which claims that since complementary circuit characteristics are less dependent on individual component characteristics than is the case with single-channel devices, yields are higher—and that this improved yield more than compensates for the additional processing costs.

In complementary circuits, n-



Stable. Register from Westinghouse uses nitride layer over oxide for stability.

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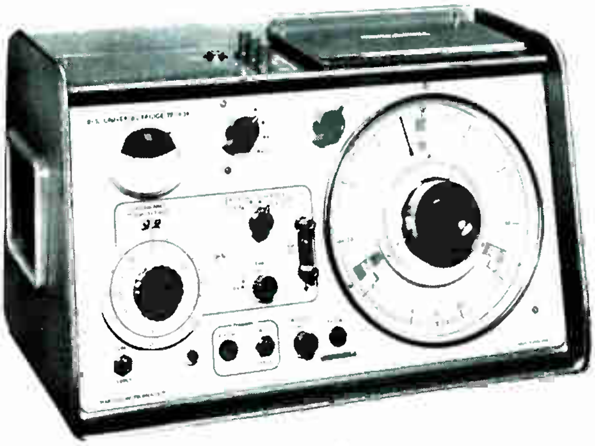

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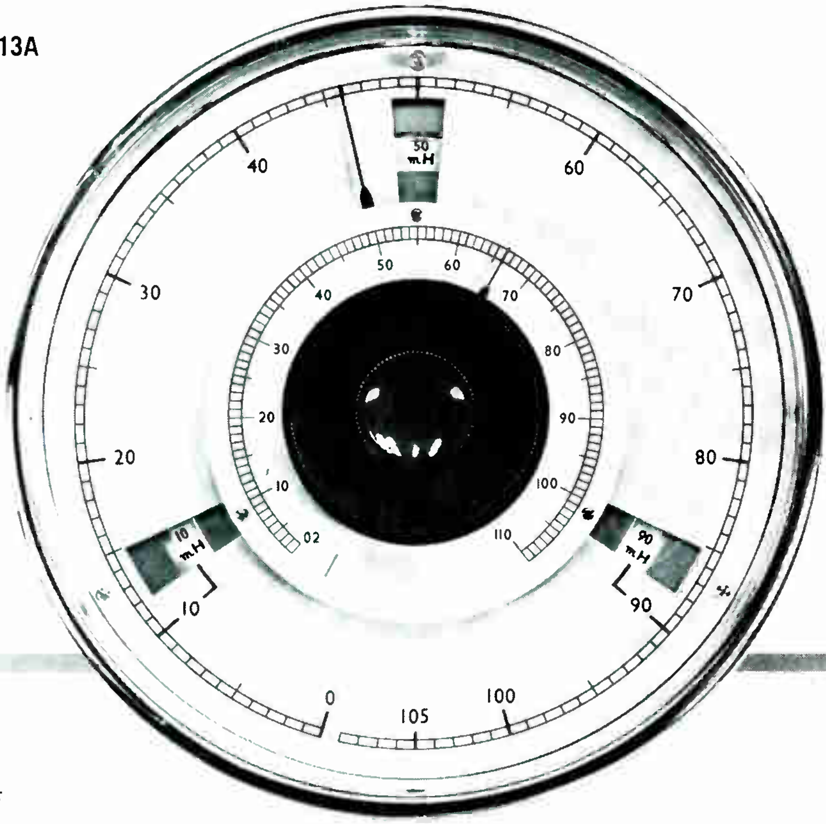

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channel and p-channel transistors are arranged so that the circuit operates regardless of input signal polarity. RCA says that single-channel makers are moving to multiphase clocks to attain complementary properties, and that this additional clock circuitry takes up space.

The Molecular Electronics division of the Westinghouse Electric Co. has also built complementary circuits, and the approach is being given heavy consideration throughout the industry. General Instruments has publicly pooh-poohed complementaries; but its competitors suspect that the successor to GI's MTOS devices, promised for this spring, may be a complementary series.

IV. Large scale picture

Even when MOS was hard to make and impossible to sell, it was heralded as a natural vehicle for large-scale integration. The high packing density obtainable has two advantages: it permits building complex devices on a relatively small chip, increasing yields; and it raises the effective speed of the circuits, since the main barrier to high-speed MOS operation is in overcoming the high input impedances while going from chip to chip.

The Hughes Aircraft Co. apparently bought the Raytheon Co.'s MOS line because it wants to exploit the technology in respect to LSI. Alden Stevenson, director of applied research at the Guidance and Control Systems division of Litton Industries, which includes a semiconductor operation, says flatly that "the era of LSI, using MOS circuits, is here." His division makes military

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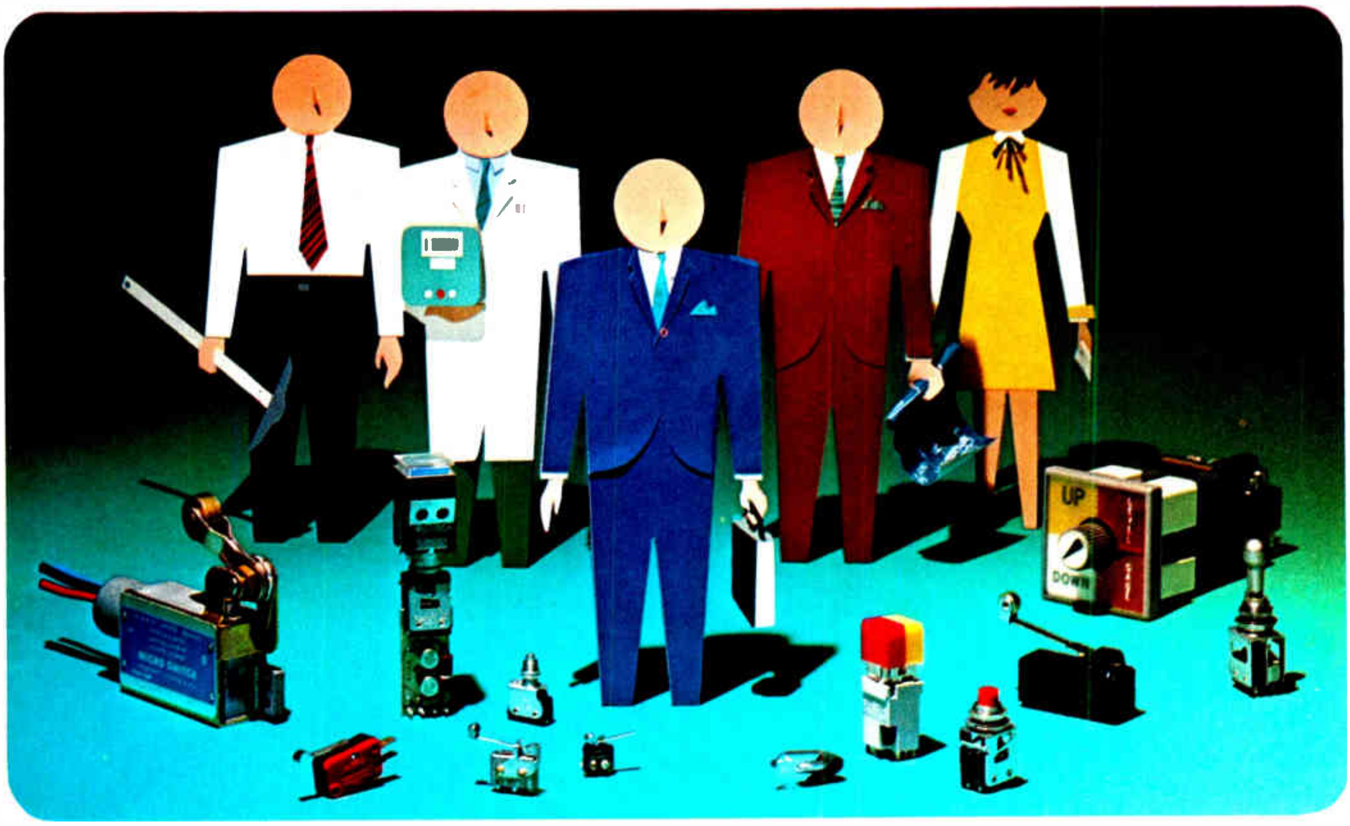

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HONEYWELL INTERNATIONAL • Sales and service offices in all principal cities of the world. Manufacturing in United States, United Kingdom, Canada, Netherlands, Germany, France, Japan.

and commercial navigation systems, and weapons release systems, which call for great numbers of digital circuits. The very name of one new MOS company, Electronic Arrays, Inc., of Mountain View, Calif., indicates that it was formed to make LSI devices; and another company is presently being formed solely to manufacture complex MOS wafers.

But nothing about LSI is simple. The custom-versus-standard circuit argument is already generating countless cost and sales curves. Earl Gregory, vice president of Electronic Arrays, sums it up: MOS certainly has no advantage in low-complexity circuits, since bipolar wins here on speed and performance. On the other hand, custom work cannot be vastly profitable. "We're learning more about systems," Gregory says. "We're trying to figure out where there is sufficient commonality in equipment to standardize on a given circuit. The key is to pick areas where MOS has a cost advantage and to design around existing equipment."

Some MOS houses say that they can live with small production runs because the MOS process is a constant, and only the geometries change in making different circuits. But Jerry Larkin, LSI marketing manager for Fairchild, says flatly that "this is a marketing cliche." Fairchild still feels that volume is necessary for profitable production. Larkin echoes Gregory's remark, saying that "We're trying to pick standards that look logical." He feels that calculators, small, medium-speed space computers, and memories are the best bet in this respect. Fairchild is about ready to announce production of a complex arithmetic unit, the 3800; but Larkin is realistic about its acceptance. "It will probably require some small, gutsy computer house which is willing to take a chance," he says.

Inertia a factor. Larkin also cautions that even where MOS offers advantages in reliability and cost per function, it will not necessarily win. In the first place, the user will have to figure his redesign cost; in the second, "not all decisions are made on the basis of economy or technical superiority," he says—meaning that the manufacturer will still have to overcome the designer's inertia. For that reason, Larkin foresees the greatest success for MOS in new markets.

Still, Fairchild has a hundred engineers working in MOS. The TI effort in Dallas is also substantial; Charles Phipps, the MOS program manager for TI, was formerly its bipolar IC marketing manager. The emphasis the company is putting on computer-aided design indicates a heavy commitment.

TI has cut artwork errors from 30% to zero by going to computer design, and intends to exploit computer technology further in complex arrays by employing two-layer metalization on a chip, and discretionary wiring. Only such techniques will make LSI arrays, which have very small production runs, profitable, Phipps says.

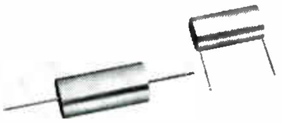
Motorola calls its development program "rather large," but still looks to bipolar devices to meet the bulk of the demand for IC's, including those for LSI.

Burned once. The cautious words on MOS voiced by major semiconductor manufacturers may be only an attempt to avoid repeating the premature enthusiasms of a few years ago. Gregory says that the false start delayed volume production of MOS by a year, perhaps to early 1969. But W.W. Vallandigham, vice president and director of operations at AMI, who is familiar with those early frustrations from his days with General Micro-Electronics, still asserts that by 1971, MOS will account for $380 million in sales and 40% to 50% of the IC market. Many in the semiconductor field expect the penetration to be no greater than 15% to 20%.

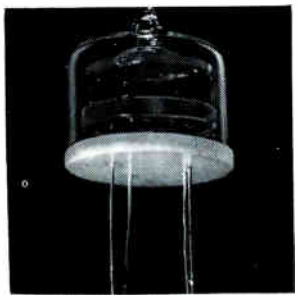
Both AMI and Autonetics talk about obtaining speeds of 20 megahertz within the next year or so; but speed is always obtained at the cost of power, and no one expects MOS to match bipolar in that department anyway.

"We've been through a long dry period," says John D. Gorman, Philco's MOS product marketing manager. "It's refreshing now to have products with reliability data so that we can talk about generating new markets impossible to reach, from a cost standpoint, with bipolar."

Contributions to this story were made by Lawrence Curran, Los Angeles; Marvin Reid, Dallas; Mark B. Leeds and Owen Doyle, New York; and James Brinton, Boston.

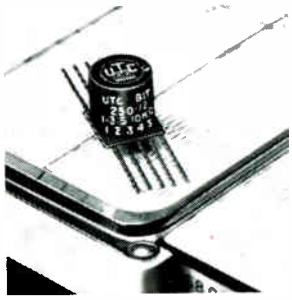


Rectangular metalized mylar capacitors, series 17W (axial) and 17U (radial) are available in 100, 200, 400, and 600 v units in capacitance ratings from 0.001 to 20 μf with 20% to 1% tolerances. Sizes range from 0.12 x 0.22 x 0.40 in. to 0.75 x 1 x 1.68 in. Units meet MIL-C-18312 group A specs. SEI Manufacturing, 18800 Parthenia St., Northridge, Calif. 91324. [341]



Crystal unit BG61AH-55 has frequency stability better than 5 parts in 10^{10} per day after 3 days. Advanced techniques produce superior aging and fast retrace characteristics with optically polished quartz plate operating on 5th overtone mode at 5 Mhz. The glass-sealed unit is 0.800 in. high, 0.790 in. in diameter. Bliley Electric Co., 2545 W. Grandview Blvd. Erie, Pa. 16512. [342]

Bandpass i-f filter 1404 has a 10.7-Mhz center frequency and a 300-khz 3-db bandwidth. The 60-db rejection bandwidth is 900 khz max. with insertion loss of less than 10 db over temperature. Operating temperature is −55° to +85°C. Maximum dimensions are 2.19 x 1 x 0.825 in. Prices (1-9) begin at $165. Helix Research Associates Inc., 5345 Timken St., La Mesa, Calif. [343]

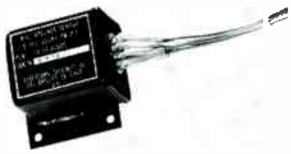


Ultraminiature transistor transformers and inductors series BIT-250 are made to MIL-T-27B, Grade 4, assuring the ultimate in rugged construction. Primary impedance is 150 to 25,000 ohms center tapped. Power level is 45 to 80 mw. Size is 0.250 x 0.250 in. Weight is 1.1 grams. Units have gold-plated ribbon-style leads. United Transformer Co., 150 Varick St., N.Y. 10013. [344]

Temperature compensated, crystal controlled oscillator JKTCXO-4, designed for p-c board mounting, is available with any output frequency between 6 and 20 Mhz over a temperature range of −55° to +85°C at stability of 1 x 10^{-5}. Input power is 100 mw max. at 12 v d-c. Size is 1.5 x 1 x 0.40 in. max.; weight, less than 1 oz. CTS Knights Inc., Sandwich, Ill. 60548. [345]

Electrostatically-focused crt WX-30764, featuring high deflection sensitivity and high brightness, is for oscillographic and data display. It has a center line width of 0.015 in. and acceleration of the electron beam occurs after electrostatic deflection. The 5½ x 4½-in. tube weighs 3¼ lbs and mounts in any position. Westinghouse Electronic Tube Div., Elmira, N. Y. 14902. [346]

Capacitor type MD offers molded construction of monolithic layers. Size is 0.155 x 0.065 in. The leads, 0.016 x 1 in., can be specified as tinned copper or gold-flashed dumet. Capacitance ranges up to 12,000 pf are offered in temperature characteristic AW. Standard tolerances are ±10% and ±20%. American Components Inc., 8th Ave. at Harry St., Conshohocken, Pa. 19428. [347]



Solid state voltage sensor model 35-71-01900 is for use in monitoring a-c power. It incorporates a 5-sec time delay and was designed to comply with MIL-Std-704A. Design includes automatic reset capability and pigtail leads. Input power is 28 v d-c. Output rating (dpdt) is 5 amps inductive. Electronic Specialty Co., 4561 Colorado Blvd., Los Angeles 90039. [348]

New components

Active filter cuts frequency, and cost

Low pass device uses 4 filter networks to achieve an 80 decibel per decade rolloff and ±0.2db flatness

Ask any engineer who designs active filters what three features he seeks most and he will probably tell you high input impedance, linearity, and sharp cutoff. Most manufacturers don't have any standards on these characteristics or even bother to list them. With a new active filter from Analog Devices the manufacturer not only lists the specs, but offers good ratings at a low price.

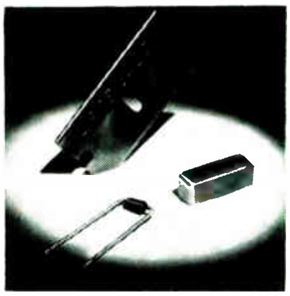
The sharp-cutoff, four pole low pass active filters, designated the series 701, are available for any cutoff frequency from 1 Hz to 1,000 Hz. The units are priced at $75 in single purchases, about half the cost of previously available active filters.

This filter uses four sets of R-C elements, arranged in matched and interdependent pairs, so cutoff characteristics are controlled by all four R-C elements. Each pair contributes 20 db/decade attenuation.

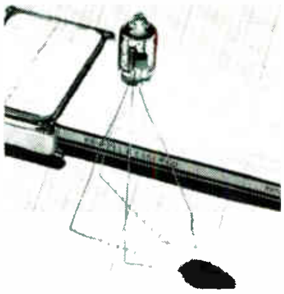
However, if capacitors and resistors with poor tolerances are used in the filter network, each R-C pair will begin to attenuate input signals at frequencies other than cutoff, thereby degrading the desired sharp-cutoff characteristics.

Although 0.1% resistors don't

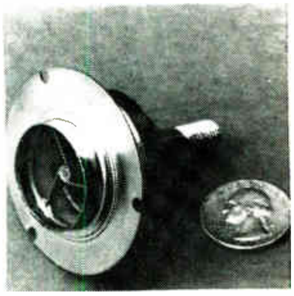
Wirewound molded resistors called Lo-Ohm are for circuits requiring inexpensive less-than-one ohm value commercial resistors in power ratings of 1 and 3 w. Resistance range is 0.01 to 1 ohm, ±10%. Dielectric strength is 1,000 v a-c. Temperature coefficient is better than 100 ppm/°C between 0.1 and 1 ohm. Ohmite Manufacturing Co., 3697 Howard St., Skokie, Ill. 60076. [349]



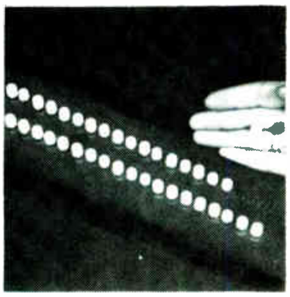
Solid state reed relay series 44-2SS incorporates a blocking or arc suppression diode within a 0.05-cu in. package. The ultra-miniature size allows 40 two-pole relays to be mounted on a 5½ x 4½ in. p-c board. Height is 0.25 in. The series is available in 1, 2, 3 and 4 poie models. Contacts are rated at 7 w. Wheelock Signals Inc., 273 Branchport Ave., Long Branch, N.J. 07740. [350]



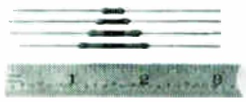
Cold cathode switch tube type KN-9 is capable of long life (2.5 x 10^7 shots) operating at current levels of from 200 ma to 500 amps. It features high hold-off votage (4,000 v d-c), low jitter (20 nsec), low delay time (200 nsec), and a high input trigger impedance. Price is $20 each in quantities of 1 to 10. EG&G Inc., 160 Brookline Ave., Boston, Mass. 02215. [351]



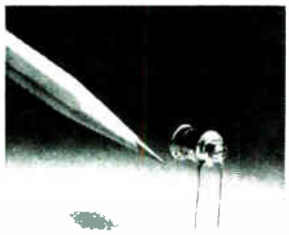
Short-arc lamps series 150X use a sealed beam construction with a prefocused integral reflector in a ceramic-metal envelope. The 150-w lamp features a reflector-shaped beam of 200,000 peak beam candlepower in a 5° beam profile. Beam flux is 1,800 lumens with average life at this output of 1,000 hours. Eimac Division of Varian, 301 Industrial Way, San Carlos, Calif. 94070. [352]



Cylindrical-shaped T-Lite incandescent indicator light, measuring $\frac{3}{16}$ in. in length and width, is suited for p-c boards where space is at a premium. It is designed for 5 to 6 v, 60-75 and 115 ma operations. Average rated life is in excess of 10,000 hours based on an industry standard of 3-hour on-off cycles. Sylvania Eletcric Products Inc., 60 Boston St., Salem, Mass. 01970. [353]



Miniature megohm resistors, with 80 ppm/°C absolute temperature coefficient, have TC referenced to 25°C taken at −15° and +105°C. The series covers the 1-to 220-megohm range, from 0.5 to 5.0 w, from 600 to 4,000 v. Uses include h-v dividers, high resistance networks, and precision RC timing devices. Caddock Electronics Inc., 3127 Chicago Ave., Riverside, Calif. 95207. [354]



Precision trimmer capacitors can be bolted directly to the chassis and tuned on the inside of the panel. Access to the tuning screw is at the opposite end from the mounting stud. Units come with tuning ranges from 0.8-4.5 to 1-36 pf. The tuning screw does not move axially but remains in position for blind hole tuning. Voltronics Corp., West St., Hanover, N.J. 07936. [355]

P-c connector with 160-pin contact density has 0.100-in. contact spacing, positive keying and glass-filled thermoplastic shell bodies. It comes with 6 Poke-Home-type contacts: wire pin or wire socket crimp, p-c pin long or short tail, and p-c socket long or short tail. Temperature range is −55° to +180°F. Amphenol Corp., 9201 Independence Ave., Chatsworth, Calif. 01311. [356]

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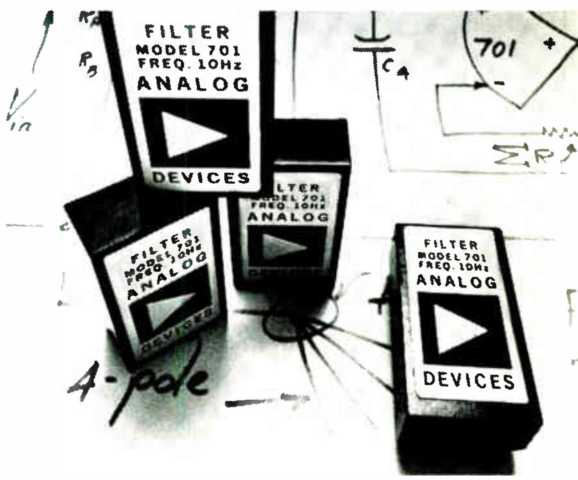
cost much, precision capacitors do. A 0.1% tolerance capacitor may easily cost five times a 20% version.

