Electronics

Introduction to computer-aided design: page 110
Glass as a design material: page 129
Pcm for telephone transmission: page 139

September 19, 1966
75 cents
A McGraw-Hill Publication

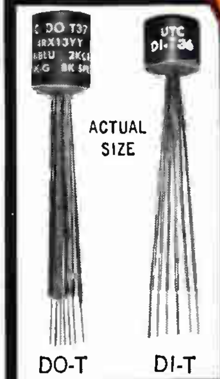
Below: Printout shows a computer-aided design: page 110

AUDIO TRANSFORMERS

DO-T No.	Pri. Imp.	D.C. Ma.‡ in Pri.	Sec. Imp.	Pri. Res. DO-T	Pri. Res. DI-T	Mw Level	DI-T No.
DO-T44	80 CT 100 CT	12 10	32 split 40 split	9.8	11.5	500	DI-T44*
DO-T29	120 CT 150 CT	10 10	3.2 4	10		500	
DO-T12	150 CT 200 CT	10 10	12 16	11		500	
DO-T13	300 CT 400 CT	7 7	12 16	20		500	
DO-T19	300 CT	7	600	19	20	500	DI-T19
DO-T30	320 CT 400 CT	7 7	3.2 4	20		500	
DO-T43	400 CT 500 CT	8 6	40 split 50 split	46	50	500	DI-T43*
DO-T42	400 CT 500 CT	8 6	120 split 150 split	46		500	
DO-T41	400 CT 500 CT	8 6	400 split 500 split	46	50	500	DI-T41*
DO-T2	500 600	3 3	50 60	60	65	100	DI-T2
DO-T20	500 CT	5.5	600	31	32	500	DT-T20
DO-T4	600	3	3.2	60		100	
DO-T14	600 CT 800 CT	5 5	12 16	43		500	
DO-T31	640 CT 800 CT	5 5	3.2 4	43		500	
DO-T32	800 CT 1000 CT	4 4	3.2 4	51		500	
DO-T15	800 CT 1070 CT	4 4	12 16	51		500	
DO-T21	900 CT	4	600	53	53	500	DI-T21
DO-T3	1000 1200	3 3	50 60	115	110	100	DI-T3
DO-T45	1000 CT 1250 CT	3.5 3.5	16,000 split 20,000 split	120		100	
DO-T16	1000 CT 1330 CT	3.5 3.5	12 16	71		500	
DO-T33	1060 CT 1330 CT	3.5 3.5	3.2 4	71		500	
DO-T5	1200	2	3.2	105	110	100	DI-T5
DO-T17	1500 CT 2000 CT	3 3	12 16	108		500	
DO-T22	1500 CT	3	600	86	87	500	DI-T22
DO-T34	1600 CT 2000 CT	3 3	3.2 4	109		500	
*DO-T51	2000 CT 2500 CT	3 3	2000 split 2500 split	195	180	100	DI-T51*
DO-T37	2000 CT 2500 CT	3 3	8000 split 10,000 split	195	180	100	DI-T37*
*DO-T52	4000 CT 5000 CT	2 2	8000 CT 10,000 CT	320	300	100	DI-T52*
DO-T18	7500 CT 10,000 CT	1 1	12 16	505		100	
DO-T35	8000 CT 10,000 CT	1 1	3.2 4	505		100	
*DO-T48	8,000 CT 10,000 CT	1 1	1200 CT 1500 CT	640		100	
*DO-T47	9,000 CT 10,000 CT	1 1	9000 CT 10,000 CT	850		100	
DO-T6	10,000	1	3.2	790		100	
DO-T9	10,000 12,000	1 1	500 CT 600 CT	780	870	100	DI-T9
DO-T10	10,000 12,500	1 1	1200 CT 1500 CT	780	870	100	DI-T10
DO-T25	10,000 CT 12,000 CT	1 1	1500 CT 1800 CT	780	870	100	DI-T25
DO-T38	10,000 CT 12,000 CT	1 1	2000 split 2400 split	560	620	100	DI-T38*
DO-T11	10,000 12,500	1 1	2000 CT 2500 CT	780	870	100	DI-T11
DO-T36	10,000 CT 12,000 CT	1 1	10,000 CT 12,000 CT	975	970	100	DI-T36
DO-T1	20,000 30,000	.5 .5	800 1200	830	815	50	DI-T1
DO-T23	20,000 CT 30,000 CT	.5 .5	800 CT 1200 CT	830	815	50	DI-T23
DO-T39	20,000 CT 30,000 CT	.5 .5	1000 split 1500 split	800		50	
DO-T40	40,000 CT 50,000 CT	.25 .25	400 split 500 split	1700		50	
DO-T46	100,000 CT	0	500 CT	7900		25	
DO-T7	200,000	0	1000	8500		25	
DO-T24	200,000 CT	0	1000 CT	8500		25	
DO-TSH	Drawn Hipermalloy shield and cover 20/30 db						DI-TSH

‡DCMA shown is for single ended useage (under 5% distortion—100MW—1KC) ..for push pull, DCMA can be any balanced value taken by .5W transistors (under 5% distortion—500MW—1KC) DO-T & DI-T units designed for transistor use only. U.S. Pat. No. 2,949,591; others pending.
§Series connected; §§Parallel connected

→ *Units newly added to series



PIONEERS IN MINIATURIZATION

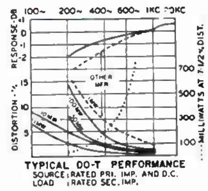
DO-T & DI-T

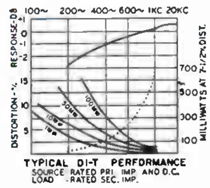
Transistor TRANSFORMERS and INDUCTORS

ALL ITEMS SUCCESSFULLY TESTED TO COMPLETE MIL-T-27B ENVIRONMENTAL REQUIREMENTS

***16 New Items Added to Stock Line**

IMMEDIATE DELIVERY FROM STOCK





- High Power Rating ....up to 10 times greater
- Excellent Response ....twice as good at low end
- Low Distortion ....reduced 80%
- High Efficiency .... up to 30% better . . . compare DCR
- Moisture Proof ....hermetically sealed to MIL-T-27B
- Rugged ....Grade 4, completely metal cased
- Anchored Leads ....will withstand 10 pound pull test
- Printed Circuit Use ....(solder melting) nylon insulated leads
- Suited to Clip Mounting ....use Augat #6009-8A clip

INDUCTORS

DO-T No.	Inductance Hys @ ma	DO-T DCRΩ	DI-T DCRΩ	DI-T No.
*DO-T50 (2 wdgs.)	§.075 Hy/10 ma, .06 Hy/30 ma §§.018 Hy/20 ma, .015 Hy/60 ma	10.5 2.6		
DO-T28	.3 Hy/4 ma, .15 Hy/20 ma	25		
	.1 Hy/4 ma, .08 Hy/10 ma		25	DI-T28
DO-T27	1.25 Hys/2 ma, .5 Hy/11 ma	100		
	.9 Hy/2 ma, .5 Hy/6 ma		105	DI-T27
DO-T8	3.5 Hys/2 ma, 1 Hy/5 ma	560		
	2.5 Hys/2 ma, .9 Hy/4 ma		630	DI-T8
DO-T26	6 Hys/2 ma, 1.5 Hys/5 ma	2100		
	4.5 Hys/2 ma, 1.2 Hys/4 ma		2300	DI-T26
*DO-T49 (2 wdgs.)	§20 Hys/1 ma, 8 Hys/3 ma §§5 Hys/2 ma, 2 Hys/6 ma	5100 1275		

POWER TRANSFORMERS

*DO-T400	Pri 28V 380-1000 cycles, Sec 6.3V @ 60 ma
*DO-T410	Pri 28V 380-1000 cycles, 2-Sec 6.3 @ 30 ma each
*DO-T420	Pri 28V 380-1000 cycles, Sec 28V @ 20 ma (Isol. Electrostatic Shld.)

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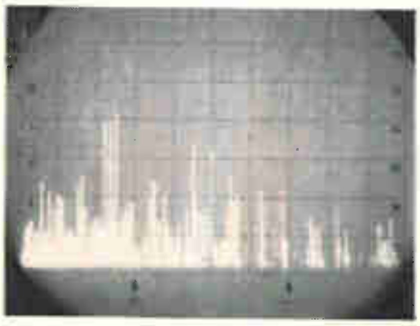
Circle 900 on reader service card

Extending spectrum signatures down to 10 kHz

new uses for SPECTRUM ANALYSIS

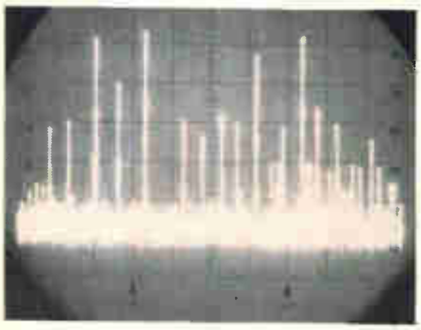
With HP's new spectrum analyzer up-converter, wideband spectrum analysis can be extended down to 10 kHz, and the entire frequency spectrum from 10 kHz to 40 GHz can be inspected with a simple measurement system.

Since all electrical devices generate unwanted signals, such as transients and harmonics that may interfere with sensitive electronic instrumentation, it often is necessary to specify the RFI from the upper audio frequencies into high microwave frequencies. The development of the Hewlett-Packard spectrum analyzer and its 10 kHz to 40 GHz capability eliminated many of the problems of RFI measurement, such as the need to use slowly tuned receivers that only covered small segments of the spectrum to be analyzed.

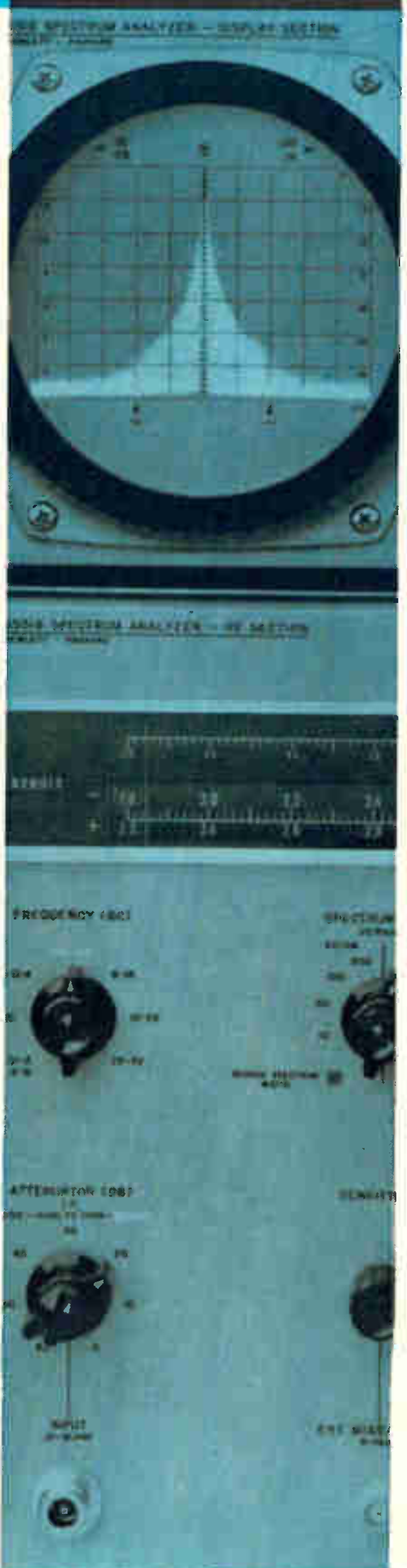


Radiation from an electric drill held next to the antenna as displayed by the spectrum analyzer and up-converter. Horizontal scale, 30 kHz/cm centered at 150 kHz; vertical scale, 10 db/cm.

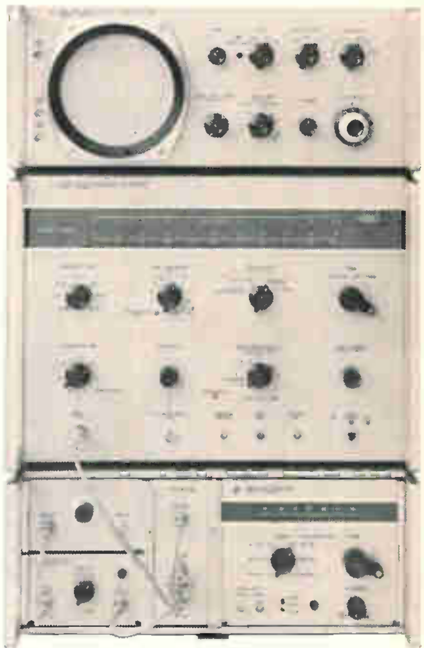
Not only does this instrument cover an extremely broad frequency range, but it also scans fast enough to detect transients often missed by older methods. This combination is equally valuable in spectrum signature work.



AM broadcast band in the Palo Alto, California, area displayed at 100 kHz/cm horizontal; vertical scale is 10 db/cm, and the smallest signals are less than 1 μV.



RFI is typical of the many problems prevalent in the congested spectrum. The Hewlett-Packard K15-8551B Spectrum Analyzer Up-converter (shown below with the Model 851B/8551B Spectrum Analyzer) is a very sensitive, flexible device for extending spectrum analysis coverage. Analyzer range without the up-converter is 10.1 MHz to 40 GHz. Up-converter extends range below to 10 kHz. Model 8551B RF Section, $7100; Model 851B Display Section, $2400; Model K15-8551B Up-converter, $1555.



Additional technical data on the analyzer and up-converter is available from your HP field engineer. Or write direct, Hewlett-Packard, Palo Alto, California 94304, Tel. (415) 326-7000; Europe: 54 Route des Acacias, Geneva.