A designer would have to buy both resistors and capacitors with 0.1% tolerance to get the desired cutoff sharpness. However, Analog buys low-cost 20% units and passes them through an automatic grader for grouping into common categories of values with up to 0.01% accuracy.

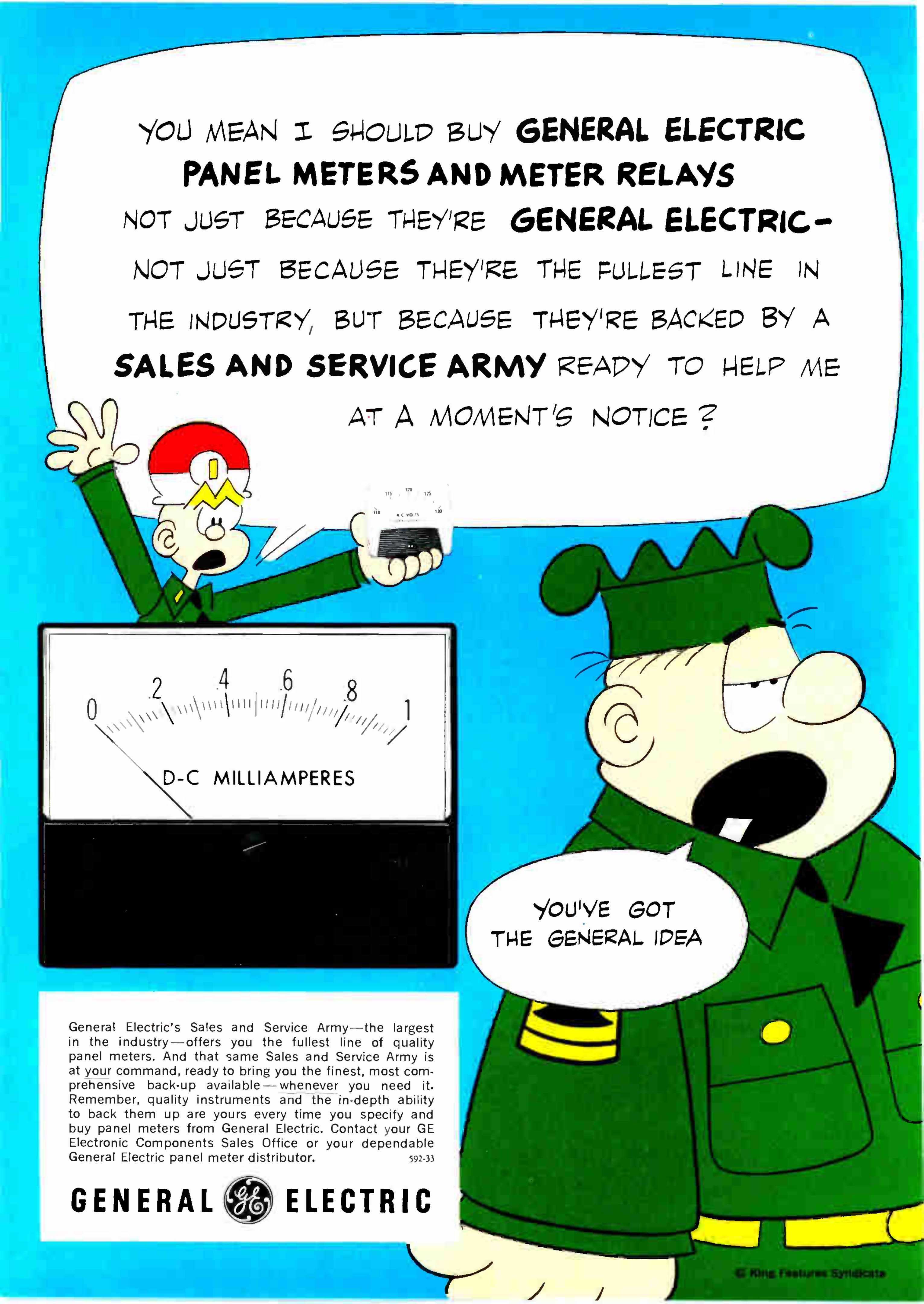
Characteristics of the 701 include 50 μv/°C max drift, 0.2 db response flatness in the pass band, four-pole operation with cutoff attenuation approaching the theoretical 80 db decade, and 100,000 ohms input impedance. Linearity is within 0.002% of the best straight line, and includes the effects of amplifier gain variation, loading, and common mode error.

High input impedance is necessary to avoid loading the signal source. This is especially true if the source impedance varies with frequency, because the voltage-divider effect created by the source impedance and the filter output impedance also varies with frequency. This adds uncertainty to the filter's final output error.

Analog Devices, 221 Fifth St., Cambridge, Mass. 02142 [357]



Slasher. Active filter provides sharp cutoff for high selectivity.



General Electric's Sales and Service Army—the largest in the industry—offers you the fullest line of quality panel meters. And that same Sales and Service Army is at your command, ready to bring you the finest, most comprehensive back-up available—whenever you need it. Remember, quality instruments and the in-depth ability to back them up are yours every time you specify and buy panel meters from General Electric. Contact your GE Electronic Components Sales Office or your dependable General Electric panel meter distributor. 592-33

GENERAL ELECTRIC

New components

Designers beat 3-way stretch

Amplifier is linear over radio frequency range for inputs up to 2 volts

Designers of radio-frequency amplifiers often stumble trying to follow the three rules: keep down the noise, make it linear over a wide voltage range, and give it a large bandwidth. They have to break one rule to carry out the other two or they build in additional circuits to compensate for amplifier deficiencies. Many times these circuits mean a lot of extra adjustments for the operator.

But Theodore Johnson, president of Comdel Inc., says his company has put a low noise figure, wide dynamic range, and a large bandwidth in one package. It's called the HDR r-f amplifier.

The power gain of the HDR is 9 decibels, and the noise figure is 2.5 decibels from 0.5 to 50 megahertz. The gain is flat from 0.7 to 10 Mhz and does not vary by more than one db in the other portions of the frequency range.

The ratio of output to input voltage is constant for inputs from 0.2 microvolts to 2 volts, a 140-db dynamic range. Comdel engineers find the dynamic range, or linearity, by comparing the HDR's input-output curve with a 9-db gain curve. They say the amplifier is linear in the region where the curves do not vary by more than one decibel. "About the best dynamic range you can get on equivalent amplifiers is 80 to 90 decibels," says Johnson.

No AGC. One thing the HDR doesn't have is automatic gain control. "We don't need it. We're still linear up close to three volts, so gain adjustment and overload are not problems with us," according to Johnson.

The active element of the amplifier is a field effect transistor, specifically made for the HDR. The FET is followed by a Tchebichef filter.

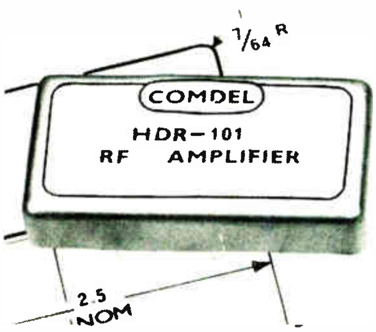
The HDR can be used either as the main amplifier in a newly designed receiver, or as a preamplifier in other sets. "Many older receivers fall down badly on noise figures," says Johnson. The HDR, used in front of a receiver's main amplifier, can increase sensitivity by up to eight dbs.

The HDR can also be used in transmitters, either as a main amplifier in a 200-milliwatt unit, or as the driver amplifier in a larger unit.

Checkout. Comdel has given out some of its new amplifiers for evaluation. Scientists are using them in propagation studies for the Bureau of Standards. The Central Intelligence Agency, the United States Information Agency, and several universities have put HDR's into some of their systems. They are also being used by Honeywell, RCA, and the Bedford Institute of Oceanography.

When Comdel starts selling the amplifier in quantity April 1, it will offer three models:

- The 101, priced at $75, is designed to plug into printed-circuit boards.
- The 102 for $77 has coaxial fittings.
- The 101A is priced at $92 and is packaged with a 110-volt a-c power supply that delivers between 18 and 22 v d-c at 40 milliamperes of current.



Wide and flat. The gain of the HDR r-f amplifier is 9 db from 0.5 to 50 Mhz.

Specifications

Source impedance	50 ohms
Load impedance	50 ohms
Temperature range	−20 to +60°C
Relative humidity	100%
Shock (for 11ms)	10 g's
Vibration	5 g's
Weight (101)	2 oz.
Dimensions (101)	2.5 x 1.3 0.7 in.
Weight (101 a-c)	1¼ lbs.
Dimensions (101 a-c)	4.9 x 2.5 x 3.4 in.

Comdel Inc., Beverly Airport, Beverly, Mass. 01915 [358]

←Circle 190 on reader service card

Dusting process brightens picture

Color television tube also has improved phosphors, electron gun

The last time there was a major change in television picture tube design was in 1964 when Sylvania Electric Products Inc. introduced a color tube using the rare earth phosphor, europium. Other tube producers followed suit and the rare earth tube became an industry standard.

Sylvania's latest innovation in the color picture tube market is called Color Bright 85. The company describes the tube as "23 to 69% brighter" than others on the market, and says it produces the truest colors attainable.

New method. By using larger phosphor crystals and applying them to the face of the tube by a new dusting process, Sylvania says, it has achieved a more consistent phosphor thickness and therefore a more uniform output of light across the face of the tube.

Color Bright 85 also has a new electron beam gun. Sylvania says it improves resolution and reduces the color fringing that can result from out-of-shape electron beams. A temperature-compensated shadow mask keeps the color purity at a constant level.

The new tube, which is used in all of Sylvania's current line of tv sets, is also being offered to producers of competitive sets. Sylvania has phased out production of its previous line of picture tubes.

Simultaneous with announcement of Color Bright 85, the company disclosed development of two new receiving tubes for color tv, a rugged high voltage rectifier and a horizontal amplifier with improved internal cooling.

Both tubes are designed to produce less radiation of X-rays, and have posted filaments.

Sylvania Electric Products Inc., 730 Third Ave., New York, N.Y. 10017 [359]

1Ω,1%,100ppm

First low-range, low-inductance thick-film resistors

These new IRC TF resistors have been designed specifically for your low-range, low-inductance needs. They provide precision performance, plus the added benefits of thick-film stability and reliability for a wide range of industrial and instrumentation applications.

Rugged Metal Glaze resistance element is inherently reliable. Tin-oxide types can't match its stability and ruggedness under severe load or elevated temperature conditions. Tough molded bodies of the TF07 and TF20 can't crack or craze during automated insertion. They resist solvents and corrosion. Write for samples, prices, and data on these new IRC low-range resistors. IRC, Inc., 401 N. Broad Street, Philadelphia, Pa. 19108.

Resistor screening. Does your low-range application require 100% burn-in? IRC is geared to perform meaningful screening tests on these new Type TF resistors on a production basis. Ask for data.

CAPSULE SPECIFICATIONS

POWER:	¼ W @ 70°C	½ W @ 70°C
RESISTANCE:	1Ω to 10Ω	1Ω to 10Ω
TOLERANCES:	±1,2,5%	±1,2,5%
TEMP. COEF.:	±100ppm/°C	±100ppm/°C
SIZE:	RL07	RL20
IRC TYPE:	TF07	TF20

IRC®

4½-Digit DVM. Compact flexibility: $1150.

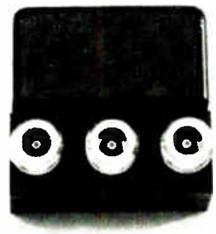
We've packed a lot of flexibility into our Model 7000 DVM. It's only half-rack size (5¼" x 8⅜" x 12"), but has five big options: auto-ranging, AC volts, resistance, DC current and BCD output. Options are contained on convenient plug-in circuit boards. A front-panel function switch controls all options. The 7000 is built with integrated circuits and provides a reading accuracy of 0.01%. Resolution is 100μV. Input impedance is greater than 1000 megohms. You also get dual slope integration, automatic polarity and display storage. Low power operation means no fan and no noise. A 7000 DVM can be yours in 15 days.
You can get our data sheets even faster. Write today.

Fairchild Instrumentation, A Division of Fairchild Camera and Instrument Corporation, 974 East Arques Avenue, Sunnyvale, California 94086, (408) 735-5011, TWX: 910-379-6944

New Microwave Review

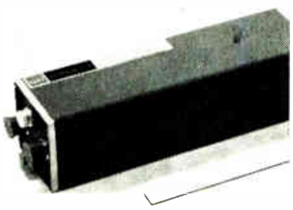
Gas discharge noise source type TN94/T44X3A is for use at 8.9 to 9.1 Ghz in the X band. The unit is fired by a negative pulse of 950 v applied to the cathode. Operating voltage is 50 v d-c nominal; operating current, 60 ma. Vswr in the fired condition is 1.5 max. and excess noise ratio is 18.5 ±0.5 db. Signalite Inc., 1933 Heck Ave., Neptune, N.J. 07753. [401]

Positive pulse beacon magnetron MA-260 provides 1-kw peak output power and is tunable from 16 to 16.5 Ghz. Output power is typically level within ±1 db and temperature coefficient varies from −60 to −85 khz/°C over the 500-Mhz band. Peak anode voltage is 3 kv and peak anode current is 1.6 amps. Weight is under 20 oz. Microwave Associates Inc., Burlington, Mass. [402]



Remote miniature coaxial switch CS-221 is a single-pole 2-position unit with a frequency range of d-c to 3.3 Ghz. Insertion loss is 0.1 db max. from d-c to 1 Ghz and 0.3 db max. from 1 to 3.3 Ghz. Vswr is 1.1 max from d-c to 1 Ghz; 1.25 max from 1 to 3.3 Ghz. Operating voltage is 28 v d-c. Prices start at $25. RLC Electronics Inc., 25 Martin Place, Port Chester, N.Y. 10574. [403]

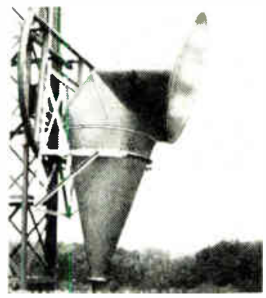
Frequency counter 960 features continuous coverage with one input from 20 hz to 6.5 Ghz. Input sensitivity is less than 50 mv over most of the range. The unit is for applications where rapid reading, unattended operation, or measurement by unskilled persons is required. It is also adapted to systems use. Eldorado Electronics, 601 Chalomar Rd., Concord, Calif. 94520. [404]



T-w amplifiers WJ-396 cover the range of 7 to 11 Ghz. Units feature noise figure of 6 db in a 3.4 x 3.4 x 10 in. configuration, and weigh 8.5 lbs. The amplifier can withstand vibration of over 5 g at frequencies up to 500 hz and over 15 g of shock in any plane for 11-msec duration. Watkins-Johnson Co., 3333 Hillview Ave., Stanford Industrial Park, Palo Alto, Calif. 94304. [405]

Subminiature bandpass filters series TBS have center frequencies ranging from 400 to 2,300 Mhz. Tubular types of the 0.05-db Chebyschev design, they measure 1/4 x 1 1/2 to 5 in. and weigh less than 1 oz. including connectors. They come with a 3-db bandwidth of 2 to 15%, in 2- to 6-section versions. Price is from $95. Telonic Engineering Co., Box 277, Laguna Beach, Calif. [406]

Solid state oscillator 28672-62 is electrically tunable over the 500 to 1,000 Mhz range. Features include power output of 100 mw min.; power output variation with frequency of ±1 db max.; typical temperature stability of 100 ppm /°C. Power required is 20 v at 150 ma. Unit measures 0.75 x 1 x 1.50 in. OmniSpectra Inc., 24600 Hallwood Ct., Farmington, Mich. 48024. [407]



Horn-type antenna can simultaneously handle both vertical and horizontal polarization of any combination of microwave bands. Frequency range of operation is determined solely by the bandwidth of the connecting waveguide. Wide angle radiation is down 60 to 70 db across all bands. Return loss is 40 db. Gabriel Electronics, Box 471, Saco, Me. 04072. [408]

New microwave

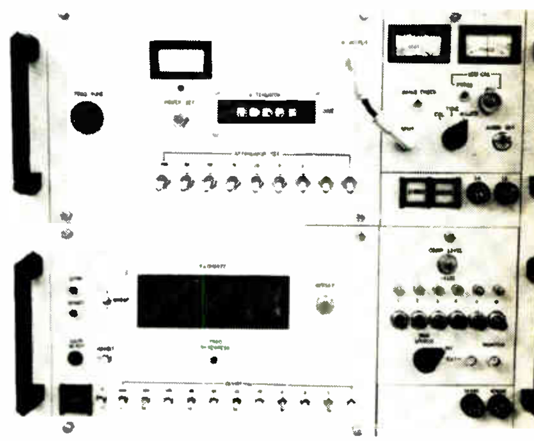
Signal generators use phase lock to sweep

Modular system with long-term frequency accuracy can be programed for computerized test setups

A modular signal generator that offers digital control of output and phase locking has been designed by New London Instrument Co.

The system, whose modules are lumped under the designation series 5000, is part of a comeback attempt for New London. A pioneer in the frequency and amplitude modulation test equipment field, the firm went out of business in 1963. It came back last April as a wholly owned division of the Crescent Communications Corp.

New London's product line already includes its series 1000 modu-



Following orders. Test oscillator is controlled by digital signals.

... counter is more accurate than a local oscillator ...

lar signal generators, and series 2000 modular monitoring systems. Generally, these instruments cost "up to $5,000." The series 5000 should run from $5,000 to $7,000 and up.

For the difference, the user can buy what amounts to a custom-built system with long-term frequency accuracy as high as one part in 10^{-7}, sweeping of either side of phase-locked center frequencies located to +100 hertz accuracy (to 10 Hz if required), digital programing for computerized test schemes, and binary coded decimal readouts.

Counter-controlled. The 5000 uses three pencil-tube cavity oscillator plug-ins to cover the r-f range from 20 to about 800 megahertz (another module reaches into S-band). A vco is used as the reference against which the r-f cavity is locked; meanwhile the vco itself is sampled 12.5 times per second by transistor-transistor logic counter circuitry. "Since our counter electronics is more accurate and stable than a local oscillator, we figured we might well control the reference with the counter," according to Alex Gordon, New London's vice president. This gives advantages other than accuracy. If frequency multiplication were used with the 5000's 10 Mhz. vco to produce uhf signals at 1 gigahertz, any error in the reference frequency would be multiplied by 100. But in the 5000, errors are not multiplied upward through a system, as in oscillator-multiplier chains.

Standard oscillator modules in the 5000 series will probably be controlled to either 100 or 1000 Hz. But, says Gordon, counter resolution, and therefore frequency accuracy, could easily be increased to 10 Hz. This not only means 10 Hz at the vco, but also at 2,500 Mhz.

To sweep, the proper commands are inserted in the digital control unit using a binary coded decimal code. These commands cause the vco to change its output frequency, and, since the r-f oscillator is phase-locked to it, its sweep follows.

The New London Instrument Co., a division of the Crescent Communications Corp., 153 California St., Newton, Mass. 02158 **[409]**

a new low in op amps.

{ Our NH 0001 dissipates only a puny 0.6mW at Vs ±6V }

Even the typical dissipation is only 1.8mW at Vs = ±15V, which must be some kind of record. Nevertheless, our mighty NH 0001 will deliver over ±10V into a 2K load from Vs = 15V supplies. That makes it a natural for space stuff.

A couple of other features of the NH 0001 are its low noise and maximum offset voltage of a mere 1mV at 25° C (only 2mV across the full temperature range). Power supply and common mode rejection are 90db. After that, there's nothing left to say except that the NH 0001 is packaged in a TO-5 and priced at $48.00 in 100 to 999 quantities.

If you need them now, call your National distributor. They're on the shelf. Or, if you would prefer to approach the matter more leisurely, write us for data sheets.

National Semiconductor Corporation, 2975 San Ysidro Way, Santa Clara, California 95051 (408) 245-4320.

National Semiconductor

Circle 197 on reader service card

New microwave

Wideband amplifier has 2 magnetrons

Covering 1 to 12.4 Ghz, unit eases field testing of microwave equipment

The most common problem in testing microwave equipment is getting uniform amplification of a signal over a broad frequency range. In most testers, the signal source is a sweeping signal generator. These units have an output on the order of several milliwatts, not enough for complete system testing, so an amplifier must be used to boost the signal to about 1 watt.

By using two specially designed traveling wave tubes, the Servo Corp. of America has developed a compact microwave power amplifier with a minimum gain of 30 decibels. Designated the model 3003, the unit has a continuous-wave output of 1 watt over 1 to 12.4 gigahertz.

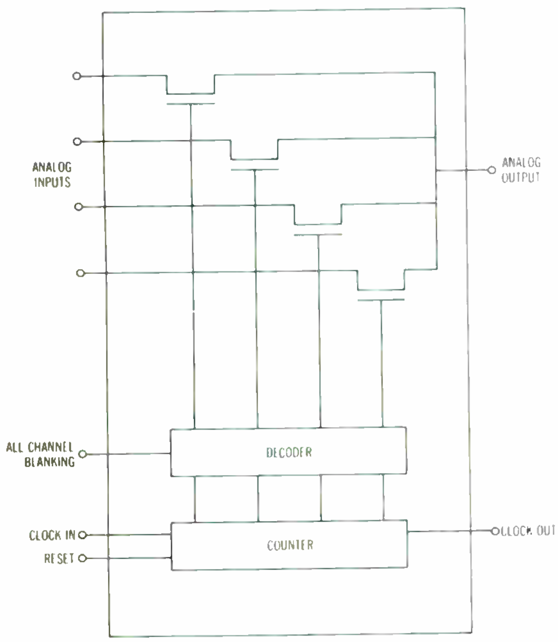
One tube covers from 1 to 4 Ghz and the second 4 to 12.4 Ghz. A front panel switch controls which tube is connected to the power supply, and thus controls the amplifier's frequency range. The gain can also be adjusted ±20 db by a front-panel switch.

Spurious output is 45 db below the signal level and the amplifier has a frequency response, for pulse-modulated signals, of from 1 kilohertz to 1 megahertz. Rise and fall time is less than 0.1 microsecond. Output power control is accomplished by metering the cathode current of the output tubes.

Servo Corp. of America, 111 New South Rd., Hicksville, N. Y. 11802 **[410]**

Booster. Power amplifier supplies 1 watt minimum from 1 to 12.4 Ghz.

Our first new MOS switch is so good, it's almost embarrassing.



MM454 Commutator

It's the MM454, a monolithic, four-channel commutator, that's capable of handling ±10V analog signals. And it provides all driver and decode circuitry eliminating the need to construct a separate counter. All-channel blanking and a reset capability are a couple of bonus features.

We've also introduced four other new switches not quite so remarkable, but still worth crowing about. Our MM450 is a dual differential switch. Our MM451 is a four-channel unit. Then there's our MM452 which is comprised of four separate switch devices in a single flat pack with 14 leads. The last one, our MH453, is a dual differential analog switch with a built-in DTL/TTL interface circuit.

Not bad for openers. And these aren't just being designed. They're already stocked on your distributors' shelves complete with price tags:

		Quantity: 100-999
MM 450	Dual differential MOS switch	$20
MM 451	Four-channel MOS switch	$20
MM 452	Four MOS transistors	$30
MH 453	DTL/TTL compatible MOS switch	$40
MM 454	Four-channel commutator	$50

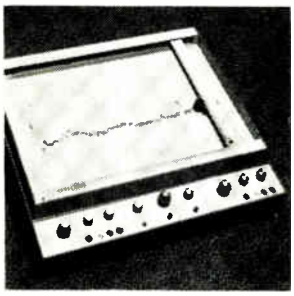
Write for data. National Semiconductor Corporation, 2975 San Ysidro Way, Santa Clara, Calif. 95051. Phone (408) 245-4320.

National Semiconductor

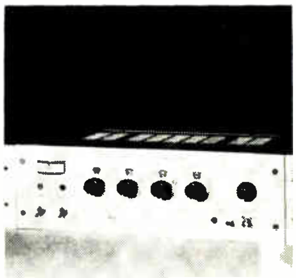
Circle 199 on reader service card

New Instruments Review

Portable scope type 453 MOD 127C has a built-in tv sync separator for viewing tv waveforms. Dual-trace sensitivity and bandwidth is 5 mv/div with 40-Mhz bandwidth, increasing to 50-Mhz bandwidth at 20 mv/div to 10 v/div. Channel 1 and 2 amplifiers can be cascaded to obtain 1 mv/div sensitivity at 25 Mhz, single trace. Tektronix Inc., Box 500, Beaverton, Ore. [361]

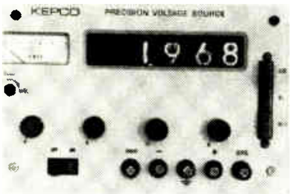


X-Y recorder model 560 has a sensitivity of 10 μv/in. It operates over 21 calibrated ranges from 10 μv to 50 v/in. This true differential input recorder is capable of plotting two-axis (record and time base) data on vacuum-held 8½ x 11 in. or 11 x 17 in. graph paper. It features all silicon logic. Honeywell Inc., P.O. Box 5227, Denver, Colo. 80217. [362]



Regulated d-c, h-v biasing supply model 245 can provide bias for photomultiplier tubes, solid state radiation detectors, and ion chambers. Output range of 0 to 2,100 v at 10 ma max. is offered in 10-v steps, and voltage selections can be made to ±1% accuracy with direct readout dials. Price is under $400. Keithley Instruments Inc., 28775 Aurora Rd., Cleveland 44139. [363]

Incremental gaussmeter 640, using a new precalibration technique, takes full advantage of the high-linearity Hall element and solid state circuitry, and allows direct interchangeability of probes without recalibration. With built-In calibration accuracy of ±0.3%, instrument accuracy is ±1% to 30 kg, ±0.5% to 10 kg. F.W. Bell Inc., 1356 Norton Ave., Columbus, Ohio 43212. [364]



Precision voltage source PVS 100-1 offers a 4-place digital display of output voltage from 0.000 to 100.00 v, with 0- to 1-amp current available. Voltage selection is by means of 4 rotary selectors offering absolute accuracy, 0.02% of full scale, with 0.001% combined line and load regulation. Kepco Inc., 131-38 Sanford Ave., Flushing, N.Y. 11352. [365]

Compact voltohmeter model 870 Millivolt Commander measures voltages as low as 0.1 v d-c full scale and 0.01 v a-c full scale. It also provides a sensitivity range from 100 mv full scale to 1,000 v full scale in 9 increments. Accuracy is within ±2% d-c and ±3% a-c full scale. Price is $99.95. Amphenol Corp., 2875 S. 25th Ave., Broadview, Ill. 60153. [366]

Forward-counting and forward/reverse counting model CB-600R is designed for precise digital measurement of bidirectional frequency signals up to 1 Mhz count rate and will change direction of count in less than 1 μsec. It features 5 input signal modes selected by a front panel switch. Price is from $1,445. Anadex Instruments Inc., 7833 Haskell Ave., Van Nuys, Calif. 91406. [367]

Solid state sweep generator VS-30 covers 300 khz to 100 Mhz. Sweep width is continuously adjustable from 200 khz to 100 Mhz. The r-f output is specified for a flatness of ±0.25 db at maximum sweep width with 1 v rms into 50 ohms. The unit has provisions for 8 plug-in crystal controlled markers. Texscan Corp., 2446 N. Shadeland Ave., Indianapolis 46219. [368]

New instruments

Measuring up to varying signals

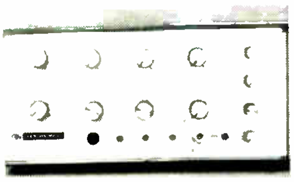
Level meter uses analog-to-digital converter to cover a range from —60 to +20 decibels

In the drive to automate as many testing and measuring jobs in communications as possible, digital measuring instruments are gaining importance as spearheads.

One example is a digital level meter developed by Siemens AG and designated the C2010/D2014. It is the first to determine exactly, levels from —60 to +20 decibels in a frequency range from 30 hertz to 120 kilohertz. Indicated numerically, the level's value can also be obtained in coded form.

The meter consists of a basic instrument and an analog plug-in unit. The voltage to be measured is fed across a stable broad-band amplifier and an automatically controlled switch (whose range increases logarithmically) and then to an extremely linear d-c rectifying circuit. The rectified signal is fed to an analog-digital converter. The logarithmic relationship to the reference voltage by which the level is defined, is determined in a comparison circuit by the discharge function of an r-c circuit. The time interval (proportional to the level) and the polarity are obtained. A limit value indicator controls the range switch of the analog unit.

Coded and stored. The measured

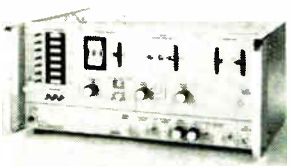


Pulse generator model PG-300 extends voltage programing capability to include linear rise and fall times from 5 nsec to 1 msec. The d-c base line offset, also programable, is continuously variable from +10 to −10 v into a 50-ohm load on both the positive and negative outputs. This allows duty cycles to 100%. Aerojet-General Corp., Box 216, San Ramon, Calif. 94583. [369]

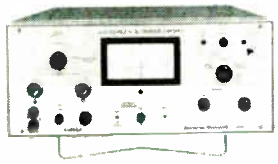
Miniaturized dvm model 211 features an accuracy of 0.05% plus 1 digit on 5 extended ranges (100 mv, 1 v, 10 v, 100 v and 1,000 v d-c full scale with 50% over-range). Resolution is 20 μv on the 100 mv range. A detented slide switch selects range and decimal point location simultaneously. Basic unit costs $275. United Systems Corp., 918 Woodley Rd., Dayton, Ohio. [370]

Vhf sweep generator system SS-300 incorporates in a single unit a sweep generator covering 500 khz to 300 Mhz, a marker generator and a detector system. It features start-stop frequency tuning, automatic leveling without frequency shift, low radiation toggle switch attenuators, and 50 to 400 hz power input. Jerrold Electronics Corp., 401 Walnut St., Philadelphia, Pa. [371]

Differential input phase meter 351 covers 10 hz to 2 Mhz with 2-channel sensitivity of 1 mv. It works from 1 mv to 100 v without external preamps or attenuators, or periodic calibration. An offset control is in 10° steps to permit phase reading to be expanded about any angle in the 360° range. Price is $1,190. Wiltron Co., 930 E. Meadow Dr., Palo Alto, Calif. 94303. [372]



Programable sweep generator A-1211 (0.5 Mhz to 1 Ghz) will accept analog d-c programing to control center frequency, sweep width, output level and selection of markers. It is readily adaptable in the design of automatic test systems for production testing of r-f components. Basic unit price is $995. Sweep Systems Inc., 3000 Shelby St., Indianapolis 46206. [373]



A-c/d-c transfer standard model ATS provides 0.01% true rms measurements in approximately 10 to 15 sec. It permits unskilled operators to make this measurement. Over-all range is 2 hz to 30 Mhz. Accuracy is rated at 0.01% of reading from 0.25 v to 1,000 v, 5 hz to 20 khz. Price is $3,500. Singer Co., Metrics Division, 915 Pembroke St., Bridgeport, Conn. 06608. [374]

Pulse generator 113 offers built-in burst capability. Two repetition rate oscillators are used. One provides rep rates from 500 khz to 250 Mhz; the other (0.5 hz to 500 khz) is used to gate the h-f oscillator for 10 nsec to 10 μsec bursts or as a trigger for low rep rates. Price is $3,375. Datapulse Inc., 10150 W. Jefferson Blvd., Culver City, Calif. 90230. [375]

Programable digital delay generator 1399 is also a frequency divider. With its internal 10-Mhz clock, time delays are available from 0.3 μsec to 10 sec in increments of 0.1 μsec. When the internal clock signal is replaced by an external signal from 100 hz to 13 Mhz, the unit provides frequency ratios of from 3:1 to 99,999,999:1. General Radio Co., West Concord, Mass. [376]

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result, which is counted out in five binary-coded decades, is recorded into a 1-out-of-10 code and fed into a storage unit. That unit, in turn, controls the Nixie tubes in the indicator window.

This instrument's 80 db measuring range corresponds to a linear voltage relationship of 1:10,000. The typical absolute measuring accuracy of ±0.1 db is very high, and holds for all indicated values. A change of level of only 0.01 db can still be read. This contrasts with analog measuring instruments whose maximum accuracy holds only for the maximum value indicated, which corresponds to the full-scale deflection.

Printers or telephone lines can be hooked up to the instrument's output for further processing or for transmitting results, in which case the values are presented in an Aiken code. Start and stop signals for the measurements can be triggered from other automatic measuring equipment. The measuring rate can also be remotely controlled.

When the digital level meter is connected to the i-f output of a selective level meter, selective digital measurements are possible, limited only by the characteristics of the latter meter. Together with

Communicating. Digital level meter sends information over phone lines.

a remotely controllable level oscillator, it's also possible to rig automatic and programable selective level measurements.

Because the level meter consists of a basic instrument and a plug-in unit, it is adaptable to other measuring tasks. Plug-in units for such other applications as level difference measurements are being developed.

Siemens AG, 8 Munich 1, Oskar-von-Miller Ring 18, West Germany [377]

New instruments

Making it simple, easy to operate

Sweep oscillator system has functional layout as part of front panel

A solid-state sweep oscillator system built by Alfred Electronics offers a front panel design that permits the instrument to be used by unskilled personnel.

"In fact," says marketing vice president Paul Fulton, "most operators will be able to use the instrument without ever referring to the operation manual." The panel design, which has been carried forward from the company's microwave instruments, provides control layout and functions that "are so well defined they are self-evident," says Fulton. He adds that it is impossible to damage the instrument by an improper setting of the controls.

The model 6151 incorporates two completely independent sweeps, a versatile f_o control—which serves as a frequency marker, the center of the symmetrical sweep and as a single frequency—and offers an optional, accentuated comb-marker generator. The graduated comb-marker generator, which shows one, five and 25 megahertz crystal-generated harmonic signals, provides progressively larger amplitude for these intervals for ease of identification when measuring frequency. When all three signals are on, the horizontal scale has the appearance

Now they call us The Giant-Killer

A lot of people are coming to Hudson for miniature, sub-miniature and micro-miniature lamps these days — even though GE and Westinghouse are still in business. Why come to us? Because we've got a full line of first quality lamps. And because our service is great.

We climb beanstalks for our customers. There's nothing more important to us than getting your lamps to you on time, in the right quantity.

And if you need a bulb that's special, we'll supply it. No back-talk, no fuss, no bother. Just the bulb you want. At the right price. Soonest.

Next time a giant gives you the jolly ho-ho-ho — make a fast telephone call to Hudson. After all, they don't call us the giant-killer for nothing. **Hudson Lamp Company, 528 Elm Street, Kearny, New Jersey 07032. (201) 997-1850.**

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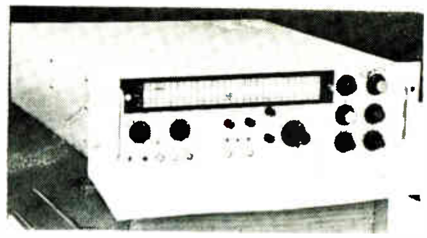
Circle 203 on reader service card



Foolproof. Front-panel design offers uncomplicated control.

of a ruler.

The frequency markers of the instrument are sharp and very narrow to achieve exceptional visual quality. Amplitude of the markers is adjustable so that the markers can be used at various signal levels and at any sweep range. The markers may also be tilted to stand out on the skirts of filters and other frequency sensitive devices.

The instrument offers a broad band swept or stable frequency operation from 10 Mhz to 1 gigahertz. Signal frequency stability and the low incidental frequency modulation will permit it to be used in place of mechanically tuned signal generators.

The model 6151 will be available for delivery in June in either rack or bench mounting. Price will be about $1,300 for the simplest combination. This basic unit would have an operational frequency range of 10 Mhz to 250 Mhz and would exclude the comb generator, which will sell for $200.

Alfred Electronics, Palo Alto, Calif. [378]

New instruments

A printer output when it counts

Input frequency or event total is expressed in BCD and by a digital display

More than a year ago, Monsanto Electronics developed a counter/timer, the 100A, that sold for under $600. The company wanted to make electronic counters available to engineers and technicians who could afford only the less-accurate

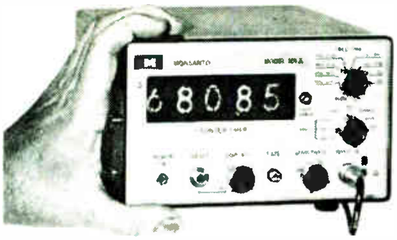
NEW OSCILLOGRAPH TUBES FROM HITACHI

WHAT THEY HAVE IN COMMON:
These Hitachi tubes are rectangular cathode ray tubes for precision instruments, with electrostatic focus and deflection.
They all use a mesh grid and inside scale, giving them high deflection sensitivity and non-parallax observation.
They're all made by Hitachi — so you know they're good. These two, the 120LB (DC-50 MC) and the 120MB (DC-15 MC) are particularly apt for portable equipment.

ONE MAY BE RIGHT FOR YOUR OPERATION:

Item	120LB	120MB	140LB	Unit
Overall Length	423±7	318±7	466±10	mm
Heater Voltage	6.3	12.6	6.3	V
Heater Current	0.3	0.15	0.3	A
Post Accelerator Voltage	10,000	6,000	15,000	Vdc
Accelerator Voltage	2,000	1,400	2,400	Vdc
Useful Scan	80×48	80×64	100×60	mm²
Deflection Factors				
Horizontal	12—16	11—16	12—18	V/cm
Vertical	4—7.5	6—10	3—5.5	V/cm

And if these aren't exactly what you're looking for, see the others —including our vidicon tubes and our cathode ray tubes for industry—from Hitachi, the people who make exacting quality available for less.



How many? The Model 101A counter/timer distinguishes between signals separated by 10 microseconds and measures up to 12.5 Mhz.

mechanical devices.

The 100A was well received, but customers started demanding something a bit more fancy. So Monsanto is now bringing out the Model 101A, which features a binary-coded decimal output for use with a printer, and an external-standard capability.

Ratios. The 101A measures frequencies from 5 hertz to 12.5 megahertz. It accepts a wide variety of waveforms, and can continuously measure the ratio of the frequencies of two inputs from 1:1 up to 10^5:1.

Used as a counter, the 101A responds to signals of periods from 10 microseconds to 10^6 seconds, and can distinguish between two signals separated by only 10 microseconds. The 101A works for both cyclic and random signals. So it can count the regular rotations of a crankshaft or the spontaneous emissions of radioactive material.

A crystal-controlled clock is used in the 101A to supply a standard frequency. But external standards from 3 hz to 5 Mhz can be substituted.

Either end. The output of the counter is displayed by five numerical tubes, and the decimal point is automatically positioned. The time base can be shifted to display portions of the output. For example, if measurements are being made in the megahertz range, the user can choose to display the first five or last five digits of the output. Display time can be set from 0.1 to 10 seconds.

The unit can be used over a temperature range from 0°C to 50°C. It operates on either 115 or 230 volts, and costs $675.

Monsanto Electronics Technical Center, 620 Passaic Ave., West Caldwell, N.J. 07006 **[379]**

Circle 207 on reader service card→

No matter how they measure it, the Honeywell 7600 checks out as the best value in the tape field!

From the way people are trying to copy it, you'd think our 7600 is the hottest tape system around. It is!

Compare the specs on our 7600 with those of some recent competitive machines and you'll notice something very interesting. A small revolution is taking place in the magnetic tape system industry. We started a trend. And now, others are following!

The Honeywell 7600 Series bears copying. Its modular design lets you specify the system you need now, and permits future expansion without costly modifications as your requirements grow. Easily maintained plug-in electronics give you a wide selection of bandwidths, and mechanical options include a choice of 10½" or 15" transport.

With its low flutter, skew, and time base error and high S/N ratios, the 7600's signal fidelity can't be matched by comparably priced units. And, due to its mechanical simplicity (no belts, pulleys, gears, or pinchrollers) and inherent reliability, our competitors are going to have a rough time building a machine that will operate as economically as the 7600. It's priced lower than you'd expect, too, giving you more performance for your money than any other tape system!

The great 7600 Series is another example of how Honeywell's broad line, backed by local sales and service, can provide the *precise* solution to your instrumentation problems. For a demonstration, call your local Honeywell Sales Engineer. For technical literature, write: Honeywell Inc., Test Instruments Division, P.O. Box 5227, 4800 E. Dry Creek Rd., Denver, Colorado 80217.

Honeywell

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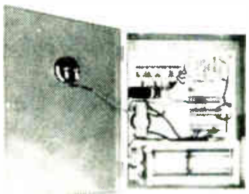
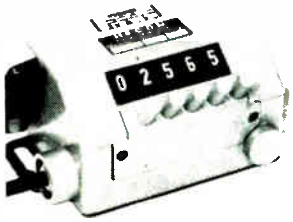
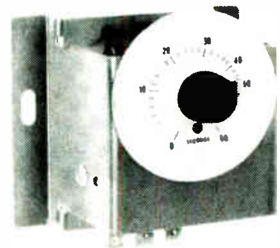
Circle 208 on reader service card



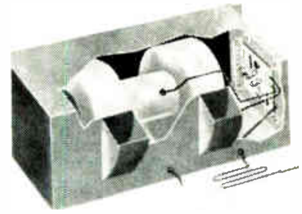
SCR power controls for furnaces, heaters, transformer primaries and inductive loads are available in 4 standard single-phase a-c models up to 50 kva, and special modifications including 3-phase designs, larger sizes and d-c outputs. All feature transient-free operation and drive a broad range of impedances. Nothelfer Winding Laboratories Inc., Box 455, Trenton, N.J. 08603. [421]



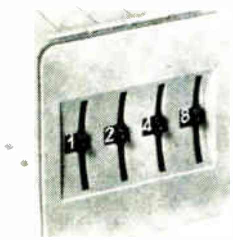
Push-button presettable predetermining counter series UE083 features rapid reset and a ball-bearing drive capable of handling in excess of 6,000 rpm continuously. Positive electrical knockoff is assured. A spdt switch can be wired to control numerous manufacturing processes. The counter operates from −40° to +140°F. Hecon Corp., Box 247, Eatontown, N.J. 07724. [422]



Electronic timer CES98 is a 1- to 60-sec unit that replaces many motor driven time delay relays. It is set by a single knob and has a calibrated dial that is easy to read. Contact rating is 5 amps at 120 v a-c or 28 v d-c resistive. Repeat accuracy is ±5% at nominal voltage and normal room temperature. Eagle Signal Div., E.W. Bliss Co., 736 Federal St., Davenport, Iowa 52808. [423]



To maintain temperatures within electronic enclosures, a temperature controller employs a thermostatic probe and transistorized circuitry that automatically modulates the speed of a blower motor. The control compensates for higher altitudes by increasing the flow of air. Temperature range is 80° to 90°F. McLean Engineering Laboratories, Princeton Junction, N.J. 08550. [424]



Thumbwheel switches for use in single-, double-, or 4-pole applications offer convenient preset control of digital information. They may be used for binary decimal coding or decoding, or for straight decimal circuitry. A built-in decoding diode gate in the rotor eliminates the need of mounting small diodes. A.W. Haydon Co., 232 N. Elm St., Waterbury, Conn. 06720. [425]

Instrument servo motor-tachometers size 21 offer a fundamental null value of less than 25 mv. The tachometer output exceeds 6.5 v/1,000 rpm. Available in a range of ratings, up to 10 w maximum output, the units are totally encapsulated with an integral servo motor and tachometer arrangement, giving lower temperature rises. Duratron Corp., 154 W. 14th St., N.Y. [426]

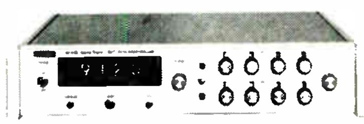
Hydrogen sulfide analyzer 722AEX provides continuous monitoring and automatic alarm with shutdown. The instrument senses the gas by chemical action on lead acetate sensing paper. H_2S produces a color change that is read by a photocell. The signal operates an alarm relay or provides voltage for process control. Houston Atlas Inc., P.O. Box 19035, Houston, Texas 77024. [427]

Reflex photoelectric control series 7201A is a self-contained unit with dpdt plug-in relay output that can operate at up to 1,200 actuations per minute on conveyor lines and other control installations. Range of the unit is 10 ft with a 3-in. retroreflective target. Dimensions are 7⅞ x 2½ x 3¾ in. Price is $43. Automatic Timing & Controls Inc., King of Prussia, Pa. 19406. [428]

New industrial electronics

Rate counter talks user's language

A selectable period adds meaning to events-per-unit-time measurement pulses



High or low. Two groups of decade dials set alarm limits.

By adding an adjustable time base to rate-controller circuitry, the Electronic Instruments division of Beckman Instruments, Inc., has designed an industrial counter that displays in engineering units.