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

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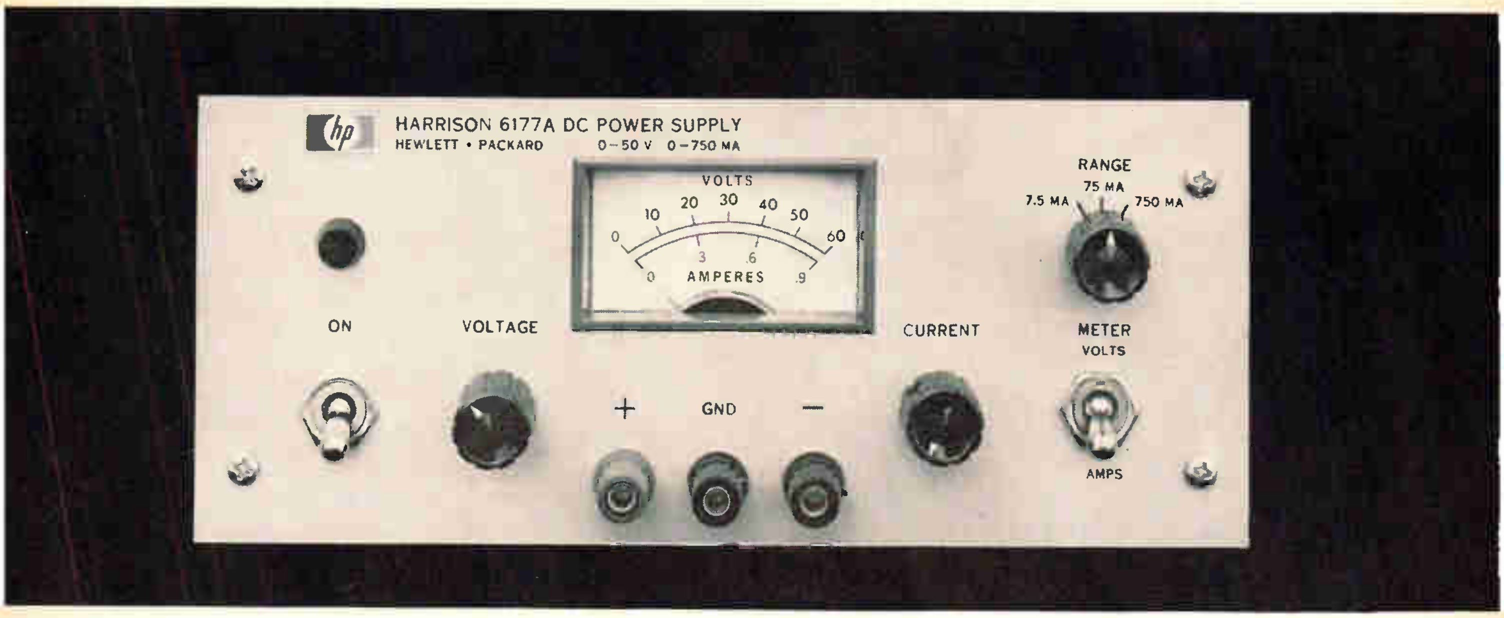
2058

new disciplines in DC



take the constant current model with <200 microsecond recovery

Accurate DC Voltage Monitoring Circuit Eliminates Output Resistance Degradation

A new series of compact, precision regulated, all-silicon DC power supplies features constant current output useful down to the microamp region. Ripple, regulation, and stability are orders of magnitude better than comparably priced constant current supplies, and permit CCB models to be used as general purpose laboratory constant current sources for semiconductor circuit development, and for component evaluation and testing.

A constant *current* DC power supply must be able to change its output *voltage* rapidly in order to minimize load current transients. With the CCB Series, less than 200 μS is required for transient load recovery to within 0.1%—even for load changes requiring full rated output voltage changes!

Placing a voltmeter across the output terminals of a normal constant current power supply degrades the load regulation and diminishes the load current both by a factor of R_L/R_L+R_V. (R_L = load resistance, R_V = voltmeter resistance.) The CCB Series eliminates this error by using an operational amplifier to feed the front panel voltmeter. This "replica" of the output voltage is also presented on rear terminals for possible connection to a more accurate differential or digital voltmeter, thus increasing the utility of these constant current supplies for component testing and sorting systems.

Three-Position Output and Meter Range Switch, 10-Turn Output Control With Resolution to 0.1 μA • Continuously Variable Voltage Limiting • Output Impedance to 20,000 Megohms, Depending on Model Number and Range • High Speed Remote Programming From Resistance or Voltage Input, Can Be Modulated Using External AC Source • No Overshoot on Turn-On, Turn-Off, or Power Removal • Front and Rear Output Terminals • Half Rack Width, Rack Mounting Hardware Available.

CCB SERIES SPECIFICATIONS

Output Current	0-750 MA	0-300 MA	0-100 MA
Voltage Compliance	0-50 V	0-100V	0-300V
Load Regulation	Less than 10 PPM of output +5 PPM of range setting		
Line Regulation	Less than 10 PPM		
RMS Ripple	Less than 100 PPM of output +10 PPM of range setting		
Size	3½" (89 MM) H x 8½" (216 MM) W x 12⅝" (321 MM) D		
Model	6177A	6181A	6186A
Price	$425.	$425.	$425.

Contact your nearest Hewlett-Packard Sales Office for full specifications.

HEWLETT PACKARD HARRISON DIVISION

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H05A

Electronics September 19, 1966 Volume 39, Number 19

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Electronics Abroad

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II. Application

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Readers Comment

Suggested guide to reliability

To the Editor:

Power supplies are among the most universal of electronic products. Thousands of engineers specify them, or use them, or evaluate them, or do all three.

Yet, in spite of the ubiquity of power supplies in systems and in spite of the overriding demands for reliability, the industry has failed to produce a simple guideline for reliability.

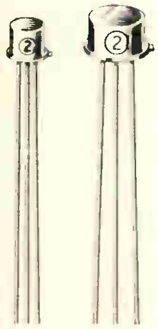
As president of a systems power supply company, I have, obviously, a vested interest in the subject. It would be better if such a guideline came from the systems engineers who are heavy users of power supplies. Nevertheless, I would like to propose such a guideline for reliability in specifying power supplies and invite comments on it.

A specification of mean time between failure would provide an excellent reliability standard. It is practical because most vendors have the necessary know-how and experience to supply valid data. Validity can be assured by standardizing on an acceptable mtbf calculation procedure, such as that set forth in Mil Handbook 217.

Most important, mean time between failure is handy for the power supply user. It enables him to apply one reliability standard to all vendors. It gives him a useful figure when assessing over-all system reliability. It provides a good yardstick to determine if a redundant power system will be required. Lastly, he can use it, along with other criteria, to evaluate the relative cost of one type of power supply system against another.

Most reputable power supply vendors offer unconditional guarantees of varying length on their modules. Many systems engineers will admit, however, that they find the guarantees more comforting than useful as standards. That is why some companies have been using mtbf in specifications for the past year or two.

If there were sufficient reaction from the field, then all the power supply vendors would have to provide this specification for reliability. I'm sure this would represent a use-



0.5db

This is the typical wideband noise figure of Sprague Types 2N4383 and 2N4384 high-gain, low-level NPN silicon epitaxial planar transistors. Maximum NF is 2.0 db, one db lower than the type that has been the industry's most popular high-gain, low-level transistor.

Sprague Electric also offers Types 2N4385 and 2N4386, with noise figures of 1.0 db typ., 3.0 db max.

Characteristic	Conditions	2N4383 (TO-5 Case)	2N4384 (TO-18 Case)	2N4385 (TO-5 Case)	2N4386 (TO-18 Case)
BV_{CBO}	$I_C = 10 \mu A$	40V min.	40V min.	40V min.	40V min.
BV_{CEO}	$I_C = 10 mA$	30V min.	30V min.	30V min.	30V min.
I_{CBO}	$V_{CB} = 30V$	10nA max.	10nA max.	10nA max.	10nA max.
I_{EBO}	$V_{EB} = 5V$	10nA max.	10nA max.	—	—
h_{FE}	$V_{CE} = 5V$, $I_C = 1 \mu A$	60 min.	60 min.	—	—
h_{FE}	$V_{CE} = 5V$, $I_C = 10 \mu A$	100 min.	100 min.	40 min.	40 min.
h_{FE}	$V_{CE} = 5V$, $I_C = 1 mA$	120 min.	120 min.	100 min.	100 min.
NF	$V_{CE} = 5V$, $I_C = 10 \mu A$, $r_g = 10 K\Omega$, Bandwidth = 10 Hz to 15.7 kHz	2db max.	2db max.	3db max.	3db max.

Evaluate these devices without delay. They're available *now* in production quantities. Call your nearest Sprague Electric district office or sales representative for prices and delivery. Or, write Marketing Dept., Semiconductor Division, Sprague Electric Company, Concord, N.H. 03302.

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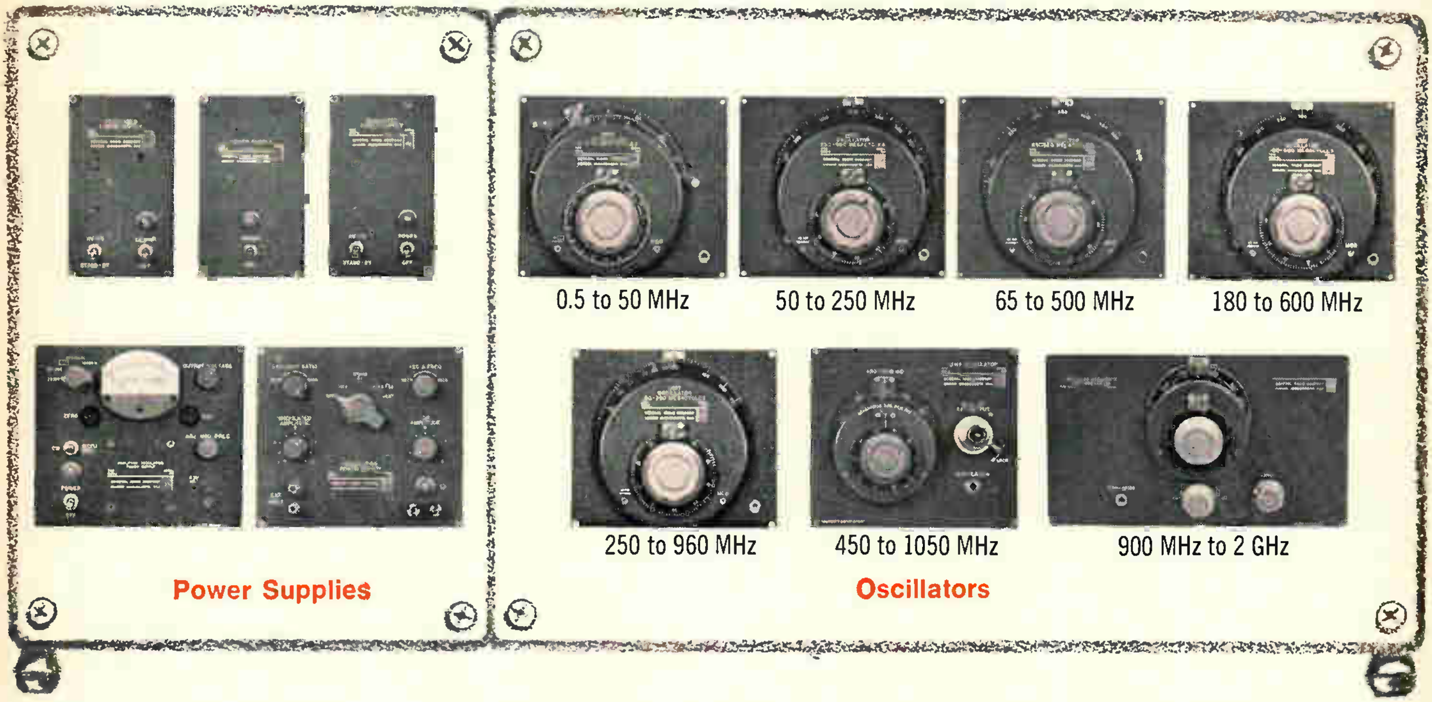
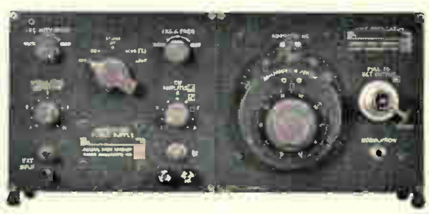
Select the oscillator you want,

then choose the power supply that gives the performance you need ... power, frequency stability, pulse and/or square-wave modulation, amplitude-regulated output, 115-V or 230-V input.



There are 32 different combinations offered here, each with a different set of features for your measurement needs. The seven oscillators from which you can choose provide continuous frequency coverage from 500 kHz to 2000 MHz and have typical outputs of several hundred milliwatts. All but two of these can be mated with any of five power supplies to provide a variety of operating conditions. Prices for oscillator/power-supply combinations range from $355 to $1104 in the U.S.A.

Please write for complete information.



Typical Oscillator/Power-Supply Combination

Type 1361-A4 . . . . $680

450- to 1050-MHz oscillator with a power supply that provides stable CW and 100% square-wave and pulse modulation, bench model. This oscillator also usable with any of the other four power supplies, for bench use or rack mounting.

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WEST CONCORD, MASSACHUSETTS

Circle 6 on reader service card

ful step forward.

William Perzley
President
Consolidated Avionics
Westbury, N.Y.

Laser correction

To the Editor:

A few errors crept into the article on IBM's laser-wavelength selector ["Many colors are better than one" July 11, p. 84].

The second formula on page 88 should read:

$$Z_1 = \frac{1}{\sqrt{2}} A \sin(wt + \theta\lambda)$$

The crystal material is potassium dideuterium phosphate (KDP). The sentence at the top of page 88 should read "the light travels down the x' axis" rather than x' axis. The memory reading system shown on page 90 does not require a selector—the word "selector" in the caption should read deflector.

M.A. Habegger
International Business Machines Corp.
Poughkeepsie, N.Y.

Significant contribution

To the Editor:

I would appreciate it if you could acknowledge the very significant contribution of William Follmer to the work described in my article "New twist for backward diodes" [July 11, p. 74].

Russell O. Wright
Manager
Microwave Department
Philco Corp.
Spring City, Pa.

Too many components?

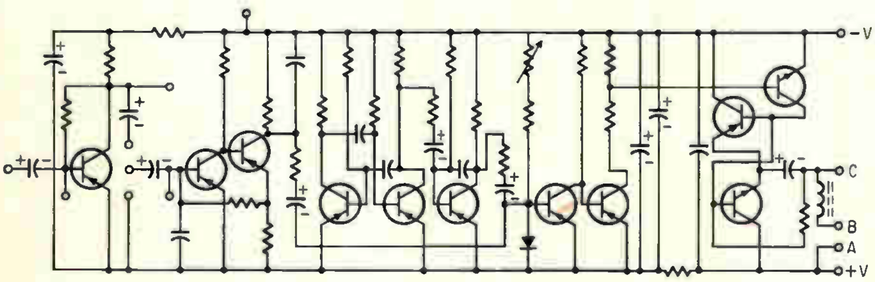
To the Editor:

You say that pulse-width modulation amplifiers have not been produced with discrete components [July 25, p. 43]. However, we have been making such amplifiers for three years. Circuit complexity is not really a problem because the components required are cheap.

Some of the high-frequency, high-power switching transistors recently developed are ideal for this type of amplifier and we anticipate extending our range well above the 20 watts of our current X-20 amplifier.

C.M. Sinclair
Managing Director
Sinclair Radionics Ltd.
Cambridge, England

▪ Many engineers will argue with reader Sinclair's statement that circuit complexity is not really a problem after examining the schematic of a pwm amplifier [below].



Are there too many components in a pulse-width modulation amplifier?

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People

Taking the position that oceanography in the past has seen "a lot of poetry but not much leadership," **Edward Wenk Jr.** intends to take a strong hand as executive secretary of the National Council on Marine Resources and Engineering Development.