The rate controller consists of two accumulators for each of four display decades—one preset for high limit and the other for low. If an operator wishes to maintain a 400-hertz line frequency, for example, he sets the high limit at 0401 and the low at 0399. Relay contacts driven from the logic circuitry operate warning lights for higher or lower frequencies. They can also be used in a feedback loop to vary motor/generator speeds to keep the frequency between the limits.

Gated for half. But if the industrial user wants to control revolutions per minute, or liquid flow, or

. . . variable time base scales the input . . .

some other rate not obligingly measured in cycles per second, he simply adjusts the reading-time period.

Revolutions-per-minute is an example. A tachometer coupled to a rotating shaft may produce 120 pulses per rotation. If the shaft is rotating at 6,000 rpm, or 100 per second, the accumulators would ordinarily count to 12,000 in one second.

In this case, the accumulators must be gated to count for only a half-second, so that the reading is 6,000, the desired display value. Then the readout can be interpreted as revolutions per minute.

Back panel switches on the Beckman model 6246 allow a wide range of scaling. The time base can be varied from 10 microseconds to 99,990 μsec in 10-μsec steps; from 100 μsec to 999,900 μsec in 100-μsec steps; and from one millisecond to 9,999 msec in 1-msec steps.

The time base is derived from a 200-kilohertz crystal oscillator 10 times more accurate than the plus-or-minus one digit of the four-place readout. The 200-Khz is divided down to 100-Khz before feeding the group of time-base dividers. Their selected output goes to one input of an AND gate. The measured

Specifications

Measurement rate (events per unit time)	3 Hz to 200 Khz (sine waves; 0 Hz to 200 Khz (pulses)
Level	0 to +5 volt level change for duration of measurement condition
Contact closure	Form C (break before make) to remain in existing state until measurement condition changes
Time-base selectors	4 rotary switches 1 through 9,999 and 1 rotary switch for 1, 10, 100 multiplier
Display storage	Display remains constant unless input parameter changes
BCD output	1-2-4-8 BCD at rear panel connector. Binary 0 = 0 to + 0.4 v, 0 =5 ma current sink; binary 1 = +4.5 to +5.5 v, 0-1 ma current source. Print command logic change from 0 state to 1 state for 25 microseconds following gate closure from any gate control.
Power	115 v a-c ± 10%, 50 to 400 Hz; internal jumper provided for 230 v operation.

... output relays can trigger bell ...

signal is the other input to the gate. When the time-base count reaches its preset limit—half a second, in the case of the tachometer—the gate turns off and further measurement pulses are blocked.

Three lights on the front panel let the operator know if he is within limits. The top bulb lights if the rate is high, the bottom if low, and the center if on target. Bells or buzzers, too, can be connected to the output relays to warn of out-of-tolerance frequencies.

Beckman Instruments, Inc., Electronic Instruments Division, 2400 Wright Ave., Richmond, Calif. 94804 [429]

New industrial electronics

It's in the cards to start new line

Component maker steps from logic-product work into numerical control

Why would a successful maker of electronic components and digital logic cards want to get involved in the crowded numerical control market?

"The NC field is just being scratched," says John Hemmert, manager of the digital applications section of the Cambridge Thermionic Corp. "We've developed the

Mil by mil. Point-to-point positioner can be programed to move a table in one-mil steps.

Now—save vital space with 30-gauge hook-up wire

General Electric saved space and weight in wiring the back panels of its GE-PAC® Process Computers by using 30-gauge hook-up wire insulated with Kynar.

. . . Made with tough, durable Kynar®

Thirty gauge wire is nothing new . . . but what is new is wire insulated with Kynar, the fluoroplastic that's tough. It has twice the cut-through resistance of other fluoroplastics, cuts and strips smoothly, takes 180° bends without splitting, stands up to the punishment of automatic wiring machines or semi-automatic hand tools.

What's more, Kynar resists cleaning solvents, won't degrade with age, and operates at temperatures from −80° to 300°F.

For samples of 30-gauge wire insulated with Kynar plus information on how you can save space, reduce weight, write Plastics Department, Pennsalt Chemicals Corporation, 3 Penn Center, Philadelphia, Pa. 19102.

Kynar...the fluoroplastic that's tough! PENNSALT®

. . . high speed unit for labs planned . . .

capability of building numerical control units with our logic cards. And by building these systems, we become a testing ground for our own logic products."

Cambridge will bring out a line of four solid-state numerical control units, designed to be used with x-y tables to form a positioning system. The lowest-priced positioner will be a bench-top unit that moves a table in discrete steps. Hemmert says this point-to-point unit will not be "dramatically different" from its competitors, but Cambridge wants to offer a complete line.

The company expects to have an edge with its continuous, or contour positioner. This unit will use a technique, centered on a digital differential analyzer, to convert digital input commands to analog positioning signals. The analyzer approach, according to Hemmert, will allow Cambridge to sell its unit at the lowest price in the market.

The line will be completed late this year when two machines, each capable of performing complex operations and being controlled by a computer, are introduced. One will be a low-speed, high-power unit for industrial use, and the other a high-speed unit for laboratory work.

Preview. At the IEEE show this week, Cambridge is exhibiting a prototype of its discrete-step model. It moves an x-y table in increments as small as ±0.001 inch at a maximum rate of 2,000 points per second, and can also move the table up to 10 inches along both the x and y axes.

A positioning routine can be programed on paper-tape, and read by the machine. Or the table can be positioned by using front panel switches. Position is digitally displayed at all times.

Hemmert says mechanical paper-tape readers will be standard, but the company is considering offering photoelectric readers for high speed units.

Prices will range from $5,000 to $50,000.

Cambridge Thermionic Corp., 445 Concord Ave., Cambridge, Mass. 02138 **[430]**

and qualify for a FREE trip to a New Year's bowl game of your choice

Recognize this team? Know what big league outfit they just joined? Any idea what they can contribute to your MOSFET requirements? Answer these questions and you'll be a winner!

RULES: If you specify or purchase MOSFET devices you're eligible. Place the answers to the two questions listed below in the famous dotted box. Correct answers will get you a free product catalog with detailed specifications on the MOSFETs this team has already developed.

This will automatically qualify you as a contestant for additional prizes and the grand prize of a three-day all-expense holiday for two, plus a pair of choice ducats to the 1969 New Year's football bowl game of your choice. And your transportation will be provided from any point in the U. S. A.

QUESTIONS:

One: What large organization did the team come from?

Clue: They didn't play for Stanford University but they were located close-by before they moved South.

Two: What well-known electronics firm is this team now producing MOS field effect transistors for?

Clue: If the big H on their jerseys doesn't give them away, then look up the article in the Jan. 1, 1968 edition of Electronic News.

No purchase of any kind is required. All entries for qualification must be postmarked not later than April 5, 1968 and received by April 15, 1968. Employees of the sponsoring firm, its special sales representatives, and its distributors are not eligible. Contest is void where prohibited by law or by participant's company policy.

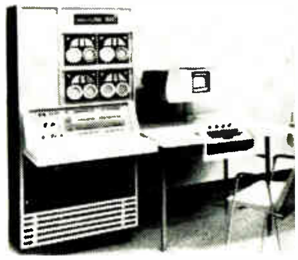
Just place your answers in the dotted box or on your letterhead and mail to MOSFETs, P. O. Box H, Newport Beach, California 92663. NOTE: Be sure to include your title and return address. Good Luck!

Please cut out along the famous dotted lines.

Load cell readout DS-100-T21X provides readout in pounds, kilograms, or other engineering units when connected to a strain gauge transducer. Channels 1 to 4 plus summing are standard. Sensitivity is 1 mv/v to 3.5 mv/v, adjustable. Speed is 2 to 20 readings/sec. Price is from $1,225 complete. Doric Scientific Corp., 7969 Engineer Rd., San Diego, Calif. 92111. [381]

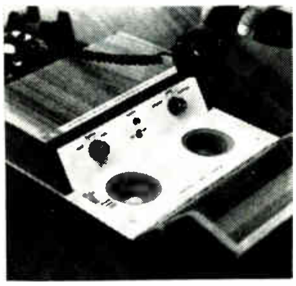
Solid state magnetic demodulator DMD 896-2 converts phase reversing a-c signal voltages into phase detected, polarity reversing d-c voltages. It gives 1 v d-c per 1 v a-c and provides 10 kilohm impedances on signal and reference windings. It provides less than 2% absolute linearity from 0.1 to 10 v output. General Magnetics Inc., 135 Bloomfield Ave., Bloomfield, N.J. [382]

High-resolution, electrostatically focused crt WX30851P11—made up in an assembly of matched tube, yoke, and shield—provides a 0.00045-in. diameter spot size for aerial photographic recording and other single-line scan data-processing applications. The ruggedized 11¼ lb package is ready to install and operate. Westinghouse Electronic Tube Division, Elmira, N.Y. 14902. [383]

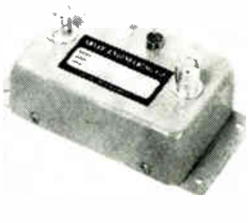


Laboratory instrument computer Micro-Linc-300 offers buffered tape, which permits parallel processing while tape instructions are being carried out. A rapid-access-to-memory feature, in conjunction with buffered tape, permits data logging at a 6,000-character/sec rate. Price is under $50,000; delivery, 90-120 days. Spear Inc., 335 Bear Hill Rd., Waltham, Mass. 02154. [384]

Bipolar antilogarithmic amplifier model 349 is a versatile tool for generating a wide variety of nonlinear transfer functions. It also has application in data expansion. It has a frequency response of d-c to 10 khz. Dynamic range is 80 db. Price is $240 each in quantities of 1 to 9; delivery, from stock to 3 weeks. Optical Electronics Inc., P.O. Box 11140, Tucson, Ariz. 85076. [385]



Acoustic data coupler 260 is for sending and receiving data between a remote terminal and a time-shared computer using any ordinary telephone. The unit is designed to handle a bit rate of approximately 300 baud. It is used at a 110-baud rate when used with a model 33 or 35 Teletype. Price is $570. Anderson Jacobson Inc., 2235 Mora Drive, Mountain View, Calif. [386]



Wideband amplifier model 311 covers 20 hz to 150 Mhz. It has 20 db gain and less than 50 μv equivalent input noise. It can drive 1 v peak-to-peak into a 50-ohm load with less than 1 db gain compression. Input impedance is also 50 ohms. The unit employs BNC connectors on a drawn aluminum housing 4 x 2⅛ x 1$\frac{1}{16}$ in. Arvee Engineering Co., Box 3759 Torrance, Calif. [387]

Double balanced modulator model 760A Mini-Modem finds application in SSB modulator/demodulators, frequency synthesizers, and broadband frequency converters. Specifications include 50 db balance and 6 db conversion loss. The unit is usable over a 3-decade frequency range from 100 khz to 100 Mhz. Price is $30 to $40. Summit Engineering Corp., Box 115, Bozeman, Mont. [388]

New subassemblies

Receiver tuned to needs of new nations

High-frequency unit designed for unskilled operators; basic two-channel model can be adapted to special jobs

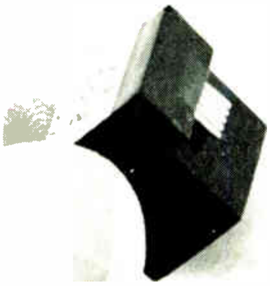
With Britain out of the empire business, many newly independent countries find themselves short of technicians. The Marconi Co., a longtime supplier of communications equipment to the colonies, has developed a high-frequency receiver that, it says, will ease some problems of that shortage.

The new unit, called the Hydrus, replaces Marconi's 12-year-old HR series of receivers. The Hydrus is one-fourth as large and has a 1.5 to 30 megahertz range.

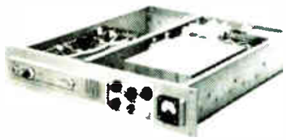
Four bands. Marconi designed the receiver to be easy to operate and easy to repair. The frequency range is divided into four bands. The operator selects a band, and then tunes the receiver with a fixed-position switch. Each click is equivalent to a 0.1-Mhz frequency change. The operator then makes a fine adjustment with a dial.

An automatic frequency control system allows the Hydrus to lock onto signals that drift by as much as 250 Hz. And the automatic gain control operates over a 90-decibel range to control the output to within six decibels.

Most of the receiver circuits are printed on cards. A repairman has direct access to most components



Microminiature, plug-in electrocardiogram amplifiers models 2100 and 2110 are intended for use with low level bio-potentials in the 1-mv range. A 500-kilohm input impedance with a voltage gain of 750 and a frequency response of 0.05 to 150 hz suits the units for other low-level signal amplifications. Signatron Inc., 17124 S. Western Ave., Gardena, Calif. 90247. [389]

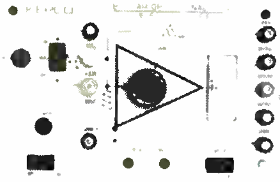


Phase lock vhf receiver model 5454 is a 5-channel, crystal controlled unit. Also designated AN/SMQ-6, the f-m receiver operates within the 125-155 Mhz range, and is designed for high dynamic range and exceptional stability. I-f image rejection is 100 db minimum and over-all system distortion is less than 1%. Data-Control Systems Inc., Danbury, Conn. 06810. [390]

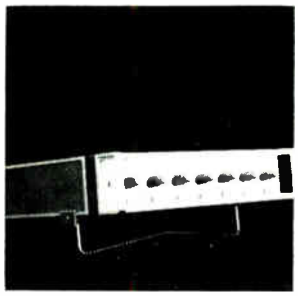
Modular power supplies series FR offer remote sensing and provision for remote programing. Voltage ranges are 0 to 15 and 0 to 30 v with current capabilities of 0.5 or 1 amp. Regulation is 0.01% or 2 mv, whichever is greater. Ripple is 1 mv peak to peak. Stability is better than 0.02% per°C. Prices begin at $75 each. Elasco Inc., 33 Simmons St., Boston, Mass. 02120. [391]

Telemetry receiver model ICR-10 is for ground based, special airborne, mobile and portable application. It uses linear monolithic IC's for all active devices, except the power supply, and features ultralinear agc. The unit has an r-f input frequency of 130-140 Mhz. Dimensions are 2 in. high, 13 in. wide, and 10 in. deep. Defense Electronics Inc., Rockville, Md. 20854. [392]

Universal data distributor model YD2 allows interfacing to any general purpose digital computer without regard to data structure or digital logic levels. It provides for timing, control and data distribution of digital inputs. Digital data of up to 15 bits may be transferred at rates of up to 500 khz. Adage Inc., 1079 Commonwealth Ave., Boston, Mass. 02215. [393]



Bipolar power supply BOP 36-5M is capable of smooth control right through zero from positive to negative voltage with no crossover distortion. It is rated ±36 v d-c ±5 amps continuous duty. The unit is terminated in an operational patch panel, offering complete access to the output, common, null and reference terminals. Kepco Inc., 131-38 Sanford Ave., Flushing, N.Y. 11352. [394]



Signal conditioning amplifier unit Accudata 117 increases the versatility of oscillographic and tape recording instruments. It is a multichannel, direct-coupled, single-ended floating d-c amplifier designed for use with high-speed data acquisition systems. Input impedance is 1 megohm; gain, with vernier, up to 25. Honeywell Inc., P.O. Box 5227, Denver, Colo. 80217. [395]

D-c power supply SC036-50-12S is for general or lab use. It is SCR regulated and provides ±0.25% voltage regulation against line and load changes combined, with less than 1% ripple. It is continuously adjustable from 0 to 37 v d-c and includes ±3% current regulation down to 0 v. Christie Electric Corp., 3410 W. 67th St., Los Angeles 90043. [396]

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and cards through the front panels.

In the wilds. The Hydrus will be available in many models. The company says the unit is suitable for use in both remote areas and major communication centers. But Hydrus will probably be used in situations where cables or microwave links are not economical, such as in one or two channel network communication links whose signals are transmitted hundreds of miles over rough terrain. The most likely customers are national communication companies, but Marconi also hopes to sell to oil and trading companies, and the military.

The Hydrus has three basic units—the two-channel receiver, the synthesizer, and the telegraph/telephone unit.

The receiver section contains demodulators, and signal, intermediate and audio frequency amplifiers. The use of field effect transistors in this section accounts for the high linearity of the Hydrus, says the company. Before turning to FET's, Marconi engineers who attempted to build high-gain solid-state receivers were plagued with

True to form. Field effect transistors are used extensively in the receiver to eliminate distortion at high gain.

. . . synthesizer provides frequency steps . . .

distortion caused by intermodulation.

With front-panel switches, an operator can attenuate the received signal between 0 and 30 db. Another switch allows the operator to monitor the output of either the upper or the lower sideband demodulator.

The synthesizer contains 2 decade oscillators, a free-running oscillator, frequency dividers, and power supplies.

The decade oscillators are used to supply mixers. One covers a 41.5 to 60.5 Mhz range in one-Mhz steps, and the other a 6.05-to-6.95 Mhz range in 0.1 Mhz steps. The free-running oscillator, tunable from 200 to 300 kilohertz produces the input for the 0.1 Mhz-step unit.

The Hydrus operates from a 24-volt d-c supply or a rectified 45-to-65 hertz, single-phase source.

The user can specify a telegraph unit, a telephone unit, or a combination of both.

Prices for the Hydrus range widely, but Marconi gives $8,400 as a typical price for a customer in England.

The Marconi Co., Chelmsford, Essex, England [397]

New subassemblies

Portable telephone always gets call

Attache-cased transceiver operates as a duplexer eliminating talk switch

Portable radio telephones are getting lighter and more versatile. They're freeing the user of total dependence on a vehicle while promising the option of using the vehicle's battery.

The latest is contained in an 18½ inch-long attache case. It was developed by the CarryPhone Corp., a Los Angeles area firm.

The unit, dubbed the Commander 701, is not the first portable telephone. Another Southern California company, International Mobile Telephone Service Inc., brought out a unit several years ago. The IMTS phone is in a leather flight bag, weighs roughly 17 pounds, and, with an accessory, can be driven by an automobile battery.

Useful all over. The CarryPhone unit weighs 13½ pounds and is totally solid state. It uses 20 integrated circuits, mainly in the decoder, the receiver, and the modulator multiplexer. The Commander can be used in about 98% of continental United States. If there is a repeater tower to hook into within 50 miles of the caller, he can telephone anywhere in the country, or across the world.

But the primary advantage of the 701 over conventional vehicle-mounted mobile radio telephones lies in its portability. With car-mounted phones, users can call only while the vehicle is running. If the instrument needs repairs the car must also be taken to the phone company. If the vehicle needs repairs the phone is out until they are completed. According to the company, the user of a Commander is able to own his unit. Car-mounted mobile telephones are owned by the telephone company and leased to subscribers.

The 701 is operated through standard phone lines and the user has a permanent number. The Commander is FCC-type accepted, and the users must obtain an FCC operating license.

To place a call, the user picks up the receiver and presses the transmit button. This sends a carrier signal that is picked up by the mobile radio phone operator's switchboard where a light flashes. She then connects the call. For incoming calls, a transducer gives off a buzzing noise. A special noise-suppression circuit buffers outside interference. There are no buttons in the receiver to push and the 25-watt transmitter automatically functions once a conversation is initiated.

Voice operated. The Commander operates at 150 megahertz, with a full range of 11 telephone channels and 30 kilohertz spacing between channels. The unit dissipates 3.8 amperes while transmitting, and 100 milliamperes while receiving

. . . phone goes where you go . . .

because the transmitter operates only when the user is talking.

Melabs, Inc., of Palo Alto Calif., is responsible for design and production of the 701. Engineer Jack Gorry says that because of the unit's solid state and modular design, maintenance costs should be far less than for conventional mobile phones. The Commander's dimensions are 3 inches wide by 18½ inches long by 12¾ inches high. Talk time is about an hour and a half and the batteries—nickel cadmium or silver zinc—have a year's normal life. Recharging requires a minimum of 8 hours.

Future units will probably have an option to make the unit compatible with vehicle cigarette lighters so the car battery can be used as the power supply, Melabs says.

Cost accounting. In Southern California, it costs $65 to have the phone company install a mobile phone, $41 a month for equipment leasing and a $7 minimum service charge. The 701 costs $2,160 or can be leased for $50 a month and also has a $7 minimum service fee. First deliveries are slated for April, and a nationwide servicing agreement is under discussion now with RCA.

The servicing would be something like a drive-in telephone repair shop, except that the phone could be left without leaving the car. And because each unit can be used on any of the channels, the user could be given another unit to use in the meantime, while his was being fixed.

Jack Wolf, president of Carry-Phone, says people who have use for a car telephone would have use for the Commander 701. He expects a market for between 50,000 and 100,000 units within the next several years.

Doctors are expected to be one of the groups to benefit from the portable telephone. Even if a doctor has a phone installed in his car, he is still out of communication with his office when he's making a house call. With the CarryPhone, he can take his phone with him up to a patient's bedside.

CarryPhone Corp., Van Nuys, Calif. [398]

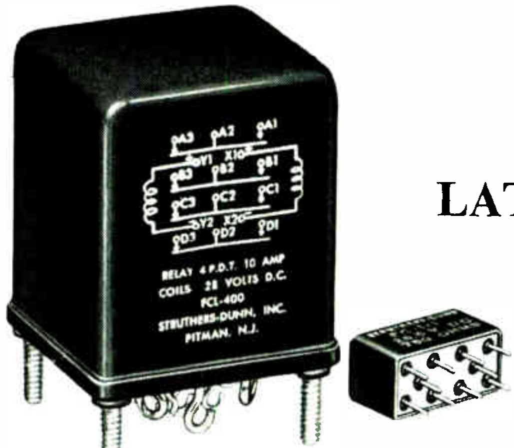
Latest in the Struthers-Dunn
YEAR OF RELAY DEVELOPMENT

one of many new relay and control refinements of special significance to users of switching devices

Here's one for aerospace.

magnets do the work, when milliwatts count . . .

LATCHING AEROSPACE RELAYS



Approx. actual size

Now, Struthers-Dunn adds magnetic latching to miniature hermetic relays . . . with no increase in size; no sacrifice of environmental resistance. They're as good as extra batteries in your aerospace or undersea system. You conserve precious energy by using it just to trip the relays, not to hold them.

The 10-amp Model FCL-400 trips on less than 35 milliwatt-seconds; the 2-amp Model FCL-1 on only 2 milliwatt-seconds. And they stay tripped—with zero power drain.

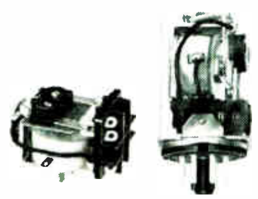
FCL-400 packs 4 double-throw 10-amp contacts in 4.15 cubic inches; withstands 25G shock; conforms to MIL-R-6106E. Check reader service number for bulletin.

FCL-1 has 2-amp DPDT contacts in half crystal can size; withstands 50G shock; conforms to MIL-R-5757. Check reader service number for bulletin.

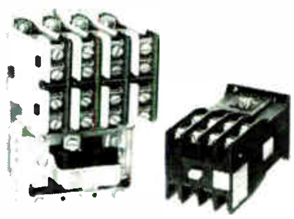
There's always more to draw on where you find the most to start with

Cutaway view

Economy Breakthrough in Reed Relays. New plastic sealing method brings you completely protected reed relays for little more than the cost of open types. Series MRRK is the newest in a complete line of standard, miniature, and shielded reeds for logic and data-handling applications. Check reader service number for complete specs.



Widest Line of General-Purpose Relays. The S-D line of low-cost, medium-duty relays has a compatible model for every control application: small motors, instruments, solenoid valves, heating elements, etc. Series 314, for example, offers 10-amp rating in open or enclosed-plug-in types; *both U.L. recognized.* Check reader service number for details.



Two Approaches to 600V Industrial Control. Series SC relays pack 600V capacity into 300V panel size . . . with four or eight 10-amp poles. Series MC features interchangeable contact modules for versatility. Choose any arrangement from 2 to 12 poles—even latching and timing types—with only two base sizes. Use reader service number for both.

SEND FOR THIS DATA

Check numbers on the reader service card for any or all of the items you need:

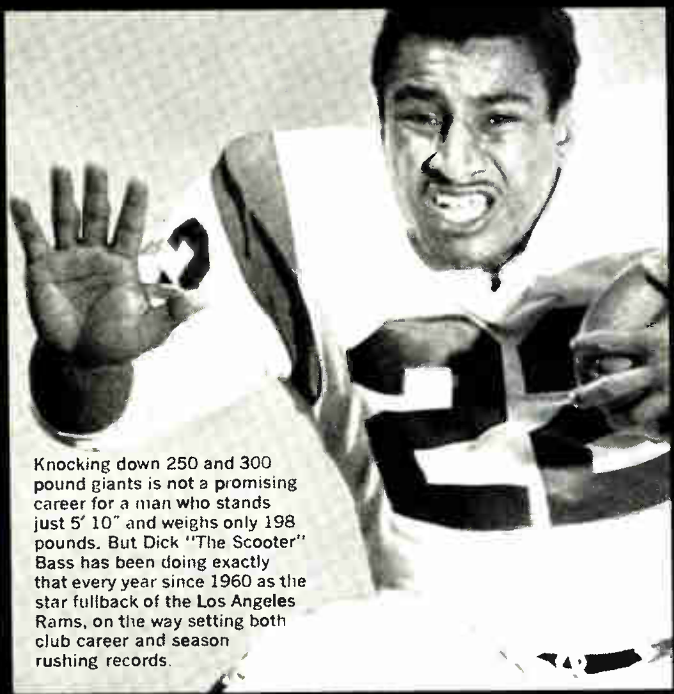
515 **Latching Aerospace Relays**
516 Sealed Reed Relays
517 U.L. Recognized General-Purpose Relays
518 600V Relays

S-D

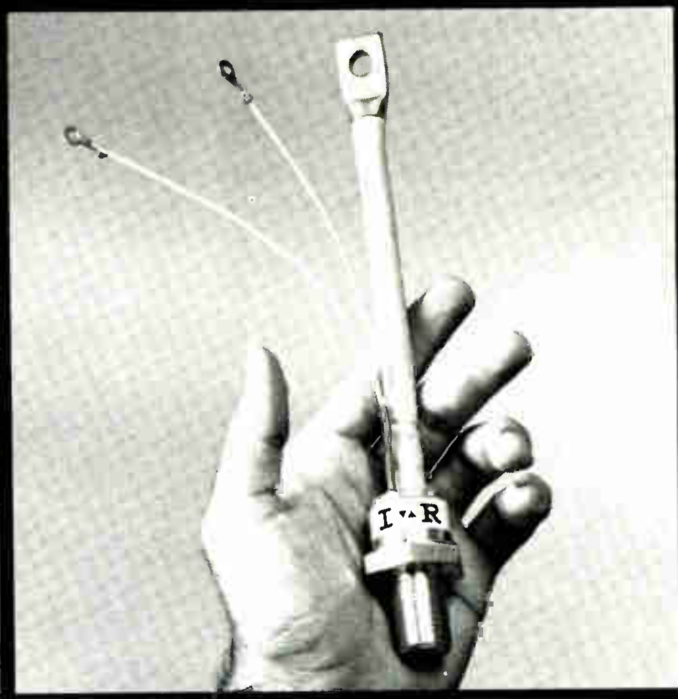
STRUTHERS-DUNN, INC.

PITMAN, NEW JERSEY 08071
Canada: Struthers-Dunn Relay Div., Renfrew Electric Co., Ltd.

Giant killers



Knocking down 250 and 300 pound giants is not a promising career for a man who stands just 5' 10" and weighs only 198 pounds. But Dick "The Scooter" Bass has been doing exactly that every year since 1960 as the star fullback of the Los Angeles Rams, on the way setting both club career and season rushing records.



When we broke the news of our logic-triac to the world last September, we suspect that we upset some of the giant names in industry who also dabble in rectifiers. ☐ Our triac is the world's most powerful (200 Amps, 400-1000 Volts), made possible by our exclusive epitaxial process. Where ordinary triacs are limited to say household appliances, our logic-triac can handle enough power to run a freight elevator. ☐ The "logic" capability means you can control both AC and DC, since the device has selective gate characteristics. Therefore the same freight elevator with a three phase induction motor will be controlled by IR logic-triacs to go up or down, slow or fast, and accomplish dynamic braking more easily by imposing a DC current through the triacs to the motor. ☐ Our complete technical and application data on logic-triac can make you master of this giant killer. Ask for it.

INTERNATIONAL RECTIFIER IR

Semiconductor Division, 233 Kansas Street, El Segundo, California 90245, Phone (213) 678-6281
Field offices and distributors in major cities around the world

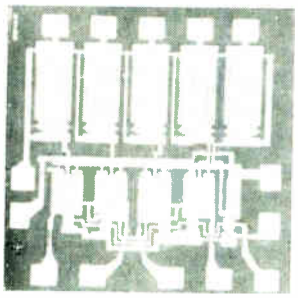
New Semiconductors Review

Diffused silicon npn transistor 1441 dissipates 350 w and has collector currents up to 150 amps. It exhibits a low saturation voltage (2 v max. at 100 amps) and is rated in 20-v steps from 40 to 120 v (V_{CEO}) sustaining. Minimum gain is 10 at collector currents of 50, 75 and 100 amps. Gain-bandwidth product is 1 Mhz. Westinghouse Electric Corp., Youngwood, Pa. 15697. [436]

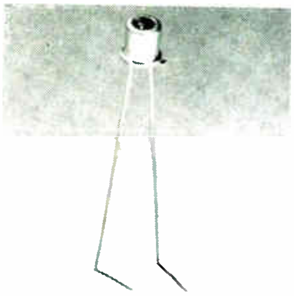
High-voltage silicon rectifier designated Sticpac is for x-ray generator use. Measuring 0.695 in. in diameter and from 3.38 to 8.50 in. long, it can replace vacuum tube rectifiers, and will eliminate many of the latter's hazards and operating inconsistencies. Sticpac is available in 5 voltages: 50, 75, 100, 125 and 150 kv. Semtech Corp., Newbury Park, Calif. 91320. [437]

Two p-i-n diodes are for switching, limiting, duplexing, phase shifting and variable attenuation uses. MO-111BL is a 200-v device with total capacitance at −50 v of 0.4 pf max.; switching resistance at 100 ma, 1 ohm max. MO-120BL is a 500-v unit with 1.1 ohms max. R_S at 100 ma. Alpha Industries Inc., 381 Elliot St., Newton Upper Falls, Mass. 02164. [438]

Germanium transistor SDT3090 is a 25-amp pnp unit in a TO-36 case. Minimum gain (h_{FE}) is 10 at 25 amps, and breakdown (V_{CEO}) 30 to 50 v. Designed for power applications up to 170 w dissipation, the unit can be used in military and industrial inverters, converters, switches, and control circuitry. Solitron Devices Inc., 1177 Blue Heron Blvd., Riviera Beach, Fla. 33404. [439]



MOS 4-channel multiplex switch type 3700 provides compatibility with npn bipolar logic and features blanking control of all channels. The output transistors incorporate very high off impedance (10^{12} ohms), very low on impedance (270 ohms) and zero offset voltage. Output leakage current is 10 na max. Fairchild Semiconductor, 313 Fairchild Dr., Mtn. View, Calif. 94041. [440]



Avalanche silicon photodiode AV-102 features high internal gain resulting in typical signal-to-noise improvements of 300:1. It is designed for the detection, characterization and measurement of low-level light signals over the spectral range from 0.35 to 1.13 microns. Frequency response is d-c to 2 Ghz. EG&G Inc., 160 Brookline Ave., Boston, Mass. 02215. [441]

H-v silicon transistors npn 2N4924-27 and pnp 2N4928-31 are complementary devices. Breakdown voltages range from 100 to 250 v with all units measured at a collector current of 10 ma. Other features are leakage current in the na region, low saturation voltage, d-c beta to 200, and high gain bandwidth product. Motorola Semiconductor Products Inc., Box 955, Phoenix 85001. [442]

Thyristor SCR's types 2231 and 2232 have maximum turn-off times of 30 and 40 µsec respectively from 150 amps, pass a forward current of 475 amps rms and 300 amps half-wave average. Surge current is 4,500 amps. Forward and reverse blocking voltages are available through 1,000 v. Units have an integral heat sink. Westinghouse Semiconductor Div., Youngwood, Pa. 15097. [443]

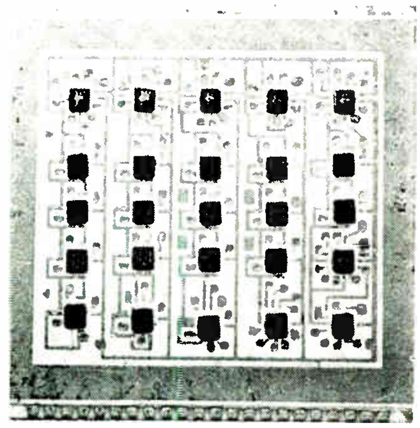
New Semiconductors

High-rise hybrids cut package size

Compact custom circuits are built with monolithic IC's by using layers of interconnections, separated by thick film

A sister division needed some special digital devices. So engineers at United Aircraft's Electronic Components division found a way to put a large number of monolithic integrated circuits and their interconnections on a small substrate.

The engineers developed a multilayer technique for packaging IC's which, the company says, is suited for building custom logic devices. Circuits are put on in layers, separated by a thick dielectric film. IC's and other components are then bonded to the top metalization



Triple decker. Three metalization layers interconnect 25 multifunction integrated circuits on a one square inch substrate.

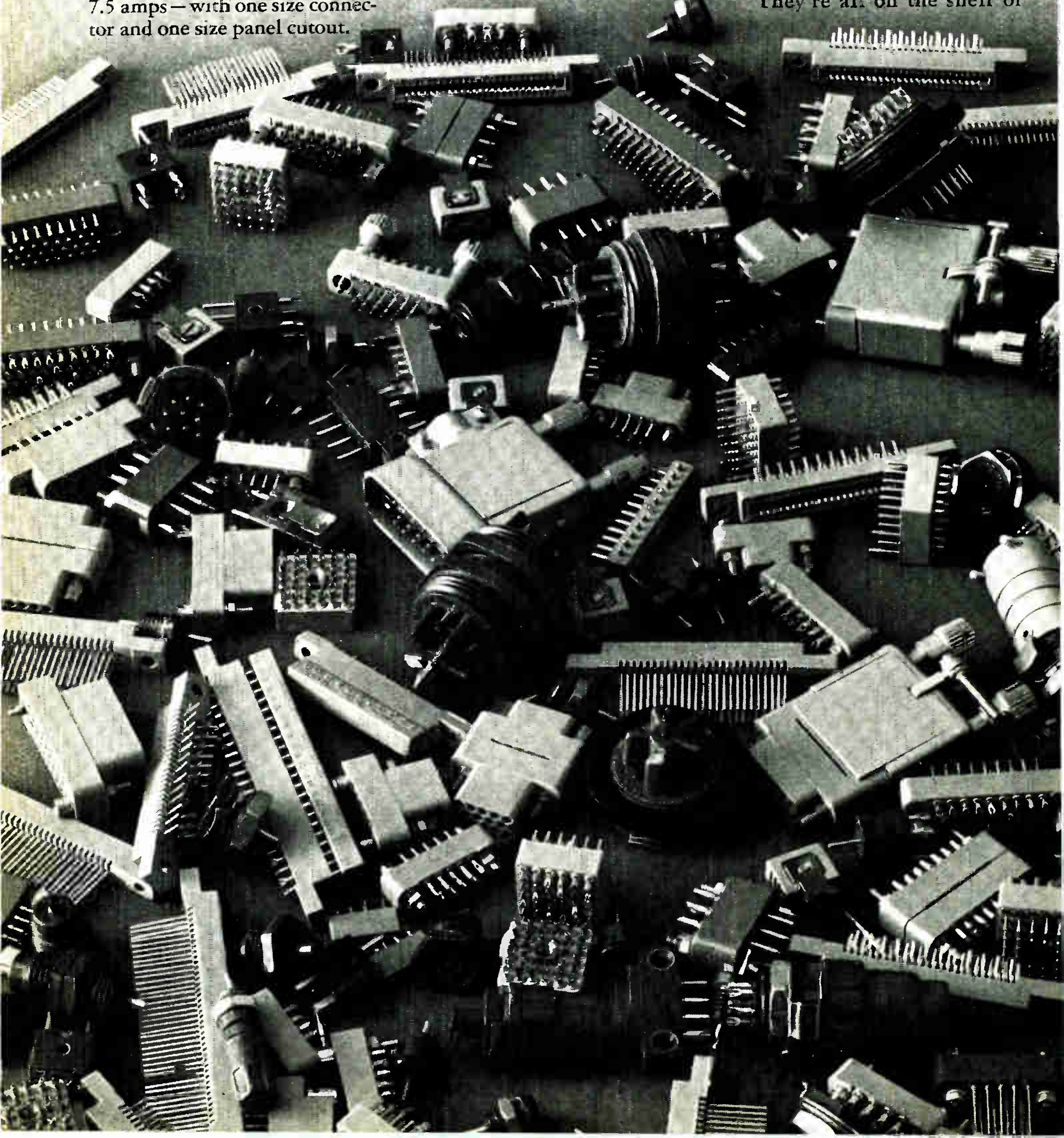
Always connect subminiatures with Winchester Electronics.

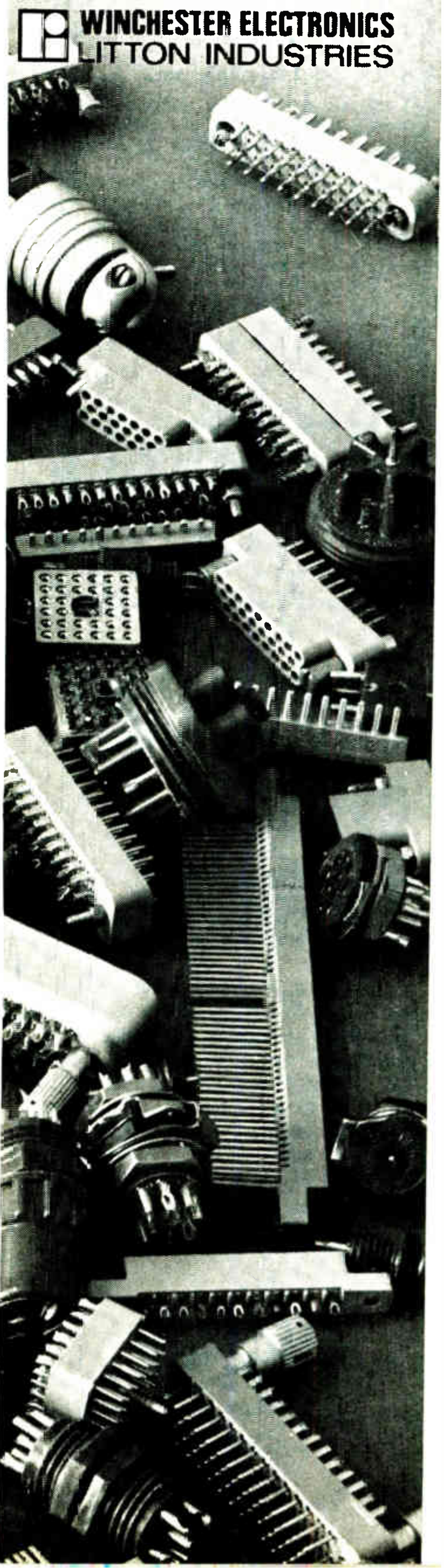
Take cable and panel mounted rectangulars. We've got them with solder or crimp removable contacts. From 4 to 50 contacts with current ratings of 3 to 7.5 amps. Standardized high-density rectangulars also, that allow you three current ratings — 3, 5, or 7.5 amps — with one size connector and one size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

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

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

They're all on the shelf of





. . . metal is screened onto the substrate, a thick film is deposited, and then another metal layer . . .

layer and electrically connected to the circuit by thermal compression.

Laying it on. The engineers start with a ceramic substrate and screen a metal layer onto it. A dielectric film is then screened over the metal. Small holes are left in the film so interconnections can be made. Another metal layer is then screened onto the film, and the metal that runs into the holes makes contact with the lower circuit segments. The metal-film screening steps can be repeated to build up the desired number of layers. The resistance of the dielectric film is in the megohm range.

David Steenhausen, product manager of the hybrid section, says four layers of metalization are within United's capability now, and he sees no reason why that number can't go up. He also points out that connections are not limited to adjacent layers, but can be made between any layers in a package.

And counting. United has been using the multilayer process to make four types of digital-transistor-logic counters for its Hamilton-Standard Division. These devices are double layered, and contain up to 10 IC's on a 1.4 square inch substrate. Steenhausen says United has also built a four-megahertz ripple counter in a three-layer package that has 25 IC's on a one square inch substrate. This counter has 44 leads and is hermetically sealed.

United will use its technique to build custom circuits, for now. Steenhausen says the company can deliver circuits four to six weeks after a customer submits a design. This delivery time may be cut to two weeks by the end of the year.

United has no plans to market off-the-shelf devices, but would if a market developed.

Stacked foe. Steenhausen says only United uses the multilayer packaging process but competition will come from companies who build up circuits on stacked ceramic wafers. He feels his firm has the edge over them in both size and price. But the big advantage for United is the flexibility of their process. To build a different circuit, engineers just change the screens used for the masking. The cost and time are small compared to the cost and turnaround time involved in ceramic retooling.

Besides packaging IC's, the technique can be used for less complex circuits. Steenhausen suggests using multilayer packs to customize the functions of operational amplifiers. He says the process also shows promise for use with flip-chip and beam lead devices.

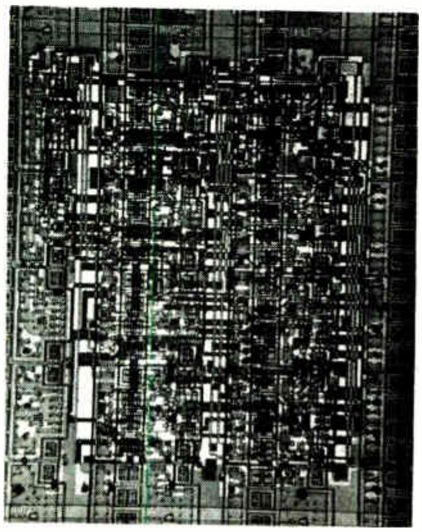
United Aircraft Corp., Electronic Components Division, Trevose, Pa. 19407 [444]

New semiconductors

Double deposit means more gates

Bipolar counter with two metal layers on a chip has 400 components, 54 gates

While systems engineers are still figuring how to use large-scale-integration products, the Philco-Ford Corp. is already talking second-generation LSI. Clare Thornton, direc-



Double duty. The input voltage level determines whether the bipolar array is a four-stage binary or a BCD counter.

← Circle 225 on reader service card

tor of research and development at the Microelectronics Division, considers four new integrated circuits as second generation LSI units.

Two of the IC's are still in the experimental stage, a 16 by 16 random access serial memory containing 1,400 transistors on a 100 by 120 mil chip, and a 2,048-bit memory containing 12,000 transistors on a 117 by 117 mil chip, designed to operate at speeds over five megahertz. Both devices are metal oxide semiconductor IC's.

A third MOS IC, a 1,024-bit read-only memory, containing 1,250 transistors on a 70 by 100 mil chip, is already on the market [Electronics, Feb. 19, p. 45].

For high-speed. The other device described by Thornton is a dual-function bipolar complex array that contains 400 components on a 110 by 88 mil chip. It acts as either a four-stage binary counter or a binary-coded-decimal counter. Changing the logic level of the control input changes the function.

By putting this device on the market, Philco is saying it's ready to talk second-generation bipolar LSI with customers. And engineers who want custom-made 100-megahertz logic circuitry or 500-megahertz shift register modules have to talk bipolar.

Open problem. According to Thornton, Philco jumped the bipolar generation gap by increasing component density by up to 100%. The double-metalization layer technique made this possible.

Thornton remembers that everybody expected shorts to be the big problem when they tried to put down layers of connections on one chip. Instead, the opposite occurred. The headache was to make sure there were no open circuits between the two layers. Philco finally refined the process to the point where adding a second layer did not reduce yield. "Holding the yield was the little hill we had to get over," says Thornton.

Most present bipolar IC's have no more than 20 gates per chip. "And that's pushing single-layer technology," says Thornton. The dual-function counter has 54 gates on a chip.

Philco expects the initial charge for double-layer bipolar devices to range from $1 to $10 per chip.

Philco-Ford Corp., Microelectronics Div., Blue Bell, Pa. **[445]**

New Books

Some protection

Grounding and Shielding Techniques in Instrumentation
Ralph Morrison, John Wiley and Sons, 144 pp., $9.50

One of the least understood areas of circuit design is proper grounding and shielding, and this is because a majority of the networks constructed must be handled on an ad hoc basis. This pecularity compounds the formulation of specific 'rules' on how to ground and shield, and is particularly evident in instrumentation, where circuit makeup is more varied than in digital and linear systems. But here is a book that does a respectable job in closing that information gap, although by no means can it be considered a designer's 'Bible' on the subject.