Wenk has a mandate to ride herd on the scattered oceanographic activities of the Federal Government. His mandate is Public Law 89-454. He also has the backing of two of Washington's leading citizens, Lyndon Johnson and Hubert Humphrey.

The law was pushed through Congress by Sen. Warren G. Magnuson (D.,Wash.), chairman of the Senate Commerce Committee and outspoken advocate of fishing interests. It creates a 15-man advisory commission to formulate long-range oceanographic plans and a cabinet-level council to put the plans in motion.

Electronics role. Wenk points out that oceanography has to move out of the era of "sealing wax and string instrumentation" and begin developing advanced techniques in data collection and real time data processing. He also expects that oceanography, like other advanced technologies, will someday be spending half its dollars on electronics. But he warns against the mounting optimism of the past year or two. "Too many people have plugged this thing as if a great pot of gold is opening up," he says.

In commanding the kind of cooperation he will need, Wenk has one big advantage: he has been in both the legislative and executive branches of the Government. After graduating from Johns Hopkins University in 1940 he spent 14 years with the Navy's David Taylor Model Basin. He then put in three years with the Southwest Research Institute in Dallas before returning to the Government as first congressional science adviser at the Library of Congress. He rejoined the executive branch in 1961 as

Circle 9 on reader service card

People

assistant to the President's science adviser but went back to the Library in 1964 to head the new Science Policy Research Division. Now he's moving back up Pennsylvania Avenue.

John L. McLucas, new president of the Mitre Corp., has the task of rebuilding the morale of his organization, which suffered when the Air Force imposed restrictions on nonprofit companies, including a ceiling on their growth [Electronics, May 2, p. 38]. "We can live with the restrictions," he says, although he frankly admits the limitations of living in a goldfish bowl. "Public scrutiny tends to make management more conservative, like civil service. And that is not the idea behind Mitre."

The Bedford, Mass., private company was chartered to work only for Government agencies. It was organized in 1958 principally to provide systems engineering support to the Air Force Electronic Systems division, also in Bedford. Its $33.5-million budget for fiscal 1967 is about half that of its West Coast counterpart, the Aerospace Corp.

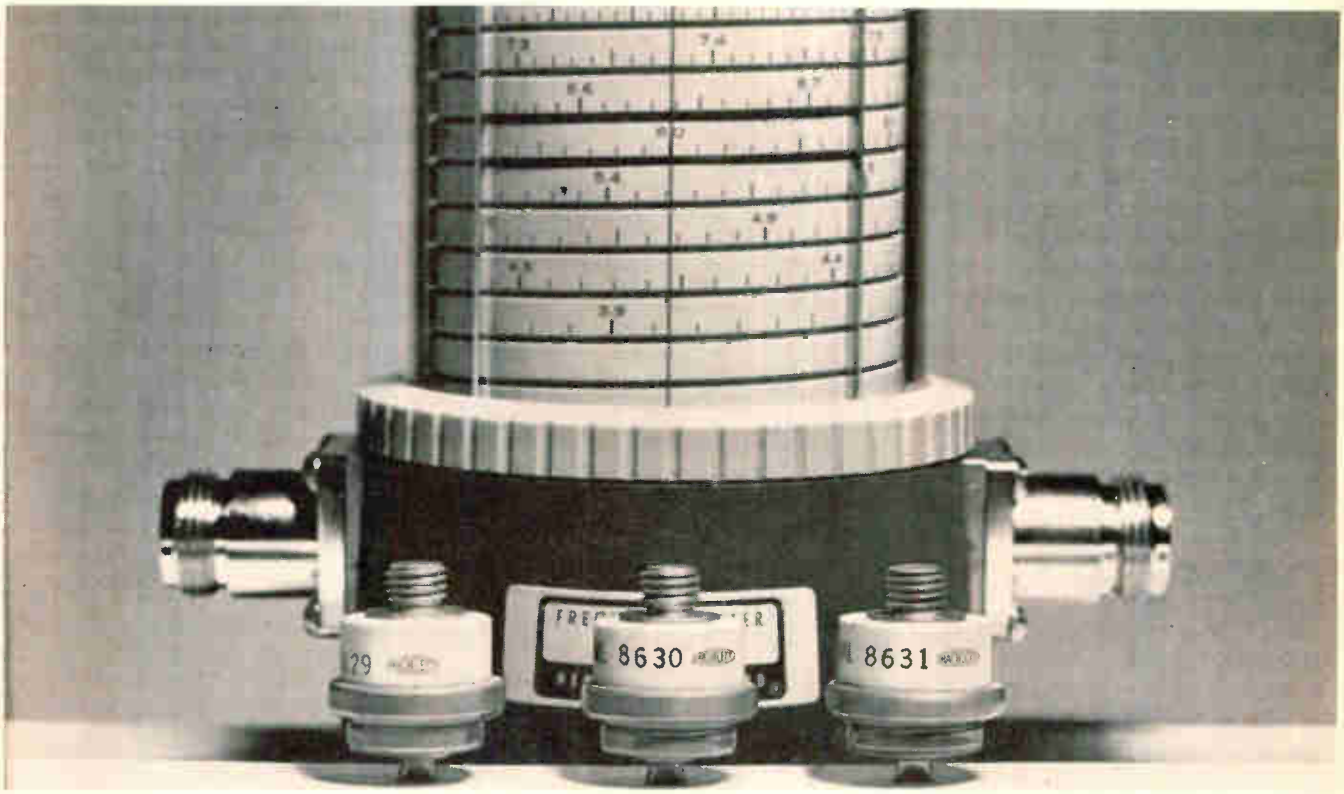
"The Air Force report cleared the air for us," McLucas says. "We and the other nonprofits were under fire; our usefulness was questioned. Now it is clear the Air Force is convinced we are needed. . . .

"I was a critic of the nonprofits myself in my Pentagon days," McLucas admits. He was deputy director of defense research and engineering for two years before he left the Defense Department in 1964 to become State Department representative to the North Atlantic Treaty Organization in Paris.

Added tasks. McLucas is seeking to expand the Mitre budget, pointing to pressures for Mitre to take on added tasks for various agencies of the Defense Department, particularly in tactical communications.

MACHLETT

Highest Power Level for RF operation at C-Band: MACHLETT miniature planar triodes



For comparable size and weight in the C-Band region, and higher, the Machlett miniature planar triode provides the highest plate dissipation capability with correspondingly high duty cycle and rf power output. 1 kW grid pulse operation is currently being achieved at 6 Gc with the ML-8630. From cathode rf heater contact to anode rf surface contact, these new tubes ML-8629, ML-8630 and ML-8631 measure only .565 inches high by .7 inch diameter. These "8600 series" tubes will dissipate 100 watts, or more, with suitable cooling devices. Frequency stable for quick on-frequency performance. Phormat cathode for high voltage stability.

For complete details, write
The Machlett Laboratories, Inc.,
Springdale (Stamford), Conn. 06879.

RAYTHEON

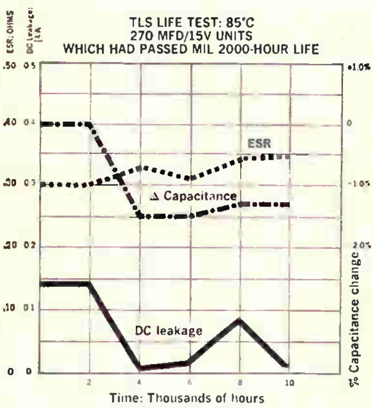
THE MACHLETT LABORATORIES, INC.

A SUBSIDIARY OF RAYTHEON COMPANY

DESIGNER'S

P. R. MALLORY & CO. INC., INDIANAPOLIS, INDIANA 46206

Type TLS (CL64/65) Tantalum capacitors pass 10,000 hour life test



10,000-hour data at 85°C for typical group of TLS capacitors.

Mallory Capacitor Company engineers recently completed a series of life tests to evaluate the stability of electrical parameters of the Type TLS wet slug tantalum capacitors beyond the MIL 2000 hour requirement. These capacitors, which are the equivalent of CL64 and CL65 per MIL-C-39006, demonstrated excellent retention of performance up to the 10,000 hours of the test, both at 85°C and at 125°C . . . and confirm the long term life capability of the Mallory TLS design.

DC leakage performance remained well below specification limits. Equivalent series resistance of all TLS capacitors tested measured in the order of one-tenth of specification values. Capacitance changes were relatively small, and these, too, stayed well within spec limits.

Tests were made both on capacitors which had previously passed 2000-hour MIL life test, and on excess MIL screening units which had not been life tested. Good correlation of results was observed for both tested and untested lots. Typical values are shown here for one of the several different C-V values tested in this series. A copy of our Engineering Report is available on request.

CIRCLE 191 ON READER SERVICE CARD

Avalanche rectifiers can take 80% overvoltage

Because of their ability to withstand switching and line transient voltage spikes well above steady state rated values, Mallory Type LA controlled avalanche rectifiers prove an ideal means of protection for power supply circuits of phonographs, calculating machines, instruments and other industrial and commercial electronic products.

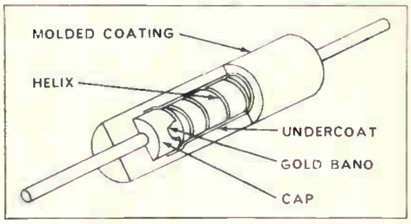
The overvoltage capability of the Type LA is comparable to that of selenium rectifiers, without the aging characteristic of selenium. A special diffusion technique produces a silicon junction which can rectify safely over a broad range of applied voltage. Current ratings of ¾, 1, 2 and 3 amperes are supplied. Maximum spike which can be tolerated safely is 80% above nominal voltage rating. Bv values, at 25°C, are 200, 300, 400, 500 and 600 volts.

Type LA is supplied in a molded case .375″ long and .200″ in diameter, with axial leads.

CIRCLE 192 ON READER SERVICE CARD

New Precision Film Resistors in new small size

Price: under 10¢ in production lots



For use where superior precision and stability are demanded, Mallory now offers precision film resistors in ⅛ and ¼ watt ratings.

These MAF resistors are designed to meet the requirements of MIL-R-10509. Their physical size, or volume however, is approximately one-half that allowed under the specification, and is about 25% smaller than that of other precision resistors of this type on the market. The ⅛-watt maximum size is .377″ long and .127″ in diameter; the ¼-watt maximum size is .627″ long and .189″ in diameter.

The cutaway drawing shows construction. A nickel chrome alloy is vacuum deposited on a ceramic substrate. Gold bands are fired onto each end, to assure positive, low resistance contact with end caps. Precision helixing produces tight tolerances. Dual protection against environment is provided by a silicone undercoat and an outer coating of molded epoxy.

Load life stability is excellent. After 1000 hours at full load, resistance changes are typically less than +.25%, and always less than ±.5%. Temperature coefficients of ±100, 50 and 25 PPM/°C are available. Power ratings of ⅛ and ¼ watt are based on 125°C ambient, and can be doubled for 70°C ambient. Tolerances: ±1.0% and ±.5%.

The ⅛-watt size can be supplied in resistances from 30.1 ohms to 499K; the ¼-watt size in values from 49.9 ohms to 1 megohm.

CIRCLE 193 ON READER SERVICE CARD

FILE MALLORY 50th ANNIVERSARY

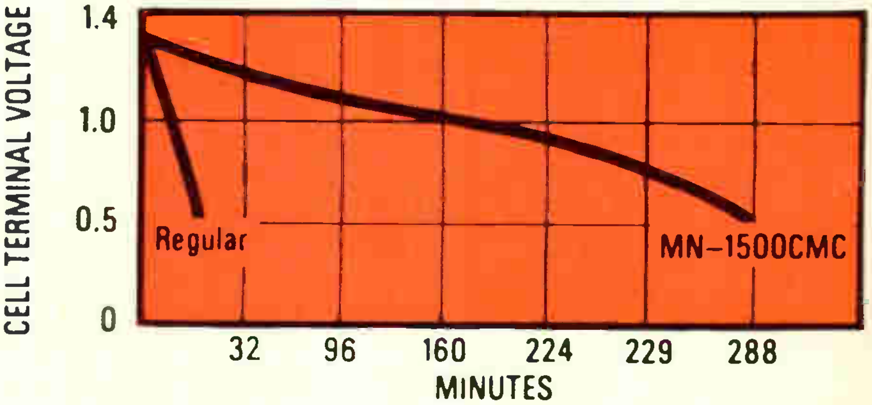
New line of medium power sealed silicon rectifiers

The new Mallory HC rectifiers cover the complete range of current ratings from ¾ to 25 amperes. All ratings are 75°C ambient. They use true hermetic glass-to-metal sealed cases, with either single-ended or axial lead construction. A passivated silicon die affords superior high temperature stability.

The ¾, 2 and 3 ampere types are in top-hat style flange cases, .450″ diameter at the flange .350″ body diameter. The 5, 10, 15, 18 and 25 ampere ratings come in press fit, solder fit and conductive epoxy case configurations. All current values are available in Peak Inverse Voltage ratings from 50 to 1000 volts.

CIRCLE 194 ON READER SERVICE CARD

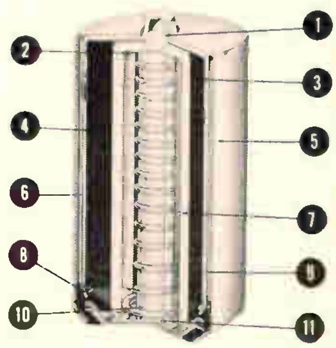
Improved performance for Mallory Alkaline Batteries



Discharge characteristic of "AA" size Mallory Alkaline Batteries at 31°F. Two cells in parallel feeding into 8 ohm lamp load.

Now, standard Mallory manganese-alkaline batteries (sizes "D", "C" and "AA") have completely new performance ratings when operating at freezing temperatures or under relatively high current drains.

For example, the graph compares service life of the new Mallory MN1500 (size "AA") versus the old when cells are discharged continuously through a PR-4 bulb at 31°F. This dramatic improvement in battery life was accomplished through changes in the battery's internal design (see cut-away), which increase the effective anode area in relation to cell volume and reduce internal impedance of the cell. Added refinements in case and seal construction have also been made to insure reliability of the seal under even the most severe vibration.



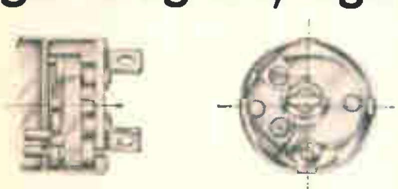
1. INSULATOR
2. ABSORBENT AND ALKALINE ELECTROLYTE
3. MANGANESE DIOXIDE DEPOLARIZER
4. INNER CAN
5. ADAPTER SLEEVE
6. OUTER CAN
7. ZINC ANODE
8. CELL SEAL (GROMMET)
9. BARRIER
10. CONTACT SPRING
11. DOUBLE CELL TOP

New internal construction of Mallory Alkaline Cells.