Ralph Morrison, an expert on the topic, has performed a service by organizing his experiences into this text. He notes that once understood, shielding and grounding concepts are simple to apply. He points out solutions of problems commonly faced by engineers.

Unfortunately, however, applications involving such widely used instruments as digital voltmeters (dvm's), and related equipment such as printers and scanners, are notably absent from the book. These applications are of great importance and deserve mention. For example, the integrating dvm, particularly the guarded version, successfully copes with many common grounding problems. Another flaw is the absence of words commonly found in the jargon of instrumentation design engineers

Sometimes, the author's proximity to the problems of shielding and grounding causes him to assume too lofty a level of writing. Take for example the section on page 33 that reads "These statements do not require that the shield be earthed or defined in any way." This seems to be true only if the enclosed charge is constant. Otherwise, as shown by equation 4 on page 12, the electrostatic charge emanating from a floating shield must change. Although this reviewer is confident the author understands this, it is not apparent to non-experts in the field.

Although quantitative data can become obsolete quickly, engineers will appreciate the tables included throughout the book, especially those on typical capacitance values between common elements such as a soldering iron and its case and between twisted wires. These are values that engineers can measure, but rarely do.

All in all, despite a few printed errors and the omissions cited, the book is still worth reading.

Paul G. Baird
Engineering group leader
Hewlett-Packard Co.,
Loveland, Colo.

Step up to vlf

Vlf Radio Engineering
A.D. Watt
Pergamon Press
701 pp., $20

The very-low-frequency portion of the radio spectrum was just about unused until the technology of the 1950's created applications more sophisticated than the broadcasting of only code and voice transmissions. But now Omega, a vlf navigation system currently in limited use and slated for expansion into a worldwide network,. is stirring general interest in the subject. "Vlf Radio Engineering" is therefore timely and may well become a standard work.

The book first charts the flow of information-bearing energy from transmitting location to receiver. Successive chapters cover transmitting antennas, the propagation mechanism, and receiving antennas. This sequence is followed by considerations of atmospheric radio noise, modulation, frequency spectrum, receiving systems, and finally, complete systems equipments.

The text contains the engineering data needed to design all elements of a vlf system, and notes many practical examples. Descriptions are given of several existing vlf transmitting antennas. Engineering information includes even the mechanical details of wind loading and conductor oscillation.

An unusual feature for this kind of work is the consideration of cost

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Circle 229 on reader service card

New Books

tradeoffs connected with each subject. The sections on cost factors could really form the basis of a course in practical economics for engineers; the questions raised and techniques described apply to many engineering disciplines.

The author is scrupulous in his acknowledgements, citing an impressive array of modern contributors to the technology as well as many historical works. Watt has put together a first-rate text that belongs on the shelf of the working communications engineer.

Wm. E. Yost Jr.
Consultant

Tuning up

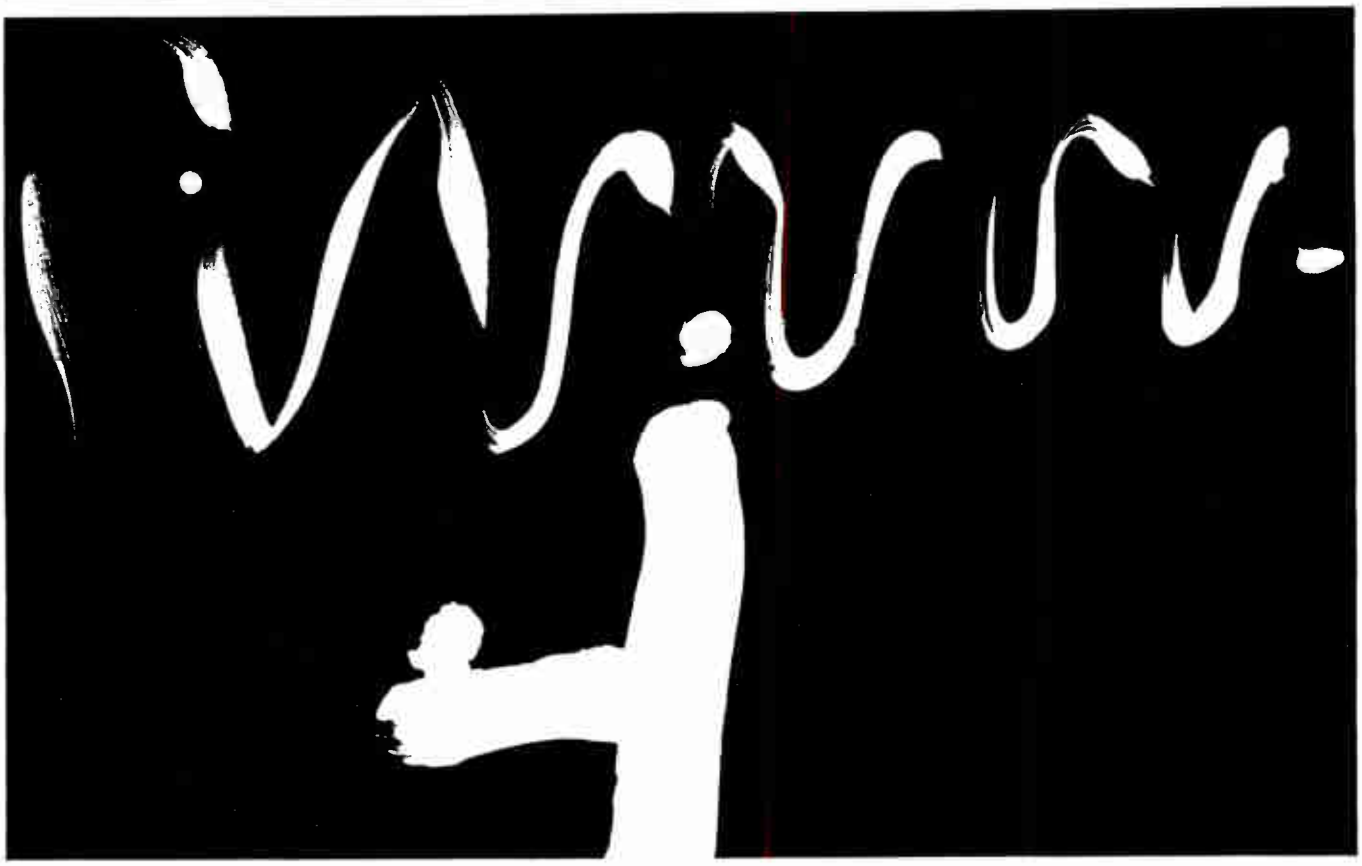
Radio and Line Transmission
D. Roddy
Pergamon Press
251 pp., $6

Basing his work on lectures to telecommunications personnel in Britain, Roddy presents his complex subject clearly and concisely. And, although he aimed at technicians, his book is valuable to both beginning engineers and experienced EE's seeking a quick refresher.

The text covers four basic topics—wave theory, devices, circuits, and systems—and employs a minimum of mathematics and physical detail. The material is practical and includes illustrations of the hardware.

Passages on signal behavior cover wave motion and propagation, logarithmic units, speech and music, amplitude modulation, and frequency analysis. The section on devices discusses passive and active components, including semiconductors, thermionic units, and electro-acoustic devices. Among circuit topics are series and parallel tuned circuits, rectifying networks, demodulators, amplifiers, and oscillators. Finally, radio, line telephone, and line telegraphy systems are described.

The book's shortcoming is the short shrift given integrated circuits and such recent discrete semiconductors as field effect transistors. But, since Roddy's work is function-oriented as opposed to device-structured, little is lost by the omission.



Technical Abstracts

IC lowdown

A new low-voltage breakdown diode
Robert J. Widler
National Semiconductor Corp.
Santa Clara, Calif.

Users of linear integrated circuits—particularly those concerned with regulation of power supply levels—have long needed a low-voltage breakdown diode element. Many problems would be solved by an element that's compatible with monolithic fabrication, exhibits more stability than current regulator elements, and can operate with the low-level signals often found in IC's.

Now there is one, a two-terminal IC that functions like a zener diode but at much lower voltages.

Discrete breakdown diodes in the 2 to 6 volts range, now made by the alloy process, exhibit a fairly soft breakdown characteristic, with the voltage changing by about 0.7 for a factor-of-10 change in reverse current. But, the reverse punchthrough of a graded-base transistor has a constant low-voltage characteristic which is superior to that of an alloy diode. Its breakdown voltage is determined by depletion of the base region, rather than an abrupt junction, so units with breakdown voltages as low as 1 v can be made, using standard diffusion techniques.

Transistors and resistors can be fabricated simultaneously with this punchthrough diode using present IC processes; and active circuitry can be put on the diode chip to provide even better performance.

The change of breakdown voltage with temperature is nearly linear; it is 3 mv/°C, independent of the nominal breakdown voltage. Also, it has been verified experimentally that the temperature-induced voltage drift of the reverse punchthrough in the 2 to 5 volt range is not significantly affected by the initial breakdown voltage for the double-diffused silicon transistors used.

At low voltages, the two-terminal monolithic voltage regulator, electrically equivalent to a breakdown diode, provides reverse characteristics which are 10 times sharper than single-junction zener diodes. Devices have been manufactured in volume with breakdown voltages from 2.4 to 5.6 v and specified for operation from 10 μa to 10 ma over the full military temperature range.

The regulator is fabricated on a 23-by-29 mil square silicon die using the six-mask, planar-epitaxial process. Because all junctions are passivated, reliable operation can be expected under extreme environmental conditions, even at low operating currents. Tests under way point to excellent long-term stability, which is to be expected since the breakdown occurs in the bulk rather than on the surface. Additionally, the breakdown mechanism is fairly quiet, giving an output noise of only 100 μa, peak-to-peak, from 10 hertz to 10 kilohertz.

Although the diode is not optimized for minimum capacitance, it is about an order of magnitude faster than alloy zeners in clipping and clamping applications. Also, because of its predictable temperature drift, it can be used in building fairly simple temperature compensated regulators, for operation with input voltages down to 3v and output voltages down to 1v.

Presented at Solid State Circuits Conference, Philadelphia, Feb. 14-16.

Toward the ideal

Line-operated transistorized tv horizontal deflection circuit
W. Hirchman and G. Ebarhard
Siemens AG
Munich, West Germany

Few television set producers will argue the merits of all-transistor tv sets—they generate little heat and are far more reliable than their tubed counterparts. But they cost more to produce, because they require a bulky and expensive transformer power supply for the horizontal deflection circuit.

The main obstacle to large-screen all-transistor sets is the horizontal deflection circuit, which must handle voltages considerably higher than the supply voltage during the flyback retrace period. The deflection yoke carries the high currents that produce the magnetic field needed to deflect the picture tube's electron beam.

In a typical case, a picture tube

with a deflection angle of 114° and an anode voltage of 18,000 v requires a peak energy of 2 millijoule from the deflection yoke. At full deflection, the peak energy stored in the yoke must be transferred back to the supply or the flyback capacitor during the prescribed retrace time. This requires the use of a horizontal output transistor having a high voltage-current rating.

Normally, the flyback voltage is directly related to the supply voltage. Therefore, if conventional low-voltage transistors are used in the deflection circuit, it becomes necessary to provide a low voltage power supply. The alternative is to use a transistor with a high collector-base voltage that can be driven directly from the rectified line voltage. All-transistor sets operating from a line voltage of 250 volts (the European standard) require the use of output transistors with a collector-base rating of 2,000 v [for a line voltage of 130 v, the U.S. maximum the output transistor must have a peak rating of 1,400 v]. Aside from the fact that these high-voltage transistors are costly, most available units lack the necessary fast switching speeds which are difficult to achieve in high voltage devices.

A proposed solution is to design a horizontal deflection circuit capable of compensating for power losses during the flyback retrace interval and thus obviate the need for the low-voltage power supply. This scheme enables the use of a horizontal output transistor whose voltage rating is the same value of the supply voltage—considerably less than the 1,400-v transistor normally required for the 130-v supply. This lower voltage also ensures faster switching speeds as a byproduct. For example, a 10-watt dissipation corresponds to a switching speed of only 2.2 microseconds, while for a dissipation of 2 watts the speed is reduced to 1 μsec, provided that the same deflection energy of 2 millijoule is maintained. Another advantage of low operating voltage for the transistor is greater efficiency and reliability at lower costs, due in part to the use of less expensive low-voltage capacitors.

Presented at the Solid-State Circuits Conference, Philadelphia, February 14-16.

New Literature

Indicating rotameters. Brooks Instrument Division, Emerson Electric Co., Hatfield, Pa. 19440, offers a six-page technical bulletin on a series of indicating rotameters that operate at pressures up to 5,000 psi.
Circle **446** on reader service card.

Printed circuitry. Croname Inc., 6201 Howard St., Chicago 60648, has issued a brochure featuring advanced techniques and advantages of a new presoldered circuit board that provides a solder wetted copper surface that can be applied to cover an entire circuit configuration, selective pads or connector pads. **[447]**

Data communication system. Communitype Corp., P.O. Box 3490, Grand Central Station, N.Y. 10017. An eight-page booklet shows how a recently introduced multipurpose data communication system saves time and cuts data processing costs. **[448]**

Industrial adhesive. Conap Inc., Allegany, N.Y. 14706, has available bulletin A-111 describing the advantages of a 100% solids, two-part epoxy paste adhesive, sealant and filler that forms permanent, high strength bonds with most materials. **[449]**

Analog multipliers. Transmagnetics Inc., 134-25 Northern Blvd., Flushing, N.Y. 11354. Catalog 1167 lists the company's line of solid state analog multipliers, covering a range from d-c to 4 Mhz in four models. **[450]**

D-c static drive. Louis Allis Co., Division of Litton Industries, Dept. P, Milwaukee, Wis. 53201. Six-page bulletin 10050 presents information on Saber 3200, 1 through 5 h-p, d-c static adjustable speed drives. **[451]**

Semiconductors. KSC Semiconductor Corp., KSC Way, Chelmsford, Mass. 01824, has issued a 16-page short form catalog listing more than 1,200 germanium power transistors. **[452]**

Coaxial magnetrons. Varian Associates, 611 Hansen Way, Palo Alto, Calif. 94303. A 16-page brochure, containing a comprehensive introduction to the subject of coaxial magnetrons, is available to design engineers interested in microwave radar transmitters. **[453]**

Hermetic Teflon terminal. Lundey Associates Inc., 694 Main St., Waltham, Mass. 01254, offers a catalog sheet covering the 609-TH Clinch-Loc hermetic Teflon terminal. **[454]**

Industrial instruments. The Bendix Corp., 3621 South State Road, Ann Arbor, Mich. 48106, has published an eight-page bulletin that describes 20 instruments for inspection and measurement. **[455]**

Drilling machine. Gardner-Denver Co., Gardner Expressway, Quincy, Ill. 62301. Bulletin 15-1 contains complete information on the model 15J Grid-Drill designed for drilling electronic circuit boards for present and future generations of computers. **[456]**

Torque motor products. Aeroflex Laboratories Inc., South Service Rd., Plainview, N.Y. 11803. A catalog/file folder covers a line of brushless d-c torque motors, d-c moving coil torque motors, d-c tachometers, and d-c torquer amplifiers. **[457]**

Electrical switches. Robertshaw Controls Co., P.O. Box **449**, Columbus, Ohio 43216. Catalog 200 covers subminiature, miniature, series 1 and 4 Tyni, rotary and open blade switches. **[458]**

Power supplies. Hewlett-Packard Co., 100 Locust Ave., Berkeley Heights, N.J. 07922. An 88-page catalog and handbook combines a text-like discussion on d-c power supplies with a complete listing of the company's units. **[459]**

Logic driver data. Weston-Transicoil Div., Weston Instruments Inc., Worcester, Pa. 19490, offers a data sheet describing the operation of stepper motors in conjunction with a logic driver. **[460]**

Automatic wire strippers. Eubanks Engineering Co., 225 W. Duarte Rd., Monrovia, Calif. 91016, has available product data sheets on the model 88 micro-wire and model 83 heavy cable automatic stripping equipment. **[461]**

Instructional tv system. Jerrold Electronics Corp. 401 Walnut St., Philadelphia, Pa. 19107. An eight-page booklet tells in detail how a 16-channel closed-circuit instructional tv system has upgraded observation of classroom methods by student teachers. **[462]**

Control knobs. Raytheon Co., Fourth Ave., Burlington, Mass. 01803, has issued a catalog describing several series of control knobs for electronic equipment. **[463]**

Vacuum measurement. The Fredericks Co., Huntingdon Valley, Pa. 19006. A 24-page booklet is designed to familiarize laymen involved in vacuum production processes with basic technology. **[464]**

Cooling systems. Zero Manufacturing Co., 1121 Chestnut St., Burbank, Calif. 91503. A 24-page catalog describes 10 series of blowers and systems for cooling electronic cabinets. **[465]**

Insulated wire and cable. Radix Wire Co., 26260 Lakeland Blvd., Cleveland,

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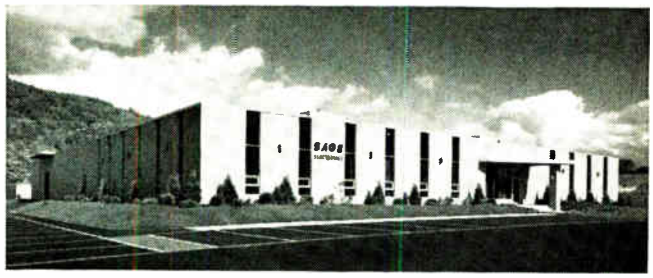

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Circle 237 on reader service card

New Literature

Ohio 44132. A 40-page catalog contains complete data on 44 types of insulated wire and cable. **[466]**

High-power oscillator. Winslow Tele-Tronics Inc., 1005 First Ave., Asbury Park, N.J. 07712, has available an engineering bulletin on the model 304A oscillator, which supplies 10 v into 50 ohms, and covers 50 khz to 100 Mhz. **[467]**

Ceramic materials. National Beryllia Corp., Haskell, N.J. 07420, has available a property chart showing the electrical, thermal, and mechanical properties of high performance ceramic materials. **[468]**

A/D converter. Control Data Corp., 4455 Eastgate Mall, La Jolla, Calif. 92037, offers a data sheet on a low-level, 15-bit integrating analog-to-digital converter with high series mode/common mode rejection. **[469]**

Coil-winding machines. Geo. Stevens Mfg. Co., 6001 N. Keystone Ave., Chicago 60646, has released a two-page catalog for two new coil-winding machines. **[470]**

Pulsed crossed-field amplifiers. S-F-D Laboratories Inc., 800 Rahway Ave., Union, N.J. 07083. A 26-page illustrated catalog introduces pulsed crossed-field amplifiers to radar system designers. **[471]**

IR analytical accessories. Instrument Division, Barnes Engineering Co., 30 Commerce Rd., Stamford, Conn. 06902, offers a four-page illustrated folder on its wide range of infrared analytical accessories and cells. **[472]**

Attenuation calibrator. PRD Electronics Inc., 1200 Prospect Ave., Westbury, N.Y. 11590. Application Note No. 20 covers the 915-B microwave attenuation calibrator. **[473]**

Dielectric screening inks. Wornow Process Paint Co., 1218 Long Beach Ave., Los Angeles 90021, offers data sheets on the 50-770 dielectric screen black epoxy ink for circuit manufacturers. **[474]**

Temperature-characteristic analyzer. Winslow Tele-Tronics Inc., 1005 First Ave., Asbury Park, N.J. 07712. A four-page engineering bulletin describes the model TCA-1070 temperature-characteristic analyzer and relates its performance characteristics to applicable MIL specifications. **[475]**

Filter design aid. Nytronics Inc., 10 Pelham Parkway, Pelham Manor, N.Y. 10803. Important information for the circuit design of low-frequency, high-frequency, and bandpass filters is contained in a 12-page booklet. **[476]**

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At home, Al popped the family off to bed after an evening's TV . . . and pondered. Everything seemed to hinge on the weight. Even latheways cast in magnesium or aluminum clocked in at 1500 lbs.; available sensor-holding units hit the scales at 300+. What was needed would have to weigh far less. So, he gave it considerable thought.

With considerable success. Resulting in the basic parameters for a portable, air-transportable, autocollimated, lab quality optical bench. Capable of ultra-narrowband spectral analysis; sensitivity checkout; testing resolution and total field of view, with micrometer sensor positioning and a built-in substitute cryosource. Total weight 300 lbs!

Funny thing about Al. He doesn't consider what he did especially unusual. It's typical of the all-of-a-sudden problems that crop up in developing multi-function AGE systems whose frequencies run from DC to light. And, he's gotten used to pioneering ideas like automated test equipment using a time-shared central computer. He likes it. All of it.

If there are any more of you out there like Al, why not investigate what our AGE laboratory can offer you. Even if you'd prefer to pit your intellect against a provocative study or development program in another advanced area, we'd like to hear from you: we'll tell you about ongoing programs in our radio communications, navigation aids, data equipment, countermeasures and tracking systems labs.

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*BZY93	7·5 to 75V	20W	DO-4
OAZ222-3	5·6 and 6·2V	10W	DO-4
BZY96	4·7 to 10V	1·5W	DO-1
BZY95	10 to 75V	1·5W	DO-1
BZY88	3·3 to 30V	0·4W	DO-7
BZX61	33 to 75V	0·4W	DO-7

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Newsletter from Abroad

March 18, 1968

Hayakawa hurrying pocket calculator

The Hayakawa Electric Co. is hustling to develop prototype versions of a pocket-size electronic calculator by the fall. Hayakawa edged out the Sony Corp. last year when both bid for government subsidies to develop the calculator, **but Hayakawa is now worried that Sony might beat it to the market nonetheless.**

Hayakawa fears that Texas Instruments might help Sony in the race. Company officials approached TI before the U.S. firm decided to join Sony in an integrated-circuit venture in Japan [Electronics, Feb. 5, p. 207]. Planning to build its eight-digit calculator around medium-scale-integration IC's, Hayakawa sounded out TI on the possibility of becoming a supplier if the packages couldn't be developed in time in Japan. **As a result, Sony's IC partner has a fair idea of Hayakawa's first designs.**

Present plans call for from eight to 10 different medium-scale-integration arrays for the computing circuits, along with miniature versions of the Digitron readout tube. **The circuits, which would have about 250 elements on the chip and about 40 external connections, are now being developed in conjunction with Mitsubishi and Hitachi. The Hayakawa calculator would be priced at about $280.**

Fiscal curbs to hit Britain's tv market

British consumer electronics companies expect bad news when the Wilson government unveils its 1969 budget later this week.