The new Mallory alkaline batteries are ideal for lighting, photoflash, motor driven applications and other heavy drain service.

CIRCLE 196 ON READER SERVICE CARD

"O" Ring-type switches in Mallory controls give long life, high reliability



The line switches supplied attached to Mallory volume controls have a unique O-ring design which provides exceptional performance. Contact is made by a freely rotating ring element that snaps into place between stationary contacts. There are no current-carrying springs. The ring rotates slightly as the switch is operated, so that a new contacting surface is presented each time and contact wear is distributed around the entire periphery. The result is long switch life, freedom from contact failure and ample ability to handle overloads.

These switches, designated Type OAC, are available in SPST, SPDT and DPST configurations, with UL ratings of 3, 5 or 6 amps AC at 125 volts, in rotary, push-push or push-pull action. Terminal arrangements can be supplied, identical with those of the volume control, for point-to-point wiring or printed circuits.

CIRCLE 195 ON READER SERVICE CARD

Meetings

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

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

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

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

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

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

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

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

Antimissile Research Advisory Council Meeting, Advanced Research Projects Agency; U.S. Naval Postgraduate School, Monterey, Calif., **Oct. 3-5.**

Materials Research Symposium, National Bureau of Standards Institute for Materials Research; Gaithersburg, Md., **Oct. 3-7**

Environmental Test Equipment Show, Institute of Environmental Sciences, Bureau of International Commerce; U.S. Trade Center in Frankfurt, West Germany, **Oct. 5-12.**

National Electrochemical Society Meeting, Electrochemical Society; Philadelphia, **Oct. 9-14.**

International Astronautical Congress, American Institute of Aeronautics and Astronautics, International Astronautical Federation; Madrid, Spain, **Oct. 9-15.**

Underwater Photo-Optics Conference, United States Naval Missile Center, Society of Photo-Optical Instrumentation Engineers; Miramar Hotel, Santa Barbara, Calif., **Oct. 10-11.**

Ultrasonics Symposium, IEEE; Statler Hotel, Cleveland, **Oct. 12-15.**

Canadian Symposium on Communications, IEEE; Queen Elizabeth Hotel, Montreal, Quebec, **Oct. 13-14.**

Systems Science and Cybernetics Conference, Systems Science and Cybernetics Group, IEEE; International Inn, Washington, **Oct. 17-18.**

International Exhibition and Congress of Laboratory Measurement and Automation Techniques in Chemistry, Swiss Chemical Society; Swiss Industries Fair, Basel Switzerland, **Oct. 17-22.**

Military Aircraft Systems Meeting, American Institute of Aeronautics and Astronautics; Dallas, **Oct. 18-19.**

Symposium on Microwave Measurement, the International Measurement Confederation; Budapest, Hungary, **Oct. 18-20.**

Symposium on Information Display, Society for Information Display; Hotel Bradford, Boston, **Oct. 18-20.**

Nuclear Science Symposium, IEEE; Statler-Hilton Hotel, Boston, **Oct. 19-21.**

International Trade Exhibition of Electronic Components, Electronica 66; Munich, West Germany, **Oct. 20-26.**

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

International Symposium on Microelectronics, International Electronics Association, Munich, Germany, **Oct. 24-26.***

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

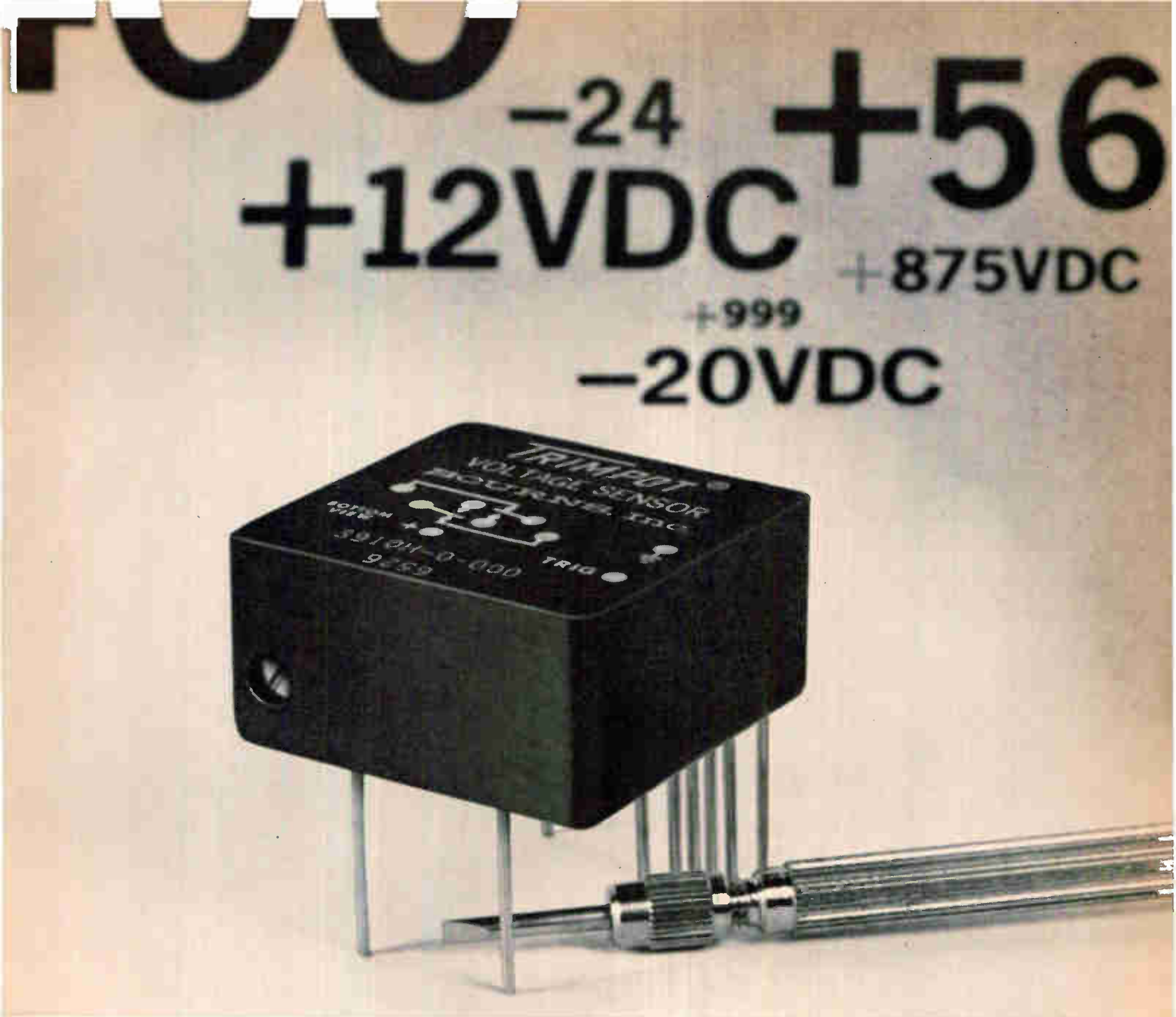
International Electron Devices Meeting, IEEE; Sheraton-Park Hotel, Washington, **Oct. 26-28.**

Call for papers

American Society of Tool and Manufacturing Engineering Conference; Chicago, April 24-28, 1967. **Oct. 24** is deadline for submission of 200- to 250-word abstracts to Marino Zapico, director of engineering conferences, American Society of Tool and Manufacturing Engineers, 20501 Ford Road, Dearborn, Mich. 48128.

Packaging Industry Technical Conference, IEEE; Holiday Inn, New York City, May 9-11, 1967. **Nov. 15** is deadline for submission of 60-word abstracts to John T. Winship, engineering editor, Modern Packaging Magazine, 1301 Avenue of the Americas, New York, N. Y. 10019.

* Meeting preview on page 16



New TRIMPOT® Voltage Sensors: 0 to 1000 VDC Range, 1/2 Cubic-Inch Size!

At just ½ cubic inch, our new Model 3910 and 3917 TRIMPOT voltage sensors are the smallest you can buy. They're ideal for such applications as fail-safe circuits, go-no-go testing and monitoring of transducers. Each unit can sense voltages from 0 to 1000 VDC with the unmatched accuracy of ±1%! Choose Model 3910 for DPDT electromechanical relay output, Model 3917 for SPSTNO solid-state output. Both models sense levels from 6 to 12 VDC without external components. With added resistors, both units sense to +1000 VDC, and, with proper biasing, to −24 VDC. When external components are used, a built-in potentiometer permits screwdriver adjustment of six volts.

These units are extremely rugged and well suited for military use. While there is no MIL-Spec for voltage-sensing relays, both models conform in general to applicable portions of MIL-R-5757D and the moisture-resistance requirements of MIL-STD-202, Method 106. They withstand 20G, 10-2000 cps vibration and 75G, 11-millisecond shock, are fully encapsulated, and are backed by the extensive testing of the exclusive Bourns Reliability Assurance Program. Write today for complete technical information.

Voltage sensing range	0-1000 VDC
Accuracy, static conditions	±1%
Repeatability, environmental extremes	±5%
Operating temperature range	−55 to +105°C
Dropout-to-pickup differential range	−1 to −4% standard −1 to −25% set at factory upon request
Trigger input current	0.7 milliamp, max.

Model 3910

Model 3917

units shown one-third actual size

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TRIMPOT® AND PRECISION POTENTIOMETERS — RELAYS — MICROCOMPONENTS: TRANSFORMERS, INDUCTORS, RESISTORS AND CAPACITORS

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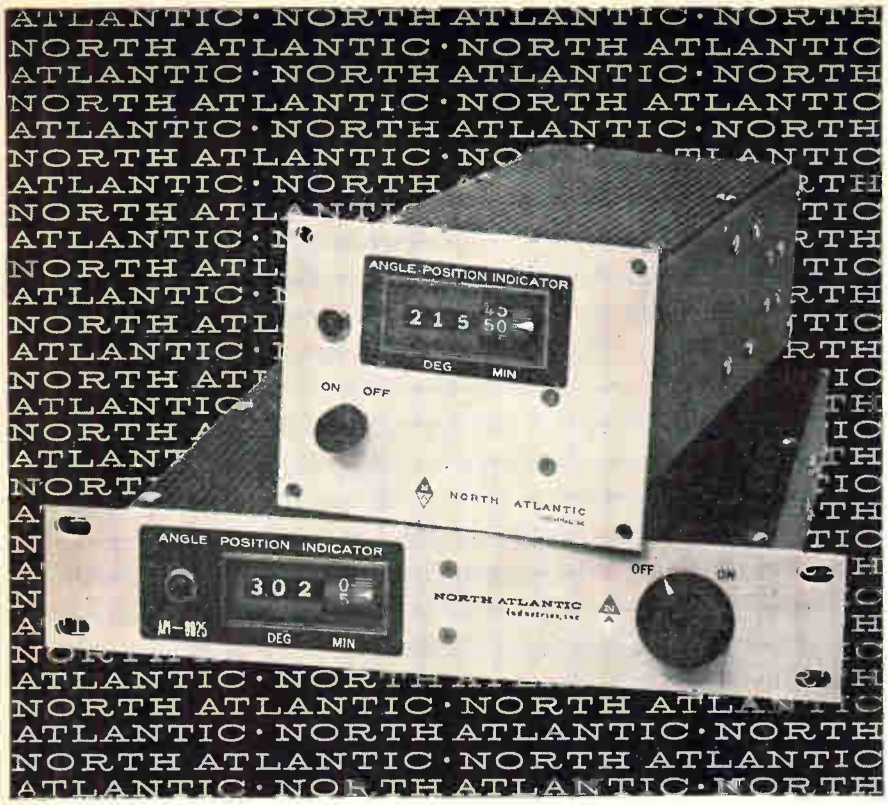


Meeting preview

Microelectronics in Munich

Solid-state devices and microelectronic components, their manufacturing techniques and applications, will be major subjects at the Second International Symposium on Microelectronics in Munich. The three-day meeting, Oct. 24-26, is sponsored by the International Electronics Association and will be held during the Electronica 66 show—a trade exhibition of electronic components, Oct. 20-26.

At least 1,000 engineers and scientists are expected to attend the symposium. According to Jurgen Gunther, chairman of the organizing committee, about 400 specialists registered before meeting programs were sent out.

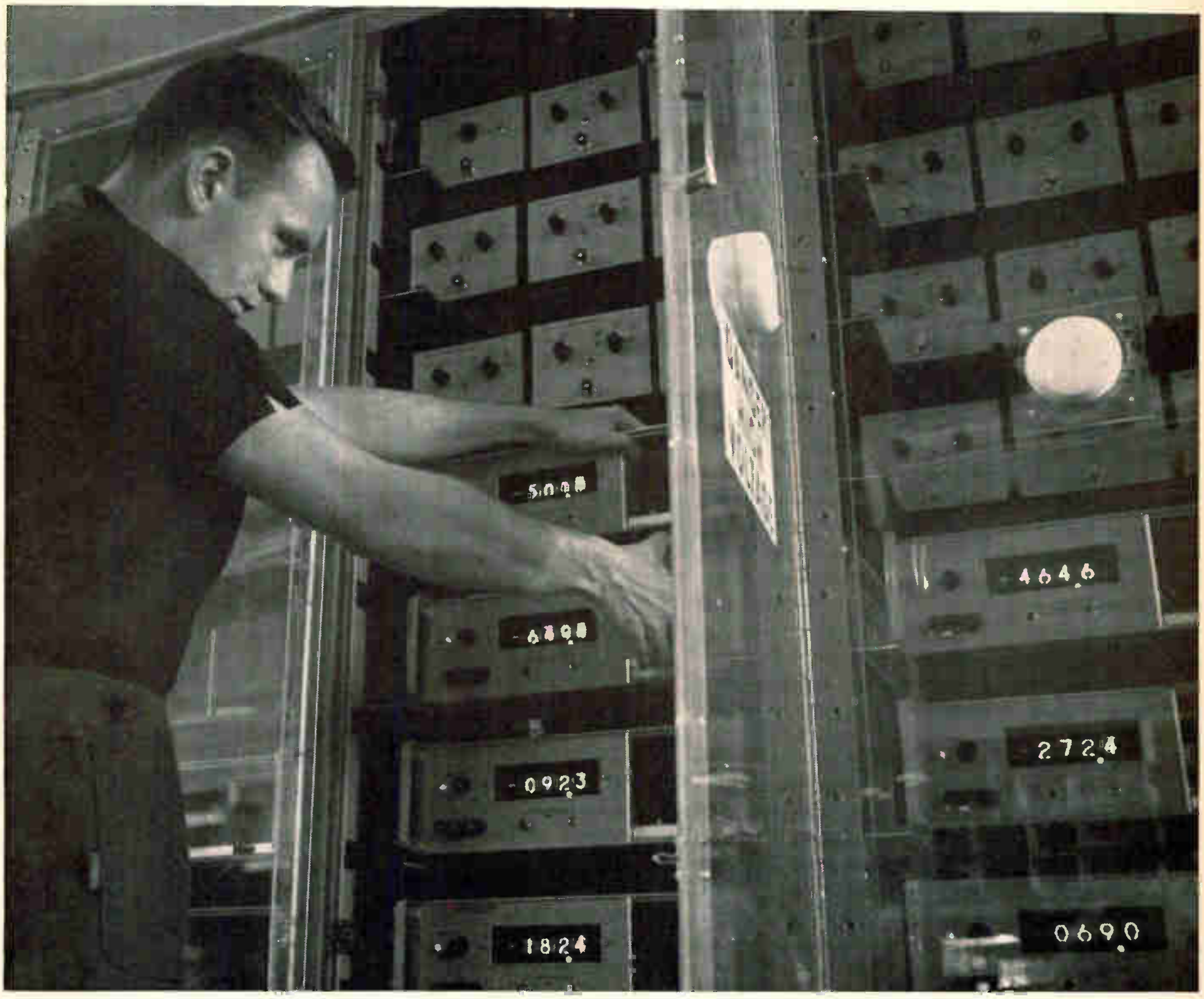
U.S. influence. More than 40 papers will be presented during seven sessions by experts from the United States, Japan and East and West Europe. About half are by American authors.