Chancellor of the Exchequer Roy Jenkins has already warned Britons that the nation is in for more austerity. The aim, apparently, is to hold consumer spending to $70 billion next year, about $1 billion less than would be anticipated without deflationary brakes.

Producers of tv sets expect to be hit with a slight rise in sales taxes plus a reinstatement of tougher terms for credit sales and rentals. Restrictions on time-payment sales and rentals were eased last August and a mild spurt in tv business followed.

Other electronics sectors—military hardware excepted—should not be hard hit. The government continues to stress investments in plant improvements, an emphasis that buoys the industrial electronics business. **Exporters, though, may lose some of the competitive edge gained in last November's devaluation. Their costs will probably be forced up slightly by boosts in corporate and payroll taxes.**

Intelsat wooing French Africa

Some of the French-speaking African countries that de Gaulle is counting on for the Franco-German Symphonie communications satellite system may end up in the fold of the International Telecommunications Satellite Consortium.

Intelsat officials this month made a strong pitch to sign up the Ivory Coast, expected to be one of the first African countries to get a ground station into service. Ivory Coast officials apparently are anxious to link up with a network before 1971, when Symphonie is scheduled to go into orbit.

If the Ivory Coast signs up for an Intelsat ground station, both Cameroon and the Malagasy Republic may follow. The other French African countries apparently would stick with Symphonie, although only Senegal has thus far signed up.

Newsletter from Abroad

Sony diode reacts to earth's field

A diode so sensitive to magnetism that it is affected by the earth's field has been developed by Sony. **Typical sensitivity for the device is 1 volt per milliampere per kilo-oersted.**

The diode, a germanium bar about 3 millimeters long with a cross section 0.6 by 0.4 mm, has a p-i-n structure, with a small recombination area added along one edge of the intrinsic region. When a magnetic field deflects carriers into the added region, recombination increases and forward current drops. The drop is linear until the diode saturates.

Sony will price the magnetodiode at about $3 and sees potential applications in brushless d-c motors, proximity switches, and volume controls.

Signetics sees future abroad

Signetics, which has carved out a sturdy reputation as a second sourcer of integrated circuits, **apparently expects further growth to come from abroad.** The Corning Glass Works subsidiary has made its former marketing director, George Didinger, head of a new international department that is organizationally equal to marketing, R&D, and operations.

The company will concentrate on Europe and Japan, according to its president, James F. Riley. "That market now is 25% of the U.S. market. It's right where the U.S. market was four years ago." **Signetics is now dickering with at least two Japanese companies for a joint manufacturing venture there, and plans to build in Europe in the future.** It already has an assembly plant in Seoul, Korea.

French tube makers shun new venture

The two French companies currently producing shadow-mask picture tubes want no part of the deal the de Gaulle government has set up to get the maskless tube developed by the Compagnie Francaise de Television (CFT) into production.

De Gaulle pushed through a plan to form a new company to produce the CFT tube early this year [Electronics, Jan. 22, p. 193]. The government left a **30% holding available in hopes of luring consumer electronics firms into the venture,** particularly the two color-tube producers—La Radiotechnique and Cie. Industrielle Francaise de Tubes Electroniques. Both companies have balked, and it now looks as if French industrialist Sylvain Floirat, a major partner with the government in CFT, will end up with 90% of the shares in the new firm, called France-Couleur.

SEL does well in East Europe

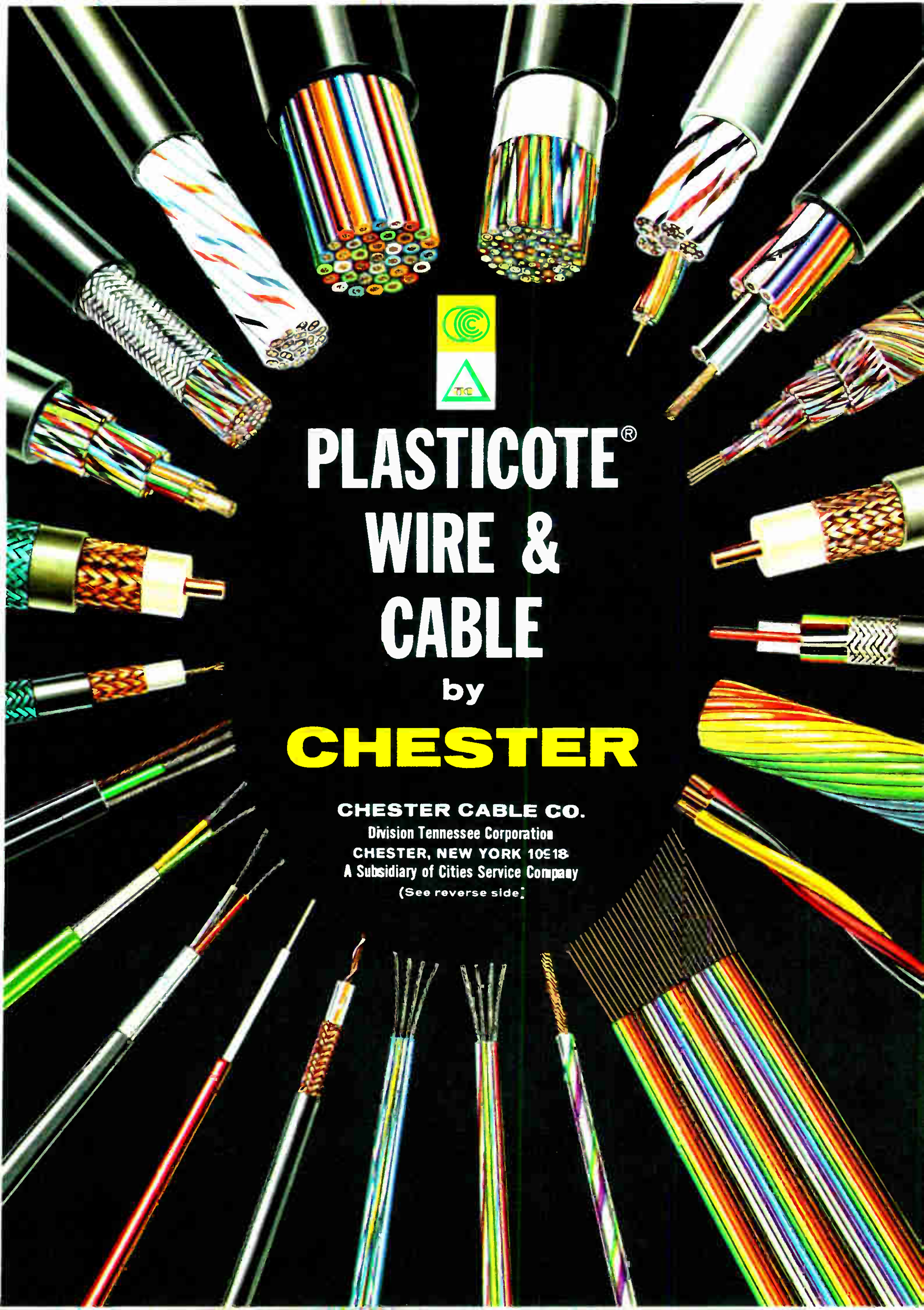
Standard Elektrik Lorenz (SEL) has just boosted its East European order backlog by $11 million through deals with Rumania, Bulgaria, and the Soviet Union.

The West German ITT subsidiary's **contract from Rumania covers construction of a black-and-white tv picture tube plant at Bucharest,** and supply of signal equipment for the country's railroads. SEL previously had sold signal gear to neighboring Yugoslavia.

The order from the Soviet Union is for teletype equipment. **The Bulgarian deal is for telephone equipment and includes a license from SEL to build some telephone-system hardware during the next five years.**

Latin satellite?

Honduras is trying to sell Costa Rica, Nicaragua, El Salvador, and Guatemala on a regional two-satellite communications network linking the Latin nations to the U.S. and Europe.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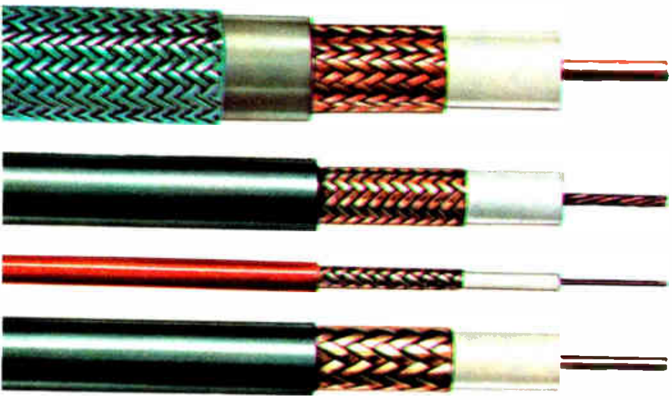

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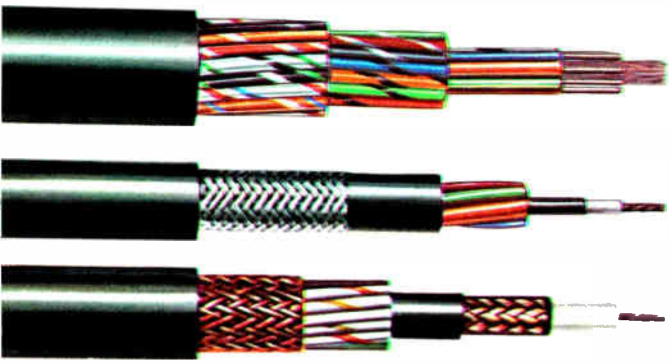

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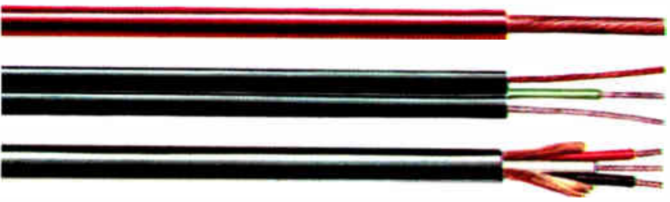

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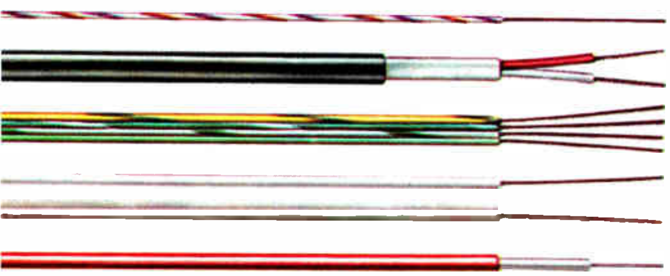

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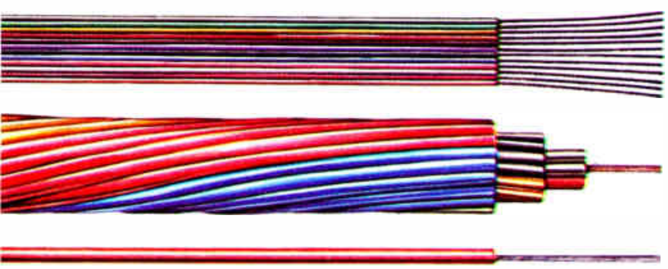

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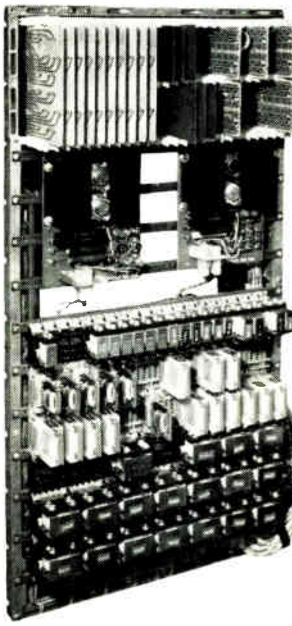
IBM Circuit Design and Packaging Topics

☐ packaging cost reductions
☐ high-speed switching
☐ reed switch application data

☐ packaging cost reductions

Performance Measurements Co., Detroit, Michigan, reports significant savings in packaging their new electronic recording system. The packaging method previously employed required two gates to mount the components in the main console. Now, with IBM's modular packaging as pictured below, only one gate is needed. That's because the IBM technique makes the most efficient use of console space with compactly mounted and connected circuit boards, relays and hardware.

Mounting time has been saved too. Pluggable components, low-cost card receptacles and interlocking card guides have so simplified the packaging job, that Performance Measurements now saves 70% on the cost of mounting hardware. Fewer and shorter wires are needed in the compact console—eliminating three feet of 1½-inch cable and shortening a second cable by eight inches. The modular chassis gave designers freedom to experiment freely with various mounting configurations. It also permits easy access for servicing and diagnostic analysis.



The same design freedom, plus significant hardware and labor savings are available in many applications.

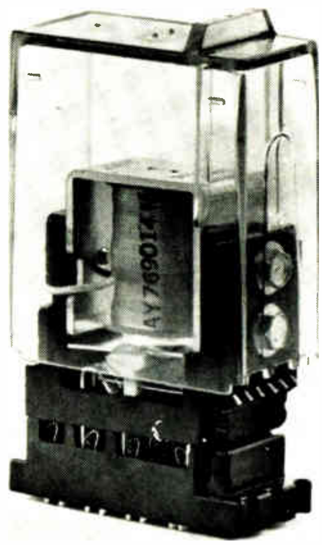
IBM components and packaging can help you in timing control, digital logic testing, telemetering, process or numerical control.

☐ high-speed switching

IBM wire contact relays were originally designed for data processing use. Now they are being used extensively in machine tool and assembly applications. One of these assembly applications is a numerically-controlled component insertion machine. It sequentially inserts random combinations of up to 24 different types of axial lead resistors and diodes into printed circuit boards. Such machines have been widely used, often on a round-the-clock, three-shift basis, in IBM's electronic assembly operations.

Insertion rates range from 3,000 to 4,500 components per hour, depending upon the type of components being inserted.

Instructions from an 8-channel punched paper tape provide the logic-input to the relay gate. The gate employs three rows of 6- and 12-pole IBM wire contact relays. These relays control the movement of each printed circuit board through the X and Y axis positioning of the board for each component insertion. They also control the component feed, component insert, and cut-and-clinch cycles for each insertion operation.



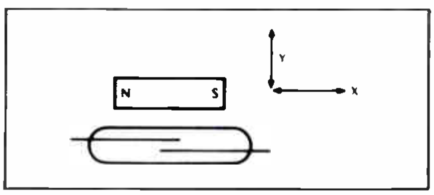
Dust covers are available for various types of IBM wire contact relays. The six-pole model above is shown with cover partially removed.

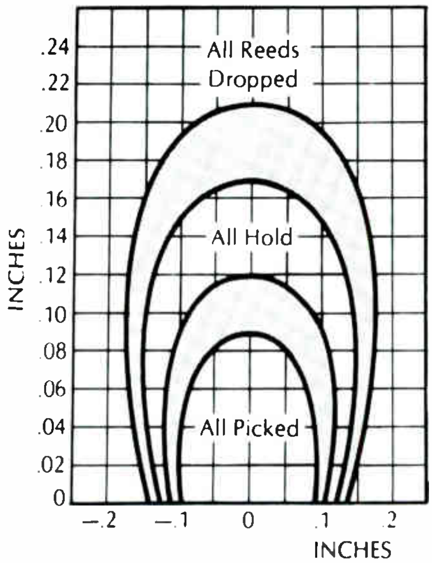
IBM wire contact relays can perform in excess of 200 million operations with an operate speed as fast as 4.5 ms, a release time of 5 ms maximum. The product line includes 4-, 6-, and 12-pole Form C relays, 4- and 6-pole latch models, all with compact, solderless, pluggable mountings—with coil-voltages up to 100 VDC.

☐ reed switch application data

Data on the magnetic switching characteristics of miniature dry reed switches is available to design engineers on request. The data was compiled from extensive tests conducted by IBM to help the design engineer use these switches most effectively. It can also help him determine the motion and position of the magnet required.

Simply described, a miniature dry reed switch operates under the influence of a permanent magnet. When the magnet is adjacent to the reed switch, the flux of the magnet flows through the cantilever beams, as illustrated. While this magnetic flux is being carried by the beams, a polarity exists across the beams. Look at the overlap area of the beams. The north pole of one beam and south pole of the other beam are in proximity. Since unlike poles of a magnet attract each other, when the magnetic force becomes great enough to overcome the physical mass of the beams, they "snap" together, thus switching.





On the graph the X axis represents the displacement (in degrees for rotary motion, inches for lateral motion) of a magnet's center with reference to the center of the reed switch. The Y axis represents displacement (in inches) of the magnet from the outer edge of the dry reed switch glass envelope. Dimensions shown along both axes represent displacement from the center of the magnet in alignment with the center of the reed switch.

There are some "gray areas" where performance varies due to minor differences in the characteristics of each switch.

Assume the zero point on the X axis is the magnetic center of an IBM reed switch. The magnet is positioned with its center at +.5 on the X axis, and .04 inches above the glass envelope. If the magnet is set in motion along the X axis toward the center of the switch, some reeds will pick when the center of the magnet reaches the point +.12 on the X axis. (The magnet has then reached the "gray area"). If motion is continued toward the center of the switch, *all* reeds will pick when the center of the magnet reaches the point +.09 on the X axis.

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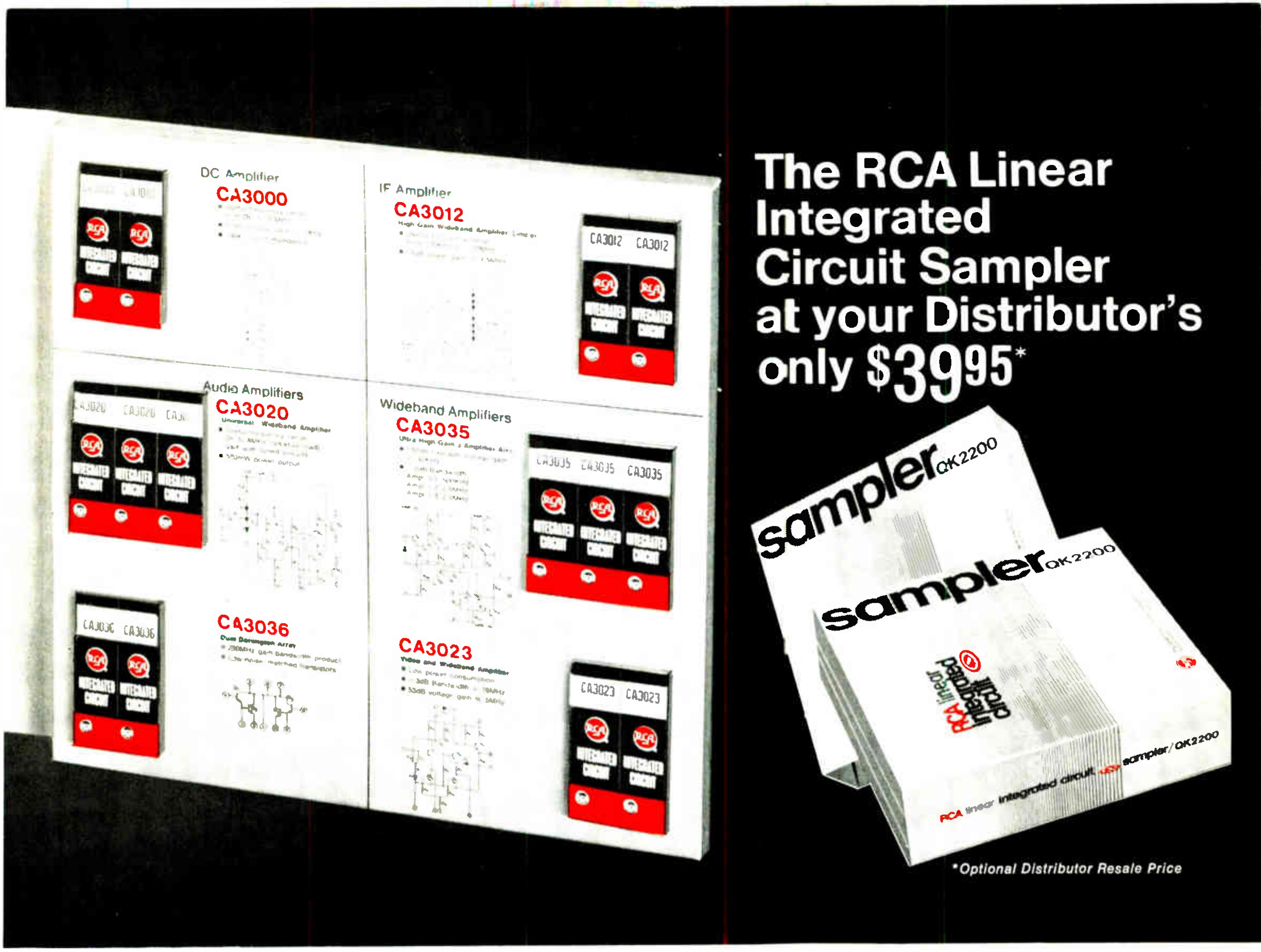

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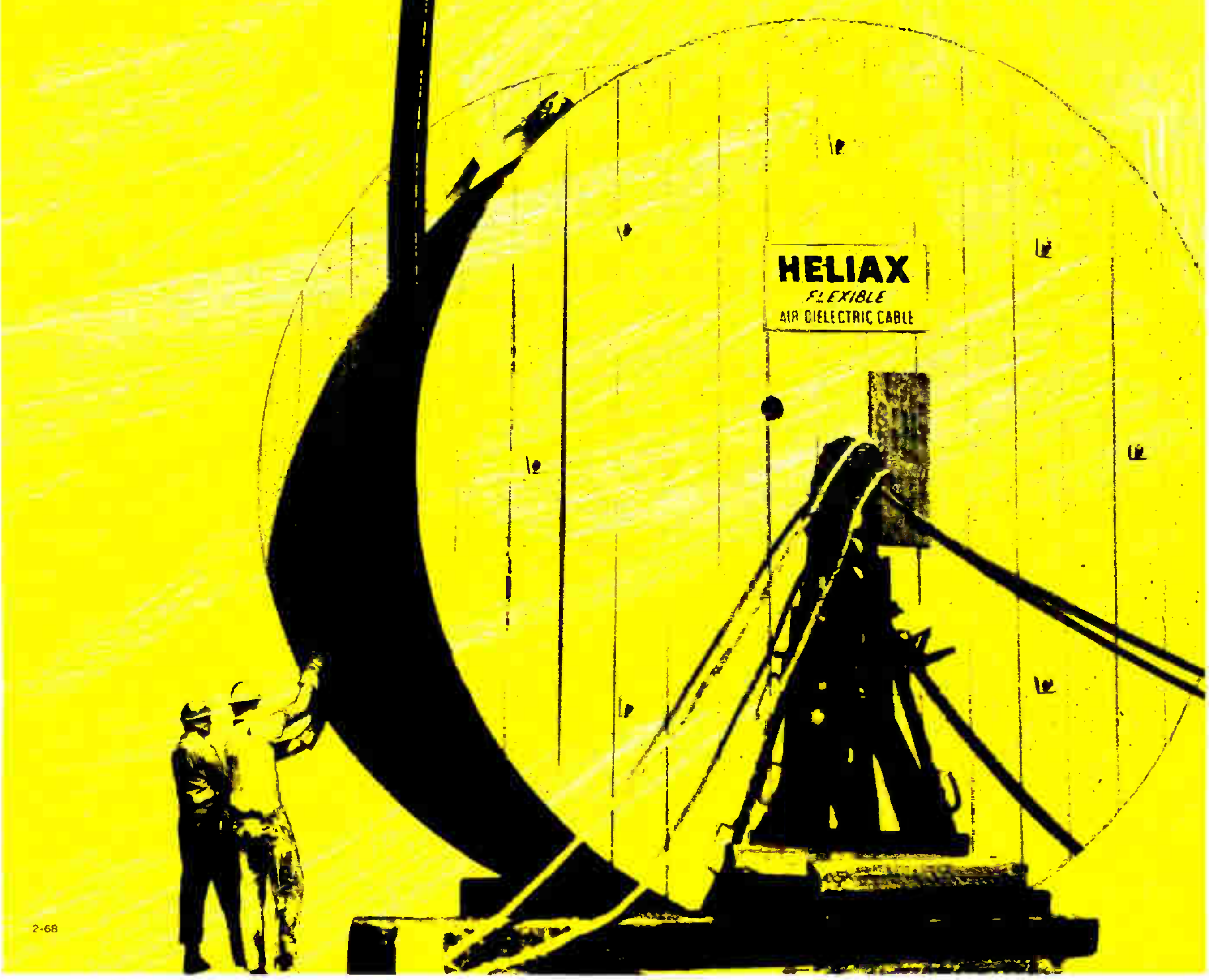


2-68

Electronics Abroad

Volume 41
Number 6

Great Britain

More with the MOST

Like their U.S. counterparts [see story p. 173], the major British electronics companies are putting a lot of their chips on metal oxide semiconductor transistors (MOST).

Mullard Ltd., for example, has a 1,024-bit MOS transistor memory array well along in development. Elliott-Automation Ltd. has MOS arrays with beam leads in the works. Associated Electrical Industries, a company now being merged with the British General Electric Co., is tinkering with MOS transistor delay-line networks.

But it's the Plessey Co. that seems to be the current British leader in MOS technology. Plessey researchers have made working MOST Hall-effect transducers and the company's production people are ready to turn out MOS optoelectronic arrays.

Two for the show. Plessey has developed five basic devices in the optoelectronic line and will show two of them at the International Components Show in Paris next month. All the devices' photocells, switching circuits, and amplifiers are packed on single chips. The simpler arrays are intended for photomultipliers and the complex ones are suitable for character-recognitions systems. Peter Noble, the head of the team that developed the arrays, sees the possibility in 18 months or so of arrays built for television cameras, with all light-sensitive elements, scanning circuits, and signal processors on one chip.

Noble opted for MOS transistors for optoelectronic arrays largely because of their low leakage current and high input impedance. These are the prime requirements for any integrating light detector, that is, any device whose output is a waveform that depends on the incident light. In the Plessey setup, the MOST switching circuits and amplifiers control the charging and discharging of capacitors in parallel with photodiodes. Because the decay rate is proportional to the current through the photodiodes, the frequency of the sawtooth waveform generated depends, in the long run, on the incident light.

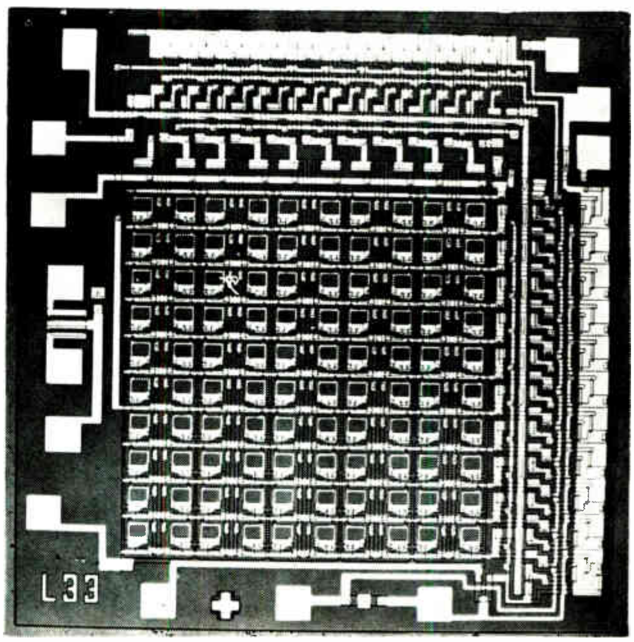
In the middle. The simpler of the two devices to be shown at the Paris show has two identical diodes side by side with an MOS transistor between them to act as a switch and differential amplifier. The diodes measure about 0.004 by 0.005 inch and the chip itself is 0.030 inch square. Plessey expects to sell this version for something like $16 or $17 in Britain.

In the OPT 1, as Plessey calls the array, the two photodiodes are charged in parallel and the voltage across them is allowed to decay. One diode, though, is overlaid with aluminum and thus develops only dark current. The output of the MOS amplifier is the difference between the two decay voltages, an arrangement that cancels out the dark-current effect and improves the accuracy of the device.

What may be the forerunner of a new generation of tv camera tubes is the 10-by-10 array Plessey will exhibit in Paris under the designation OPT 5, and will sell in Britain for about $250. For the money, the buyer gets the photodiodes, the associated amplifiers, and the scanning circuits on a single chip 0.070 inch square.

Samplings. Plessey sees the array as the key element in character-recognition equipment, but there are also possibilities for it in position sensing, fringe counting, and similar applications. Each diode in the array registers the light level on the corresponding part of the scanned area, and the ouput of each diode-amplifier combination is sampled in turn under control of the scanning circuitry, essentially one ring counter for each of the two axes of the array. The sampling is timed to come near the end of the charge-decay cycle for the diode, when the output signal reaches its maximum level.

Noble says it's an easy task—essentially a change of masks—to build the arrays in any desired



First reader. Plessey has readied for production this 10-by-10 MOS array of photodiodes, amplifiers, and scanning circuits on a single chip. Most likely first application: character readers.

geometry. One that's already been made in the laboratory for character recognition, for example, has a 72-by-five layout on a chip 0.100 by 0.400 inch.

Noble is working on an array of 40,000 diodes, plus associated circuitry, for a closed-circuit tv camera. He hopes to eventually go to a 625-by-625 layout that would make today's tv cameras obsolescent.

Gem of a delay

Ordinarily, designers of radar sets like to keep delay lines in the intermediate-frequency stages rather than in the harder-to-handle radio-frequency stages. But for some reason that the British military establishment is keeping classified, one set under development in Britain needs a delay that will hold up X-band signals for about 7 microseconds.

Standard Telecommunication Laboratories, a subsidiary of the International Telephone & Telegraph Corp., has the job of building the delay line—but not the radar equipment. And at last week's Physics Exhibition in London, it showed an experimental version built around a sapphire rod.

Cool. The experimental rod, about 0.67 inch long, operates at liquid nitrogen temperatures and gives a delay of about 3 μsec. The pass band is almost flat over 1 gigahertz and loss is only 70 decibels.

Since the delay varies with the length of the rod, it seems as if the 7-μsec line will run about 1.5 inches long. The loss, though, presumably won't rise much above the 70-db level. At very low temperatures, most of the loss comes from the transducer through which the X-band pulses are fed into and out of the rod.

It's the transducer, Standard Telecommunication points out, that presents the big problem in building the delay, even though the tolerances on the rod itself are stringent. Standard uses a layer of cadmium sulphide over a layer of gold to form a piezoelectric transducer that converts the X-band signal into an acoustic wave that travels the length of rod and back and thus delays the pulse. The gold layer, sputtered onto one end of the rod, has a thickness 1/7th the acoustic wavelength generated by an input signal of 8.9 gigahertz. The thickness of the cadmium sulphide layer evaporated on top of the gold is half the acoustic wavelength.

Data pack. Anyone who can slip a cassette into a tape recorder can feed data into this computer setup. Unit only reads unless "write" clip is in cartridge.

Japan

King-size cassette

Ensnarled in coils of paper tape, many a small-computer user has longed for the convenience of the costly magnetic tape handlers that are part of medium and large data-processing installations.

The longing is over for users of small Fujitsu computers with $183 monthly to spend on top of what they're paying now for their machines. For that fee—or for $7,600 and an outright purchase—they can get a Facom 401A magazine file that works with cartridges holding 330 feet of ½-inch magnetic tape.

Facom opted for the giant cassettes—slightly over one-foot long—so that secretaries and others without any special computer training could slip the tapes into the handler without slipping up. So far, the cartridges are being used to store system programs, auxiliary data for the internal drum file, and as a standby store for sorting operations—the sort of jobs where paper tape is anything but ideal.

Economies. To keep prices in a range that heretofore has been the preserve of paper punches and readers, Fujitsu designed the magnetic tape file around the interfaces previously developed for paper-tape peripherals.

For further economy, Fujitsu adopted a four-track format for the ½-inch tape. More expensive readers generally use a seven-track format. With four tracks there's an obvious saving in read and write amplifiers. There's also less chance of lost data with the wider tracks.

Data is recorded in duplicate—the redundancy prevents error—on the four tracks in the form of an eight-bit byte. The transfer rate of the bytes is 167,000 per second. Except for the reading-head preamplifier and the writing-head driver, most of the circuits in the file work both ways—converting incoming data into the eight-bit format and outgoing data into the paper-tape interface format.

Reeling. Economies turn up in the tape drive as well as in the reading and writing circuits. Instead of the usual capstan and pinch-roller arrangement, there's a direct drive on one reel and braking on the other. This cuts down the length of tape that can be used on a reel since speed variations, which can't get out of hand, depend on how much tape is wound onto the reel. But the sacrifice in tape length, Fujitsu felt, was more than offset by the savings of a direct drive.

At a 330-foot tape length, the average tape speed is 30 inches per second. The variations in speed do not affect the data rate, because the speed for any segment of the tape is essentially the same at both reading and writing. Start and stop times are 150 milliseconds and the average spacing between data blocks is 5 inches.

Side-by-side. Low as it seems at first glance, the $7,600 price tag is in a sense misleadingly high. The tape handler has a common control system that can handle tape feed cycles, interblock gap detection, and data protection for two other "add-on" units that cost $3,400 each. In groups of three, then, the unit cost becomes $4,700 and the total monthly rental $350. The cartridges—not rented—cost $13 each.

Checking the dose

Whenever the Japanese spot an obvious gap in the lineup of instruments produced in their country, chances are they'll fill it with something a little better than others can offer.

This month, for example, the Matsushita Electric Industrial Co. introduced a thermoluminescent dosimeter that gives a digital readout of the amount of radiation people working in laboratories or nuclear plants have been exposed to. Thermoluminescent dosimeters have been in production in the U.S. and Europe for three years or so, but none of them—Matsushita claims—can equal the new Japanese instrument in sensitivity. And none is quite as small as Matsushita's readout unit since it's built around integrated circuits.

New. Matsushita's dosimeter was designed to work with a "new" thermoluminescent material—calcium sulphate. It's been known for some time that calcium sulphate with a manganese impurity shows a marked increase in its thermoluminescence—the light it emits when heated—after it's been exposed to radiation. Trouble is, the sulphate loses its thermoluminescense a few hours after it's radiated.

Add a rare earth impurity, though, and the effect becomes long-lasting, Matsushita found. The calcium sulphate material Matsushita uses for the disks in safety badges worn by people working where there's a radiation hazard holds its thermoluminescence for at least a month. The disks have a sensitivity of 0.1 milliroentgen, roughly the amount of background radiation anyone is exposed to during 12 hours. By contrast, the film badges used in Japan so far at best have a sensitivity of 10 milliroentgens.

Hot. For the readout, which takes about 10 seconds, the disks are slipped into a small drawer in the instrument that is heated to 300°C. The "glow peak" for the disk is 220°C.

The light output of the glowing disk is picked up by a photomultiplier tube and amplified by a metal-oxide semiconductor field-effect transistor followed by a high-gain IC amplifier. The total thermoluminescence, integrated by multiple negative feedback loops around the amplifier, is converted to a digital value by counter circuits built around IC's.

Four ranges in the instrument cover radiation exposure from 0.1 milliroentgens to 10,000 roentgens. Scale switching is automatic and so is ejection of the disks after a reading. As with other thermoluminescent dosimeter disks, Matsushita's can be reused after readout.

Australia

New approach

At some of the world's major airports earthmoving—rather than hardware—is the main cost of an instrument-landing system. But land-leveling may soon cease to be a kingpin consideration. Robert Redlich, an American engineer working under a grant from Australia's Department of Civil Aviation, has come up with a transmitter array that slashes the stretch of flat land ordinarily needed beyond the end of the runway to get a good glide path signal.

The new Australian gear, in fact, figures to make standard instrument-landing glide paths possible for runways where conventional null-reference arrays won't work because of the surrounding terrain. One such is the 07 runway at Sydney's Mascot Airport. There, a prototype of the new transmission setup is under test with the array spotted only 600 feet from the end of the runway, beyond which lies a concrete drainage duct and a canal. The conventional array had to be sited 1,800 feet back from the runway's end and for that reason the glide path is 90 feet high—50 feet is standard—at the approach threshold.

An earlier prototype of the new system proved successful in tests at a small airstrip near Sydney. In the U.S., special arrays that do much the same job as the Australian array have been installed at about 10% of the airports, but Federal Aviation Administration experts admit they'd welcome something better.

No reflections. Either way, the solution is an array that needs no reflected ground wave to establish its glide path. Conventional null-reference systems do need such a wave and to get a good signal they must have about 2,500 feet of hard, flat terrain in front of their arrays. To obtain the standard 50-foot threshold height, the arrays are sited 1,000 feet from the end of the runway, meaning an additional 1,500 feet is required beyond.

Like conventional gear, Redlich's

system operates on the standard glide-path band of 329 to 335 megahertz using 90-hertz and 150-hertz tones to modulate the carrier. But instead of two dipoles, the array consists of two vertically stacked "elements," each made up of seven trios of dipoles in horizontal corner reflectors. The array is 45-feet high and needs only 300 feet of smooth foreground so that sidelobes cannot be reflected into the region of the glide path.

Change of phase. The phase centers of the new array lie at 30 feet and 15 feet, the same heights as the dipoles in null-reference glide-path equipment. Ordinary null-reference signals, though, would not set up a very good path with the new array. The demodulated 90-hz and 150-hz tones would be too distorted to be useful in airborne glide receivers, whose tone filters are not highly selective. Instead of the usual 45° phase difference between the audio tones and the carrier, a 15° phase difference is used for Redlich's array. This eliminates, for practical purposes, tone distortion in the path region. As with conventional modulation, the percentage differences between received tones are used to actuate a cockpit display that shows the pilot whether he's in the glide path, below it, or above it.

France

Mover and shaker

Traditionally, French researchers go about their business in relative calm. But these days there's a trend to restiveness in the government-run laboratories where much of the country's research is done. A new man heads the French science establishment and many old hands in the test-tube hierarchy regard him as an iconoclast.

Pierre Aigrain, 43, took over as head of the Délégation Générale de la Recherche Scientifique et Technique only last month. And with him came his reputation as a mover and a shaker. As director of higher education for the Ministry of Education, Aigrain proposed three years ago that the cumbersome French university system, with its top faculties concentrated in Paris, be broken up into autonomous schools dispersed throughout the country. Now, to the dismay of the rigid scholastic bureaucracy, there are signs the minister of education plans to follow through on Aigrain's schemes.

New tack. So far, Aigrain hasn't come forth with any sweeping proposals for restructuring the government's non-military research setup. But as top civil servant for science—he reports to Prime Minister Georges Pompidou—he can, and undoubtedly will, steer French science in a new direction.

For one thing, Aigrain is an engineer by training—first at France's Naval Academy and then at Carnegie Tech where he acquired a doctorate in electrical engineering. (Later, though, he took a second doctorate in physics and joined the faculty of the University of Paris where, among other things, he led a group doing basic semiconductor work.) For another, Aigrain is convinced the country's shortcomings in technology lie in production and marketing rather than in research.

A case in point, he says, is metal-oxide semiconductors. Aigrain maintains that at one time CSF-Compagnie Générale de Télégraphie sans Fil was out in front of U.S. companies—in the lab. And he feels that CSF and other French semiconductor firms once were abreast of the U.S. leaders in large monolithic integrated circuits but have fallen behind in the market place.

Back and forth. Part of the solution to the production-marketing problem, Aigrain thinks, can come from breaking down the traditional gulf between the government's scientists and industry's development engineers and marketing men.

Aigrain would like to see more researchers shuttling back and forth between government and industry laboratories. But there are barriers. Frenchmen generally are wary of changing jobs. And once a government researcher moves into a job at a company he rarely returns to a civil service slot because the pay is poor by comparison.

Pick and choose. If the production gap can be closed, Aigrain figures, France won't have any real troubles keeping her technological independence. There's no question of matching U.S. technology across-the-board. But he expects France can stake out front-line positions in some key sectors.

One is large-scale integration, where Aigrain says "minor corrective action" could put France up with the front runners in about five years. For the longer term, Aigrain has a few ideas of what sectors to push and which to let languish. Three likely candidates for a solid push are chemicals, optics and some areas of mechanical engineering. The country is seriously lagging in mechanics, he says, and "mechanics will be very important, even to electronics."

Master of science. Pierre Aigrain now sets research policy for the French government's non-military laboratories.

To put his ideas into action Aigrain will be able to pull the purse strings for about 40% of the government's research funds. Last year's spending, for example, totalled slightly more than $1.8 billion. Some $732 million of that was earmarked for non-military programs over which the Délégation Générale has either direct control or considerable influence.

Figures on industry's research outlays are hard to come by, but it seems certain the government far outspends French companies in this field. Estimates for 1965—the latest available—indicate that some $880 million was spent on research in nongovernment labs, with industry picking up slightly more than half the bill and the government and foreign customers paying the balance. Aerospace research accounted for the largest share of 1965 expenditures, with electronics second.

West Germany

How bright?

Outdoor-lighting specialists take considerable pains to find out exactly how much illumination they can get from a light source. The more precisely they know a source's rating—the mere wattage indication as found on ordinary household bulbs is only a rough guide at best—the better they can light a street or a sports arena.

Conventional methods of checking light output require elaborate and sometimes bulky equipment. One common way to measure luminous flux is to take readings on a source mounted in an Ulbricht sphere, often 12 feet or more in diameter. Even with the sphere, flux readings are accurate only to within 5%. And additional apparatus is needed to determine such other characteristics as flux by sector and luminous intensity.

On the beam. One German outdoor-lighting firm, Gantenbrink-Leuchten OHG, has substituted electronics and a rotating steel beam for the bulky Ulbricht sphere. Its setup measures and records to an accuracy of 1% the total flux, the partial flux of selected segments, and the luminous intensity.

The equipment, worth about $17,000, was designed for Gantenbrink by the lighting technology institute at the Berlin Technical University. The sensor is a selenium photocell mounted on one end of a 10-foot-long beam that carries the cell around the light source. The source, too, is set up to rotate, and this plus the beam rotation results in a spiral scan that takes 6½ minutes to cover the full area of the source.

Gantenbrink is currently using a photocell that can handle illuminations ranging from 100 millilux on up to 3,000 lux, but it plans to shift soon to a cell that can measure emissions as bright as 200,000 lux. Broad daylight produces an illumination value of about 100,000 lux; 1,000 lux, however, is considered adequate for an auditorium.

Readout. The current output of the equipment's photocell is translated into a corresponding voltage by an operational amplifier at a remote console. The amplifier's output, in turn, is corrected by a sine potentiometer and then fed through an impedance transformer to a motor. The motor drives a chopper that interrupts a reference light beam played on a photodiode array, setting up a voltage-to-frequency conversion.

The pulse output of the diodes then becomes a reading of the total luminous flux in lumens. For readings of the illumination in lux and in new international candles, the sine potentiometer is bypassed.

Around the world

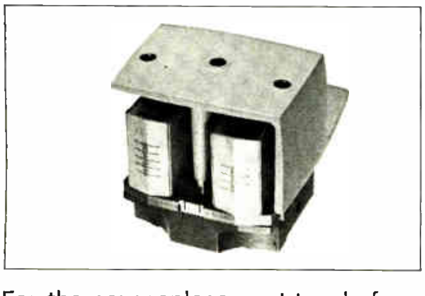
Soviet Union. The Russians now are producing lasers in 10 models, divided about evenly between continuous and pulsed types. The lasers are complemented by a line of modulators and optical receivers that have been used for both experimental television transmissions and satellite communications.

Great Britain. International Computers & Tabulators has ordered a batch of 100,000 transistor-transistor-logic circuits from Mullard Ltd., a British subsidiary of Philips' Gloeilampenfabrieken of the Netherlands. Mullard believes the order is the largest yet logged for British-made integrated circuits.

Japan. The Matsushita Electrical Industrial Co. has set up a subsidiary in Sydney, Australia, to produce consumer electronics goods. The new operation is Matsushita's eleventh outside of Japan.

If you're still putting up with down time... you should have your heads examined.

Your analog magnetic recording heads, that is.



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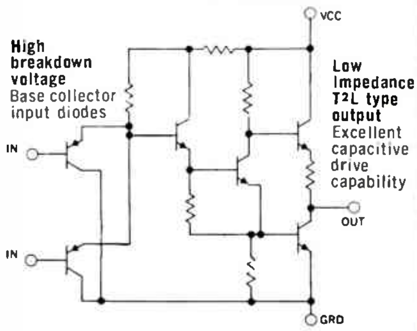

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