Leading off the meeting will be a paper by Edward Keonjian of Bethpage, N.Y., who will review predictions he made two years ago at the first microelectronics symposium and progress made since then. Silicon-on-sapphire thin-film integrated circuits is the subject of a paper by W. Downing and P.J. Hagon, of the Autonetics division, North American Aviation, Inc.

A.H. Benny and J.A. Hayers, two specialists from Manchester, England, will describe metal oxide semiconductor (MOS) transistors in integrated arrays. A. Cerny of the Institute for Industrial Development in Prague, Czechoslovakia, will discuss some stability problems of MOS transistors and R. Paul of the Technical University of Dresden, East Germany, will describe MOS transistor behavior at high frequencies.

A researcher from the principality of Lichtenstein, F. Gaydou of Balzers AG, will analyze a method for manufacturing thin films by ion atomization in the 10^{-4} torr region. H.T. Go, N.J. McAfee and H.C. Jones, all from the Westinghouse Electric Corp.'s Aerospace division will examine microelectronics reliability from a system manufacturer's point of view.

Warm-up



When you take delivery of a Hewlett-Packard 3439A or 3440A DVM, you can be sure of one thing: It's going to work. We've already warmed it up for you. After it's tested and calibrated, every 3439A and 3440A goes into this "oven" for an overnight dynamic test at 50°C. ■ All night long it's cycled. On, off, on, off, until morning. Then we retest it. If any troubles show up, they're fixed. And then it goes through the whole procedure again. ■ This environmental test is only one reason these DVM's are the most reliable you can buy. Another example: the readout boards. Before assembly, each one goes through a 24-hour run-in, a million turn-ons. ■ Any failures show up at our place, not yours. ■ We take a lot of trouble with your DVM. That's why you have so little trouble with it. And that's not just talk. ■ By the time it leaves our plant, we have enough faith in your 3439A and 3440A to back it up with a year's warranty. Ours is a confidence you don't find with other manufacturers. But then, they don't have the 3439A or 3440A either. ■ So if you want a reliable DVM, we have one all warmed up and ready to go. ■ The 3439A. Solid state. 4-digit readout. Manual, automatic, and remote ranging. Extra-high sensitivity. Ac / dc voltage / current resistance measurements (dc accuracy better than 0.05% of reading ±1 digit). Price, $950. The 3440A has BCD output. Price, $1160. Plug-ins, $40 to $575.

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

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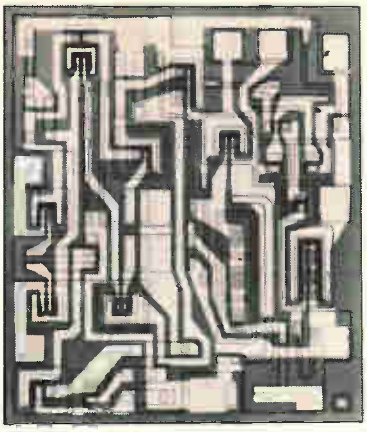
1892



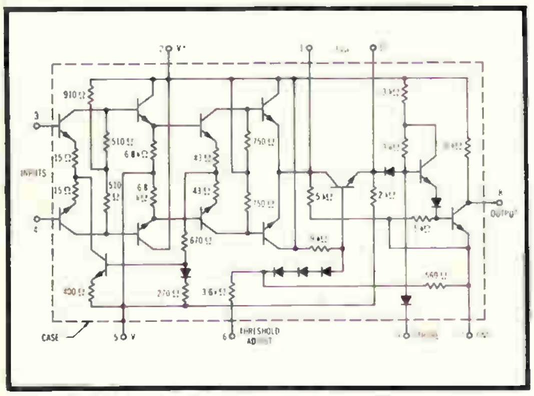
HIGH-SPEED CORE MEMORY SENSE AMPLIFIER

TYPE MC1540

. . . with adjustable threshold voltage!

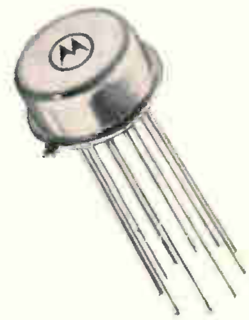
Typical performance:

- Fast recovery time — t_r = 40 ns compatible with 0.5 microsecond cycle time memories
- Saturated logic output signal
- Narrow uncertainty region — 6 mV
- High sensitivity — V_{th} = 17 mV (adjustable)



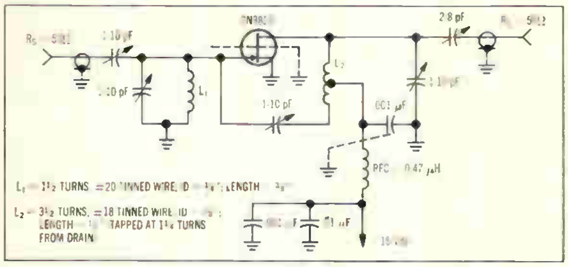
. . . for all applications requiring core memory signal sensing — such as, industrial control systems, data processors, and airborne computer systems.

MOTOROLA ANNOUNCES THREE NEW STATE-OF-THE-ART MONOLITHIC INTEGRATED AMPLIFIER CIRCUITS!



GUARANTEED LOW-NOISE FET FOR VHF AMPLIFIERS AND MIXERS

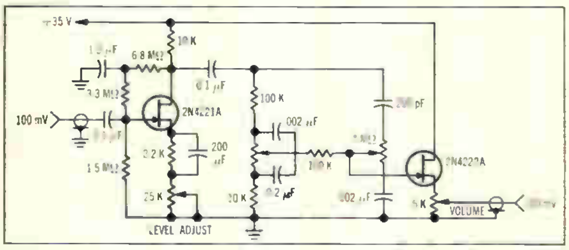
Now, RF receivers, including high-quality FM sets, can be virtually free from spurious responses, if you specify Motorola's new 2N3823 state-of-the-art **JFET**. An extremely low 100-MHz noise figure of 2.5 dB (max) is complemented by low cross-modulation and intermodulation distortion.



200 MHz Low-Noise Amplifier Circuit

- Symmetrical geometry in TO-72 package — can plug right into existing sockets.
- Also useful in UHF applications — up to 500 MHz.
- Low transfer and input capacitance . . . $C_{rss} = 2$ pF (max).
- $C_{iss} = 6$ pF (max).

GENERAL PURPOSE JFETs OFFER LOW-NOISE & LOW-COST FOR INDUSTRIAL & CONSUMER USES



Tone Control for High-fidelity Audio Amplifiers

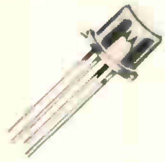
Ease of converting audio preamplifiers to FET designs with Motorola types 2N4220A-22A has excited the imaginations of engineers. The high input-resistance allows for "vacuum-tube" design principles in selection of tone control elements — permitting use of small, low-cost capacitors.

The low guaranteed noise figure of 2.5 dB (max) at 100 cycles/sec. provides a definite advantage over bipolar transistors. For additional savings, the cost is only $2.90 (100-up), even lower in larger production quantities.

- N-channel for high gain $|y_{fs}| = 1{,}000$ μmhos (min) 2N4220A
  2,000 μmhos (min) 2N4221A
  2,500 μmhos (min) 2N4222A

N-CHANNEL IGFET OFFERS HIGH GAIN FOR GENERAL PURPOSE APPLICATIONS

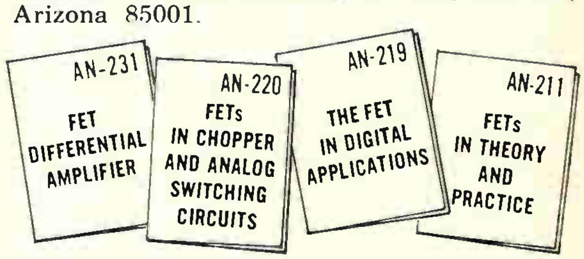
Motorola's new MFE3001 IGFET operates in both the enhancement and depletion modes, for a broad range of applications in industrial, military, and consumer equipment. And, the 100-up price of $3.90 makes it practical for most applications. Typical uses are audio amplifiers, switches and controls. A low drain current results from its small geometry, and the n-Channel construction provides high gain indicated by the $|y_{fs}|$ specification of 1,800 μmhos (typ).



- Extremely high input resistance $I_{GSS} < 10$ pA at 10 Vdc
- High Signal-handling capability at low drain currents. $I_{DSS} = 0.5$ mAdc (min).

FOUR MOTOROLA APPLICATIONS NOTES EXPLAIN NEW FET TECHNOLOGY

To explain the advantages of field-effect transistors in both digital and analog systems, Motorola's Applications Engineers prepared a series of technical papers. The information covers a broad range of applications, and includes sample circuit designs as well as operational theory. Any one or all of them can be added to your semiconductor library, simply by completing and mailing the coupon below, to Dept. T.I.C., Motorola Semiconductors, Box 955, Phoenix, Arizona 85001.



YES, I am interested in learning more about field effect transistors. Please send me the following Motorola Application Notes:

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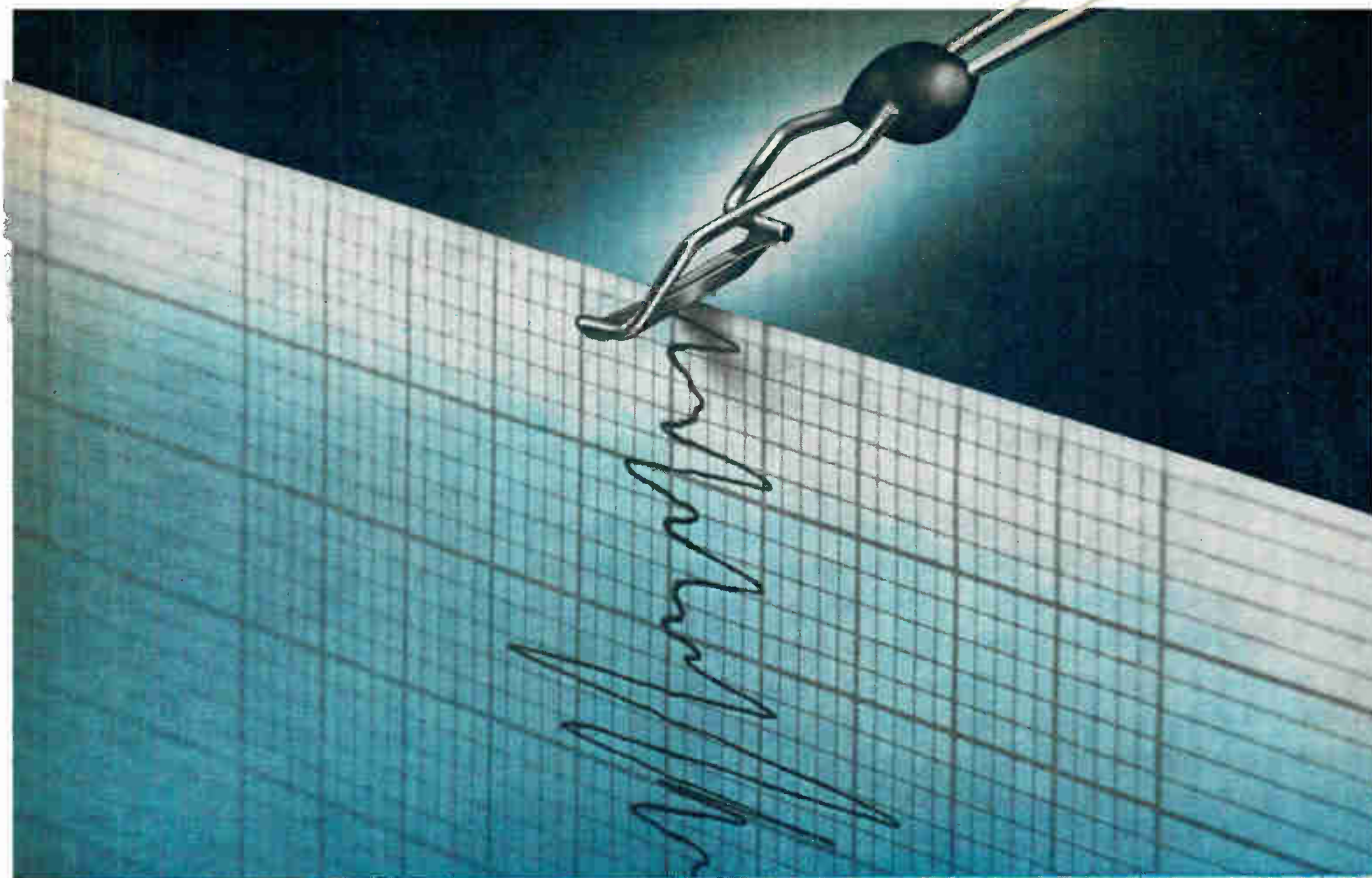
Name __________ Title ______

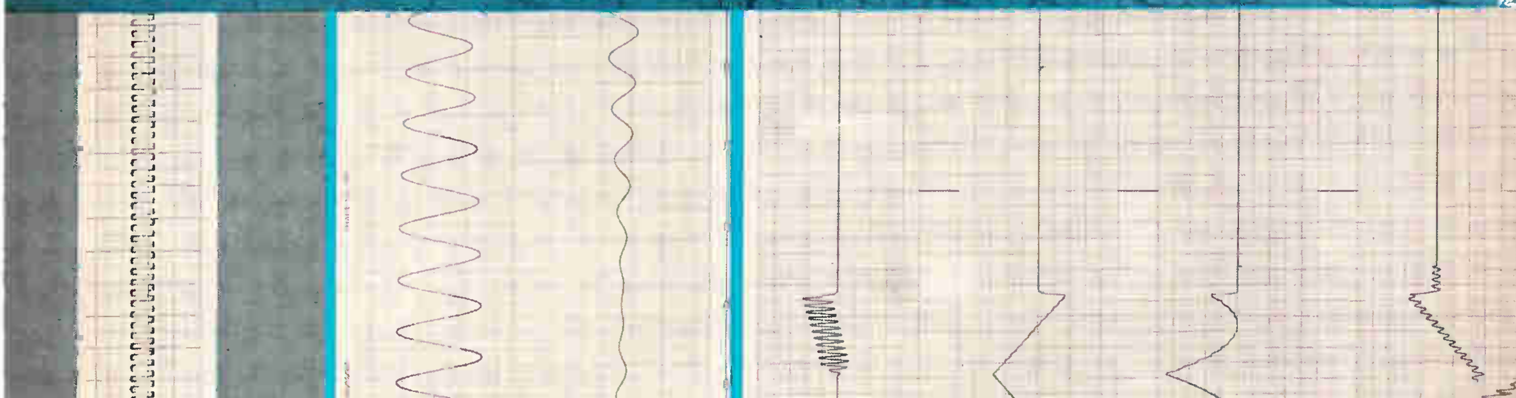
Company __________ Address __________

City __________ State ______ Zip ____

MOTOROLA Semiconductors

—where the priceless ingredient is care!





SINGLE-CHANNEL

Economical "briefcase-size" recorders. ☐ MODEL 7701A — 100 mm chart. Frequency Range DC to 30 cps. Linearity 0.5%. Sensitivity (depending on "8800" Preamp used) 1 uv/div to 5 v/div. Four chart speeds, 4 more optional. With case: $1,325 plus preamp. ☐ MODELS 299, 301 — 32 mm chart. Frequency Range DC to 100 cps. Linearity 0.625%. Sensitivity 10 mv/div (Model 299), 10 uv rms/div (Model 301). 2 chart speeds. Model 299: $800, Model 301: $850.

DUAL-CHANNEL

In portable, rack-mount, or mobile cart units. ☐ MODEL 7702A — Two 50 mm channels. Frequency Range DC to 125 cps. Linearity 0.5% Sensitivity (depending on "8800" Preamp used) 1 uv to 5 v/div. Four chart speeds, four more optional. $1,675, plus preamps. ☐ MODEL 7712A — Uses "350" Preamps. Sensitivity 2 uv to 5 v/div. With mobile cart: $1,770, plus preamps. ☐ 320 SERIES — Two 50 mm channels. Frequency Range DC to 125 cps. Linearity 0.5%. Sensitivity: 0.5 to 20 mv/div and v/cm (Model 320), 10 uv rms/div to 2 mv/div (Model 321), 10 mv to 10 v/div (Model 322). Four chart speeds, more on special order. Model 322 has zero suppression. Prices with cases: Model 320: $1,650, Model 321: $1,650, Model 322: $1,395.

FOUR-CHANNEL

Sanborn MODEL 7704A recorder provides improved overall reliability, wider dynamic range, higher gain and more versatility through all solid-state "8800" Series preamps. Frequency range DC to 150 cps. Linearity 0.5%. Horizontal chart plane, nine chart speeds. Sensitivity (depending on "8800" preamp used) 1 uv/div to 5 v/div. In vertical cabinet, $4,020 plus preamps. ☐ MODEL 7714A combines the convenience of horizontal chart plane with the flexibility and high performance of interchangeable individual-channel 350 Series preamps. Four 50 mm channels. Frequency range DC to 150 cps. Linearity 0.5%. Sensitivity (depending on "350" preamp used) 2 uv/div to 5 v/div. Nine chart speeds. With vertical cabinet, $3,970 plus preamps.

See all measurements — down to the last microvolt

with high resolution Sanborn thermal writing oscillography

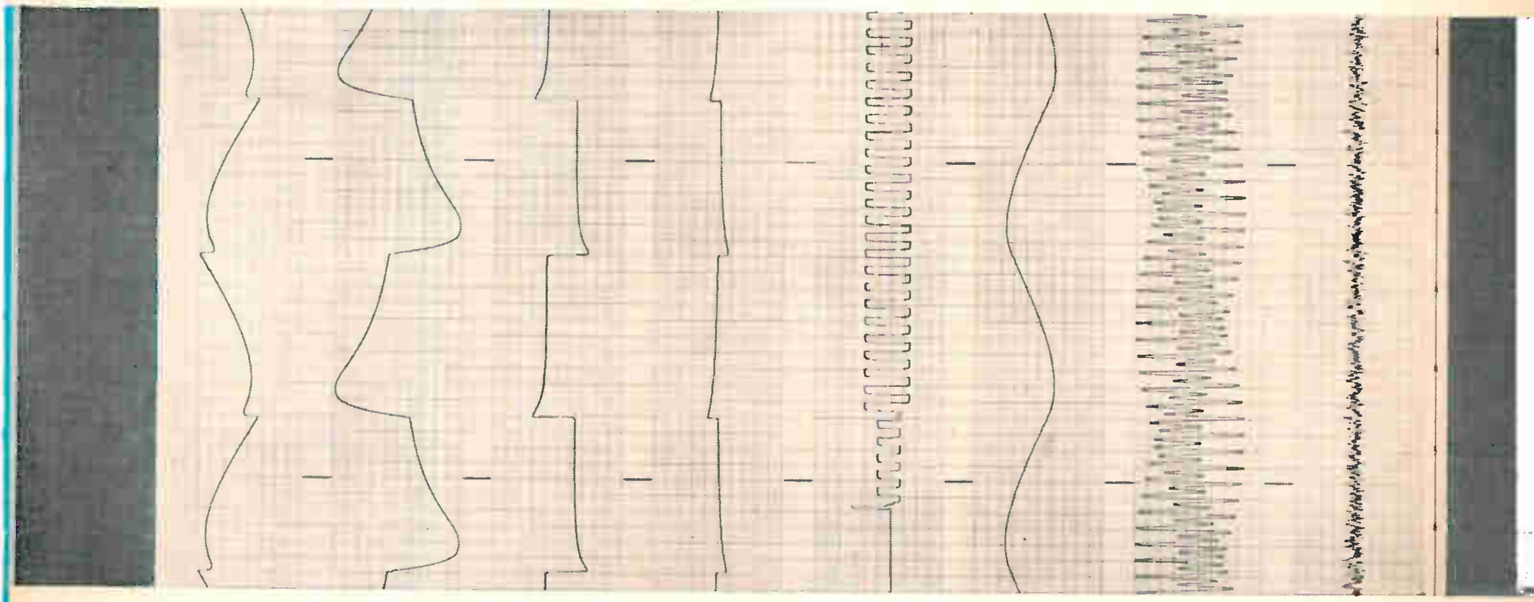
Resolve and read the smallest variations in your test parameters — even at *higher* frequencies, *small* amplitudes, and at *slow* chart speeds. Sanborn heated stylus oscillographic recording on matching Permapaper® charts gives you an immediate, permanent and clear record of test variables . . . lets you make "straight across" comparisons and correlations of multiple channels quickly and accurately because of rectangular coordinate traces . . . lets you clearly see what happened — as it is happening, and at any future time for more study or proof of performance.

The advantages of Sanborn thermal writing are available in many combinations of standard catalog system choices. The extensive Sanborn line allows you to select the number of channels, chart speeds, and the type of signal conditioning circuits you need, and to choose the packaging method that best suits your facilities. The wide range of signal conditioners includes low-cost built-in units, all-channels-alike amplifiers in six or eight-channel modules, and two series of individual channel plug-in units — miniaturized solid-state signal conditioners and highly sophisticated, maximum performance units.

Check the brief specifications of the systems shown below or call the H-P field engineering office in your locality for complete technical data and application engineering assistance. Offices in 47 U.S. and Canadian cities, and major areas overseas. Sanborn Division, Hewlett-Packard Company, Waltham, Massachusetts 02154. Europe: Hewlett-Packard S.A., 54 Route des Acacias, Geneva, Switzerland.

HEWLETT PACKARD hp SANBORN DIVISION

Circle 21 on reader service card



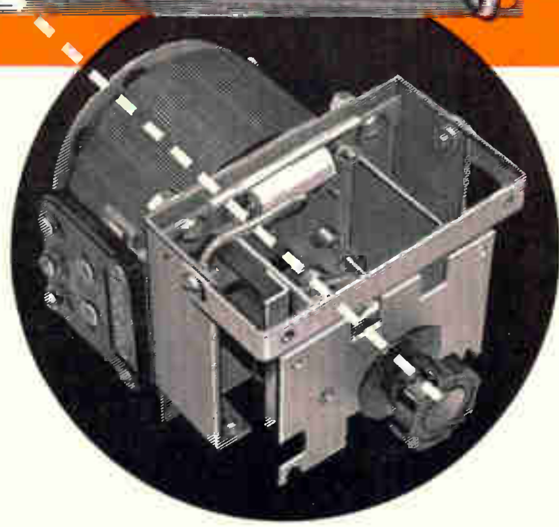
SIX AND EIGHT-CHANNEL

These versatile recorders have a wide range of input capacities, are completely integrated from signal input to galvanometer, and field-proven electronics. Six channel systems have 50 mm charts, and eight channel systems have 40 mm charts. All have DC to 150 cps frequency range. Linearity 0.5%. Nine chart speeds, nine more optional. ☐ MODELS 7706A, 7708A — Sensitivity (depending on "8800" preamp used) 1 uv/div to 5 v/div. With 6-channel cabinet (7706A) $4,820 plus preamps, with 8-channel cabinet (7708A) $5,495 plus preamps. ☐ MODELS 7716A, 7718A — Sensitivity (depending on "350" preamp used) 2 uv/div to 5 v/div. With 6-channel cabinet (7716A) $5,325 plus preamps, with 8-channel cabinet (7718A) $6,350 plus preamps. ☐ MODEL 7728A — Sensitivity (depending on "950" amplifier used) 10 uv/div to 5 v/div. With 8-channel cabinet $3,425 plus amplifiers. ☐ MODEL 7709A 8-channel "control panel" recorder for basic inputs such as telemetry and computer outputs and other relatively high level ac-dc signals. Economical system uses no preamps, but has individual-channel front panel controls for gain, position, sensitivity selection (7 positions) and calibration. Polarity reversal is optional. Frequency range DC to 150 cps. Linearity 0.5%. Sensitivity 50 mv/div to 250 v/div. Nine chart speeds, nine more optional. Solid-state power amplifiers, constant 1 megohm input impedance, low drift. In vertical cabinet $5,030.

IN DC POWER SUPPLIES

THE KEPCO VOLTAGE CONTROL

MAKES THE DIFFERENCE!



THE NEW KEPCO SM▪▪A GROUP

The familiar Kepco SM Power Supply is sporting a new suffix these days, "A." The new "A" version, in the Kepco tradition, designates a product improvement, introduced without price increase. Specifically, we've redesigned the voltage control assembly of the SM Power Supplies to accommodate a precision, 10-turn potentiometer control of the type used in most other Kepco Power Supplies.

This latest improvement continues a sequence of refinements that have marked the successful six-year history of reliable SM Series Power Supplies. Last year, for example Kepco's engineers gave the SM a better reference and jacked up the loop gain to tighten its regulation from 0.1% to 0.01% line, 0.05% load. Together with a 0.05% stability spec, less than a millivolt (rms) of ripple, and the new 10-turn control, the fifteen SM models are a pretty impressive group of supplies.

The SM design employs a mechanically coupled variable autotransformer and voltage control rheostat to limit dissipation, reduce overvoltage potential and control output. The new "A" models, with an efficient, low backlash gearing assembly, couples a full 3600° (10-turn) precision rheostat to the 320° variable autotransformer to improve resolution (to 0.05%).

The supplies employ Kepco's patented *Flux-O-Tran*® regulating transformer in an RFI-free (non-SCR) control circuit which includes a full feedback series transisitor regulator. Plug-in circuit cards and plug-in transistors simplify maintenance (even the power transistors are "plug-in"). Front *and* rear output terminals are provided, with remote error sensing connections at the rear. The table on the right lists the available models.

REGULATION
0.01% LINE – 0.05% LOAD

MODEL	DC OUTPUT RANGE		DIMENSIONS			PRICE
	VOLTS	AMPS	H"	W"	D"	
SM 14–7AM	0–14	0–7	3½	19	13⅞	$405.00
SM 14–15AM	0–14	0–15	5¼	19	13⅞	525.00
SM 14–30AM	0–14	0–30	8¾	19	13⅞	725.00
SM 36–5AM	0–36	0–5	3½	19	13⅞	395.00
SM 36–10AM	0–36	0–10	5¼	19	13⅞	525.00
SM 36–15AM	0–36	0–15	8¾	19	13⅞	625.00
SM 75–2AM	0–75	0–2	3½	19	13⅞	425.00
SM 75–5AM	0–75	0–5	5¼	19	13⅞	525.00
SM 75–8AM	0–75	0–8	8¾	19	13⅞	625.00
SM 160–1AM	0–160	0–1	3½	19	13⅞	425.00
SM 160–2AM	0–160	0–2	5¼	19	13⅞	525.00
SM 160–4AM	0–160	0–4	8¾	19	13⅞	625.00
SM 325–0.5AM	0–165–325	0–0.5	3½	19	13⅞	4[illegible]0.00
SM 325–1 AM	0–325	0–1	5¼	19	13⅞	555.00
SM 325–2AM	0–325	0–2	8¾	19	13⅞	675.00

Applicable Patent Nos. furnished on request

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Editorial

A traveler's lament

Last month, when the Boeing Co. announced it would proceed with its announced plan to build the 490-passenger Boeing 747, air travelers all over the world groaned in anguish. Those who remember the pleasurable experience of flying in the golden days of the DC-7 and Superconstellation have been complaining about the excursion-bus atmosphere of today's jet travel. The prospects of climbing aboard with 489 others are almost too enervating to face.

What's wrong, of course, is that the airlines insist on following ground procedures they developed 30 years ago for the DC-3, even though they are flying jets now and talking about super-loaded jets tomorrow. Most have given only lip service to changing their ways to take advantage of advancing technologies. Nobody who knows the slightest about data-processing techniques and communications can understand why the airlines have so much trouble checking in a passenger who has confirmed and reconfirmed a reservation.

The problem is more than just electronic equipment. Although American Airlines has invested over $30 million in Sabre, a complex electronic data processor and communications system, for all the good it does, the airline operates as if Bob Cratchit were sitting on a stool in the room behind the check-in counter and writing the reservations with a quill pen. But you can't point an accusing finger at American Airlines alone; others are worse. It takes almost as long to fly to Japan as it does to check in on the Pan American Airways flight that takes you there—with only slight exaggeration; United Airlines has sold so many services it doesn't deliver that travel by it is virtually impossible; checking in at Western Airlines, Eastern Airlines, TWA, National Airlines, or Northwest Airlines is an exercise in frustration and futility.

Instead of just mechanizing today's ground procedures, the airlines have to alter them to face up to increasing passenger loads and to utilize today's technology. For example, there's no reason why a passenger has to check in three times (once with his baggage, once at the check-in counter and once at the departure gate) for a single trip. There's no reason why data processing cannot assign passenger seats when the reservation is made instead of at the departure gate. There's no reason why some form of information retrieval cannot be used to tell an agent how a passenger gets from New York to Omaha without his having to thumb through five or six volumes the size of the telephone book. There's no reason why an agent has to write a ticket out by hand. There's no reason why he has to use the backs of envelopes to calculate the cost of a ticket.

The introduction of Boeing's giant 747 is likely to open a sizable market for electronic navigation equipment and communications gear. Yet the biggest market ought to be for data-processing and communications equipment on the ground. Makers of electronic equipment have to educate the management personnel of airlines to the need of modifying reservation and check-in procedures, just as computer-makers had to teach customers that data processors could be more than electronic bookkeeping machines.

If airline passengers have to ride in 490-passenger airplanes, they ought to be able to get aboard quickly and painlessly.

Moment of change

Rarely can man recognize a chain of technology that will radically alter his way of working at the instant the new developments appear. Generally, only by looking back into history can one pinpoint those innovations that changed his approach to his job or the importance of his role. Computer-aided design seems to be an exception. It is just starting to take hold in industry, yet nearly everyone can see how it will alter the role of the engineer. With computer-aided design, some of the decision making normally done by an engineer will be accomplished by an electronic data processor. The series that starts on page 110 may be one of the most significant ever published in Electronics.

Computer-aided design can be more efficient because it speeds up engineering at least two ways: by doing computations quickly and by trying a variety of designs and wiring interconnections in seconds. Some of the complex networks and large arrays of integrated circuits cannot be engineered economically any other way.

To many, such an advance is unwanted and undesirable. But it cannot be stopped. The clearest clue of what lies ahead can be found at the engineering schools where courses are now being changed to teach students to use and rely more on computers.

An engineer who chooses to ignore the promise of computer-aided design asks for a chance to become obsolete.

September 19, 1966

U.S. weighs plans for global network of listening posts

The United States is quietly studying plans for an overseas network of seismic nuclear detection arrays modeled on the Large Aperture Seismic Array (LASA) in Montana [Electronics, July 26, 1965, p. 91]. **The Defense Department's Advanced Research Projects Agency, which sponsored LASA, has turned the program over to the Air Force Electronic Systems division, Hanscom Field,** Mass. Because of foreign policy and fiscal considerations, final decision will undoubtedly come from the White House.

LASA's performance in distinguishing an earthquake from an underground nuclear explosion has been kept under wraps during its first 18 months of operation. **The goal of the 500-seismometer array in Montana is to increase bomb detection sensitivity at least tenfold.** It has been estimated that 10 or 12 such arrays around the globe would be able to check and classify more than 80% of earth shocks.

In addition to engineering problems, the Air Force is studying the possible effects of a global seismic network on disarmament negotiations and is weighing alternatives of construction and financing.

One question is how the investment overseas will affect this nation's balance-of-payments deficit. The announced cost of the Montana LASA was $9 million, but actual cost is estimated to be more than $12 million. Also to be answered is how a network of the arrays can be integrated to yield the best information on earth shock waves. Another question is whether construction should be left to foreign countries or whether, for the sake of standardization, the U. S. should install the arrays and leave their operation to the host countries.

Laser identifies railroad cars

A first of its kind is claimed for the automatic railroad car identification system recently developed by the Union Switch & Signal division of Westinghouse Air Brake Co., Pittsburgh. **The system consists of a helium-neon laser, two mirrors to direct the beam and a photo field effect transistor for scanning.** Railroad cars using the system have a reflective pressure-sensitive tape stuck to their sides to reflect the laser beam back to the identification equipment.

The company will introduce the system at the Railway Signal and Communications Suppliers Association meeting Sept. 20 in Washington. The system, expected to sell for between $12,000 and $14,000, will compete with light-bulb optical systems, radio systems and microwave systems for a market estimated at $50 million to $70 million over the next 10 to 15 years.

Navigation satellite must communicate, committee reports

A navigation satellite system that can't provide communications for ships and aircraft is not economically feasible, according to the final report of a committee set up two years ago by six Government agencies. **Current navigation techniques are adequate for all projected needs, but the committee pointed out in its long-overdue report that air traffic controllers on the North Atlantic route have an urgent requirement for better communications.** The demand will be intensified when the supersonic transport aircraft is flying this route.

Development of an initial satellite system for the combined job of navigation and communications would cost $66 million, according to the committee: $30 million for two satellites, $16 million for two Atlas-Agena launch vehicles, $17 million for ground equipment and $3 million for supporting research.

High costs keep auto electronics at a minimum

The auto industry is putting more electronics in its 1967 cars—especially frequency-modulated radios and stereo tape decks. **But the only technological innovation disclosed so far is the use of plastic optical fibers to transmit light to turn indicators and ignition switches in the big Chevrolets and Chevrolet trucks with automatic transmissions.** Chevrolet, a division of the General Motors Corp., says the fibers, made by E.I. du Pont de Nemours & Co. [Electronics, June 27, p. 184], are as reliable as the bulbs they replace and cost about the same.

The Ford Motor Co. offered a transistorized ignition system as a standard item in one of its cars and several heavy-duty trucks last year. This year more Ford cars and some from GM's Oldsmobile division will carry transistorized ignitions at extra cost. For two years GM's Pontiac division presented such systems as an option but admits the $63 extra charge ($73 for air-conditioned cars) held sales down.

On target

The Gemini-11 astronauts' faultless performance in making a first orbit rendezvous with Agena was carried off with a precision that did credit to the onboard electronics equipment. The flight proved out a capability that the astronauts coming back from the moon will have to have—**the ability to link up with the Apollo spacecraft in a single orbit.**

RCA to market home tape units

To get its share of what company market researchers think will be a six-million-unit annual market, the Radio Corp. of America's Home Instruments division has introduced 14 versions of transistorized magnetic tape recorders, including an eight-track unit that will play the stereo cartridges used in cars.

RCA has turned to foreign manufacturers, undoubtedly Japanese, to keep prices of the units low—from $40 to $250. The lower priced units would be battery-powered; the more expensive versions could use either a-c or d-c power.

Grundig and CSF join to develop consumer products

Two major West European electronics companies—Germany's Grundig GmbH and France's CSF-Compagnie Generale de Telegraphie sans Fil—have moved to strengthen their positions in consumer markets through joint development of new products. **The two companies still have to nail down details, but they indicate their working arrangements will cover integrated circuits and color television receivers.**

The deal brings together a strong consumer electronics company, Grundig, and a heavyweight in component production, CSF. The French company produces some consumer products, but its sales in that sector have stagnated. CSF, though, should get a big lift in consumer markets when color tv broadcasts start in France next year using the Secam system developed by CSF [Electronics, June 13, p. 161]. Grundig is on the PAL side of the color-tv line since Germany, like most other West European countries, will broadcast color using the PAL system. But this won't hamper joint development of color-tv receivers. About 90% of the components in PAL and Secam receivers could be interchangeable.

Component and Circuit Design IDEAS

from SYLVANIA Electronic Components Group

INTEGRATED CIRCUITS

Speed digital computations with the fastest (50 MHz) J-K flip-flops yet

Sylvania's two new TTL J-K flip-flops are the fastest in the integrated circuit industry. Twice as fast as our own SUHL J-Ks, they will coast at a logic rate of 50 MHz and retain the high noise immunity, high logic swing, high fan-out, low power, and capacitance drive characteristics of the SUHL II line. The extra speed of the new units allows computer control and arithmetic sections to be redesigned for faster operation.

Both new devices, the SF-200 series AND J-K and the SF-210 series OR J-K, have a propagation delay of 10 nsec off and 13 nsec on. This high speed capability is achieved by using a fast switching flip-flop buffered by a SUHL II gate structure. This means total delay of the circuit is the $t_d$off delay of the fast flip-flop plus the $t_d$on of the SUHL output.

The improved J-K flip-flops aren't restricted by the clock; asynchronous entry permits operation in between clock pulses. The internal buffering also means that output loads will not affect input triggering. Output is symmetrical.

Other performance characteristics include power dissipation of 50 mw, noise immunity of ±1 volt, and logic offset of 3.5 volts for logic "1" and 0.2 volts for logic "0." Fan-out is from 9 to 15 and fan-in is 3. Operation is from a single 5-volt source.

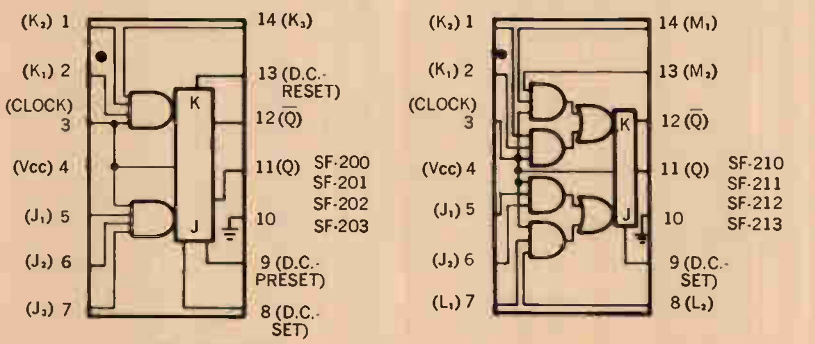
Available in MIL (−55°C to +125°C) and industrial (0°C to 75°C) grades and in dual in-line plug-in packages or flat packs, the SF-200 and SF-210 series have pin connections identical to other SUHL J-Ks. Thus, they can be used as replacements for present SUHL J-Ks.

These new units can be applied to a host of digital systems including computers, communications equipment, and digital readout systems. Specific digital subsystems which can be speeded up with these units are synchronous binary decade counters, synchronous binary counters, ripple counters, serial to parallel and parallel to serial counters, up-down counters, and circulating ring counters with decoded readout.

In summary, these flip-flops can be used in synchronous applications, where registers and counters are set and reset in conjunction with the system clock; and also in asynchronous applications, where registers and counters are set and reset independent of the system clock.

CIRCLE NUMBER 300

J-K Flip-Flop (AND Inputs) | J-K Flip-Flop (OR Inputs)



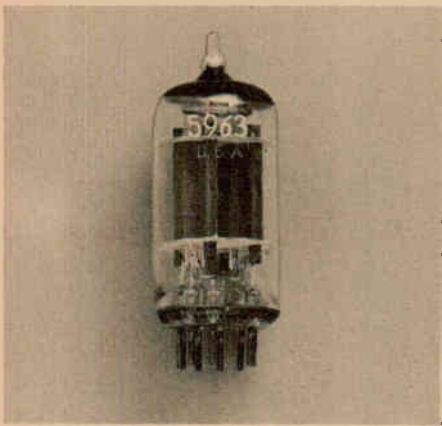
$Q_{n+1} = J_1 \cdot J_2 \cdot J_3 \cdot \overline{Q}_n + \overline{K_1 \cdot K_2 \cdot K_3} \cdot Q_n$

$Q_{n+1} = (J_1 \cdot J_2 + L_1 \cdot L_2) \cdot \overline{Q}_n + \overline{(K_1 \cdot K_2 + M_1 \cdot M_2)} \cdot Q_n$

This issue in capsule

RECEIVING TUBES

Highly reliable tube offers advantages in computer applications



CHARACTERISTICS AND TYPICAL OPERATION	
Class A1 Amplifier (Each Unit)	
Plate Voltage	67.5 Volts
Grid Voltage	0 Volt
Amplification Factor	21
Plate Resistance (Approx.)	6600 Ohms
Transconductance	3200 μmhos
Plate Current	8.5 Ma

COMPUTER SERVICE	Cutoff Condition	Zero Bias Condition
Plate Supply Voltage	150	150 Volts
Grid Voltage	−15	0 Volts
Plate Circuit Resistance	20,000	20,000 Ohms
Grid Circuit Resistance	47,000	47,000 Ohms
Plate Current	0	5.1 Ma

A miniature medium-mu twin triode, Sylvania's Type 5963, is being successfully used in long-life computer applications, primarily as a flip-flop.

Extreme stability throughout a long life, a high degree of balance within each device, and uniformity between different units are key characteristics of Sylvania's Type 5963 tube. Specially designed for accurate computation in computers, counters, and other digital equipment, this improved tube offers an economical approach to circuit design. It eliminates the need for special temperature compensating networks, redundant circuits, and tightly regulated supply voltages while offering higher reliability, easier maintenance, and lower initial component cost.

In Type 5963, the extreme stability during operating life is the result of an improved cathode. With the special alloys used in this tube, the severe "zero" to "one" switching associated with flip-flop circuits is handled easily. Even when these voltage changes are imposed rapidly after lengthy periods of standby operation, performance and life are not degraded.

The high degree of electrical balance between the tube's two triode sections enhances flip-flop operation and eases the design requirements placed on associated circuitry.

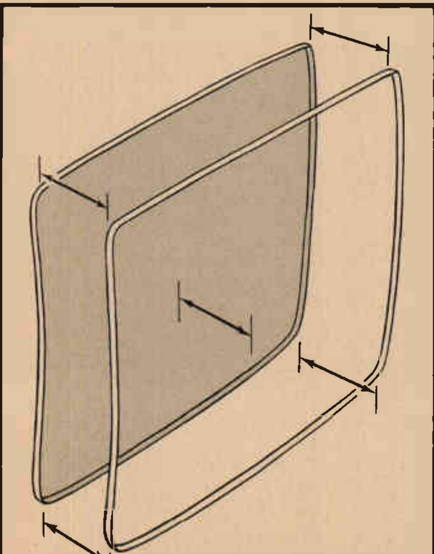
Because all Sylvania 5963 tubes are manufactured to meet rigid in-process and final test limits, they exhibit excellent uniformity from tube to tube. This means replacement is simply a matter of changing tubes. There are no trimmers to adjust, no components to replace, and no preselection of devices. And these triodes are available from conveniently located Sylvania distributors.

In addition to its application in flip-flops and other switching applications, the 5963 is used as an amplifier as indicated in the table which shows typical operation data.

CIRCLE NUMBER 301

COLOR TELEVISION

True, more vivid color is assured with prestabilization



Precise computer measurements at five points match face panel to mask.

Three basic color picture tube refinements that go into all color bright 85® *picture tubes by Sylvania—the true-tempered screen, computer precision alignment and cross-hair gun indexing—combine to reduce the effect of changes that may normally occur during tube life.*

Sylvania's true-tempered screen is the result of a stabilizing process used for some time by Sylvania but not publicly announced until this past June. The most recent issue of IDEAS described how the glass face panel is prestabilized, actually tempered to a predetermined dimensional density. While other screens can shift as much as 2 thousandths of an inch, during tube manufacture, *color bright 85* tubes have near perfect alignment between phosphor dots and the holes of the aperture mask.

Precision alignment between aperture mask and screen is assured in a new computerized process. The relationship of the shadow mask to the screen is determined automatically and precisely as the computer takes measurements in all four corners and in the center of rectangular tubes and adjusts for normal deviation and tolerances. (See drawing)

The third essential ingredient is cross-hair indexing of the tube's three electron guns. Initial alignment of electron beams and phosphor dots on the proper axes is assured with positive location and positioning of guns inside the tube neck.

These controls are not the full story in controlling the performance of the end product. Because of the broad diversity among company divisions, Sylvania controls the production of virtually all parts within its tubes—phosphors, guns, aperture masks, tube bases, and electron optic parts included.

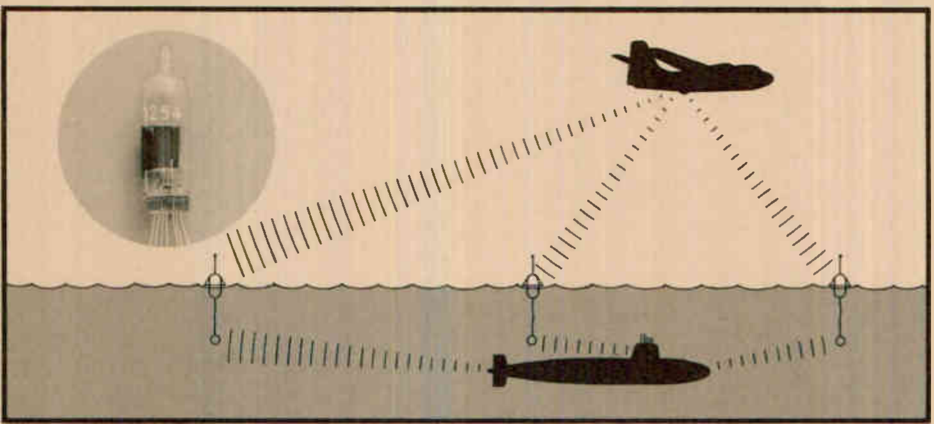
There is 100% testing to critical requirements throughout all processes. For instance, because of its in-house controls, Sylvania assures that all vital characteristics of electron guns are top quality. All Sylvania guns have a shielded cathode (for minimizing leakage and arcing), shielded prefocusing lens, low heater power (lower than most competitive types), double coated heater with premium rhenium-tungsten, and Sylvania's own method of cutoff control. All of these aspects are fully checked long before further tests which will assure the precise rotational location of the three guns in the color tube.

These controls are just a few of the set designer's and circuit designer's assurances that only the most advanced methods and materials are always used in Sylvania picture tubes.

CIRCLE NUMBER 302

RECEIVING TUBES

How a noise-free tube helps detect enemy submarines



Sonobuoys provide a highly efficient means of protecting surface ships and coastlines. By dropping a group of these units from a plane and then interrogating them, it is possible to determine the location of an enemy submarine. But interpreting the response of Sonobuoy hydrophones is a skilled art. Telling a sub from a whale or other natural objects is no easy task. If noise generated by the tube used in the front end of the hydrophone masks the sound of the submarine, the job becomes impossible. Sylvania's Type 1254 subminiature high-mu triode is a low-noise amplifier tailored to meet the strict requirements of Sonobuoy and similar applications.

ELECTRICAL DATA

CHARACTERISTICS		
Plate Voltage	100	150 Vdc
Cathode Resistor	1,500	680 Ohms
Plate Current	0.73	1.85 mAdc
Amplification Factor	70	70
Transconductance	1,700	2,300 μmhos
Grid Voltage for Ib = 50M Adc Max.	—2.5	—3.8 Vdc
RATINGS (Absolute Maximum)		
Plate Voltage		165 Vdc
Peak Plate Forward Voltage		330 V
Plate Dissipation		0.55 W
Plate Current		3.3 mAdc
DC Grid Voltage		
Positive Value		0 Vdc
Negative Value		55 Vdc
Heater-Cathode Voltage		
Heater Positive with Respect to Cathode		200 V
Heater Negative with Respect to Cathode		200 V
Grid Circuit Resistance		1.2 Meg

The Sonobuoy application places severe demands on the tube which first amplifies the sound detected by the underwater microphone. The tube in this first stage of amplification must not only overcome the rough environmental conditions seen by the other tubes, but it must amplify low-level audio and sub-audio signals without introducing any significant noise of its own. Modifying the features of tube Type 5719, a premium aircraft tube for multi-purpose use, Sylvania developed the Type 1254, a low-priced, extremely low-noise device.

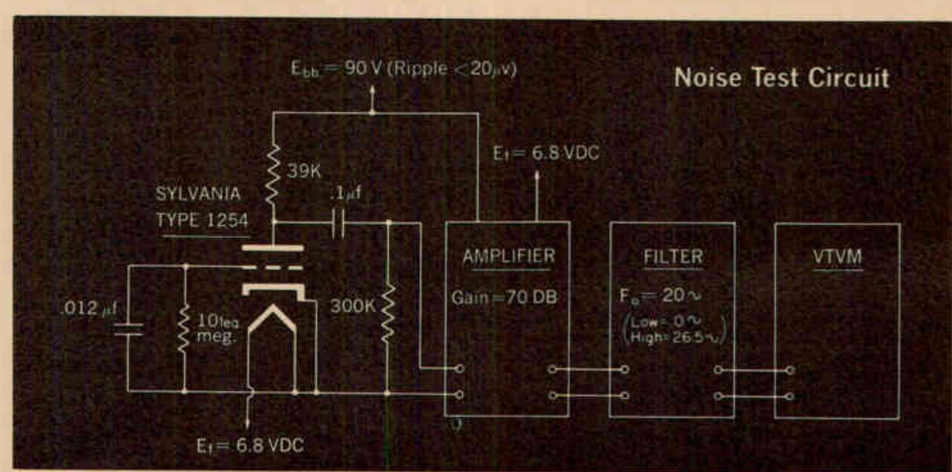
Sylvania designers have gone to extraordinary lengths to produce these exceptionally low-noise characteristics. The method and material processing were changed to further enhance the low-noise properties already present in Type 5719. Special test procedures and circuits were developed to evaluate the changes in processing and manufacturing and to test the final units.

A typical example of these efforts is the noise test circuit shown here. A similar test is also used on tubes for front ends of high fidelity applications in the transferral of technology to benefit other markets. The same technology and skills used to detect enemy submarines are also now used to produce the lowest noise front ends in high fidelity history.

There is no price premium for this low-noise characteristic and for the other features which Sylvania has built into its reliable line of tubes for industrial and entertainment audio applications—i.e., 6AN8A, 7543, 12AU7A, 7591A, and the 7868.

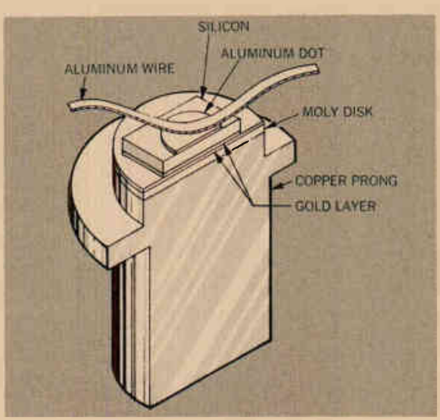
You may not have any need to detect enemy submarines — but if low-noise performance is a must for your equipment, you are assured of the highest quality with Sylvania tubes —readily available from your local Sylvania distributor.

CIRCLE NUMBER 303



MICROWAVE DIODES

Newest varactors reach highest levels yet in reliability and power handling



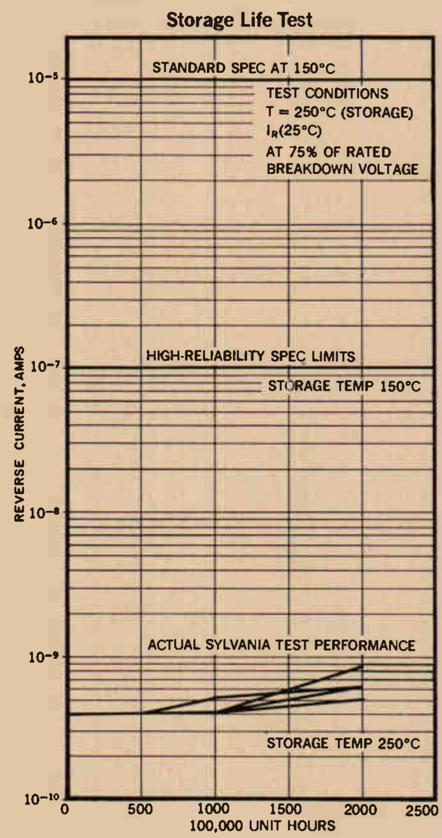
Until now, the solder bonding technique was a major step in varactor construction and processing. Circuit designers found that, although these devices met the specifications that manufacturers published, there was still decided room for improvement in three regards — higher reliability, power-handling capability, and storage temperature characteristics. Here's news of how the state of varactor art has just been advanced.

Reliability and life of high-power varactors have been increased with new assembly techniques developed by Sylvania. High-temperature test results with these new diodes show an MTBF of over 5 years, based on 100,000 unit hours of testing. As a result, these devices are suitable for new levels of exacting requirements and are especially suited for use in current manned space and communications satellite programs.

After being stored for 2,000 hours at 250°C, these units have shown no changes in electrical or physical characteristics. High-temperature capability, in fact, is the direct result of the new construction technique now being utilized with Sylvania's D-4800 varactors.

In the new process, after an aluminum dot is metallized to the silicon (see line drawing), an aluminum ribbon is then thermal-compression bonded to the dot. Note, too, that the underside of the silicon area is now metallized with gold, making possible a high-temperature bond of gold to gold. A molybdenum disk between the gold layer and copper pedestal acts as a thermal shock absorber that permits Sylvania to use high-temperature bonding methods.

Another critical step in varactor processing is cleaning. With the new Sylvania construction it is now possible to use superior cleaning procedures within the package prior to baking and sealing. A further assurance of varactor reliability is that Sylvania subjects all these units to a



300°C bakeout, driving off any moisture and all volatile contaminants. Finally, the packages are placed in a dry box and sealed in a controlled dry atmosphere having less than 20 parts per million of water vapor.

CIRCLE NUMBER 304

INTEGRATED CIRCUITS

It's easy to implement serial addition with SUHL

Before integrated circuits, how many different components and how much time did it take to wire a serial binary adder? With Sylvania's SUHL line of ICs you need only two basic component types, full adders and carry flip-flops, and a bare minimum of wiring. Here's how these SUHL units can be used to implement a variety of serial additions.

A serial binary adder accepts two bits of information at a time and adds them to produce a sum bit and a carry bit. The carry bit is stored in a flip-flop so that it's available for the next addition. In the 4-bit serial adder of Figure 1, initially one Augend and Addend bit are added producing a sum and possibly a carry. The next clock pulse shifts the first sum bit into the sum register and shifts the next Augend and Addend bits into position to be added. If a carry was generated by the first addition, it is stored in the carry flip-flop. Now another addition is performed, and the second sum bit and carry bits are formed.

At the second clock pulse, the sum, Augend and Addend are all shifted to the right and the carry is stored in the carry flip-flop. This operation of adding and shifting continues until all Augend and Addend bits have been summed. Since in this case there were four bits to be added, the final sum is available in the sum register after four clock pulses.

Figures 2, 3 and 4 show the actual implementation of serial addition using the SUHL family of ICs. All the circuits use the SM-10 series single-stage full adders.

In the basic serial adder with single-phase clock (Figure 2) and the basic serial adder where the sum is collected in the Augend register (Figure 3), the SUHL SF-50 J-K flip-flop is the only other type IC required. To make the Addend register of Figure 3 into a circulating type, simply use one SUHL SF-60 OR-input J-K flip-flop in place of the SF-50 in the MSD stage.

Figure 4 shows how to build a serial adder with two-phase clock using SM-70 four-bit binary registers.

CIRCLE NUMBER 305

Figure 1

Augend serial shift right register

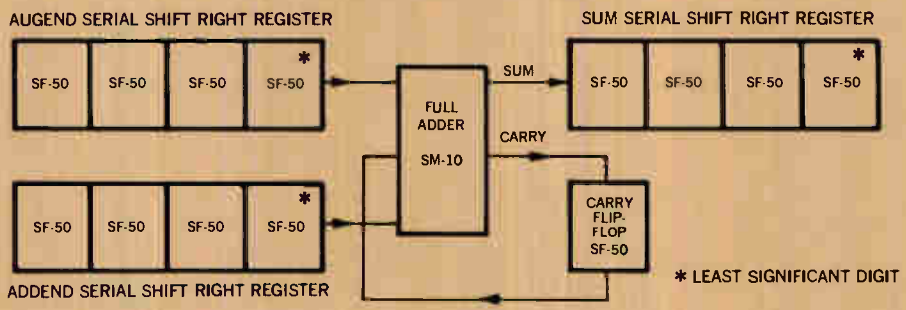


Figure 2

Basic serial adder, single-phase clock

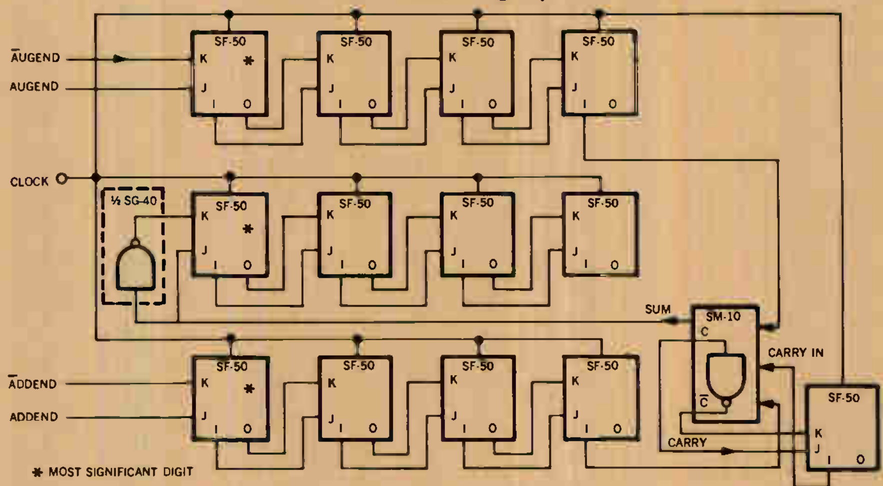


Figure 3

Basic serial adder, sum collected in Augend register

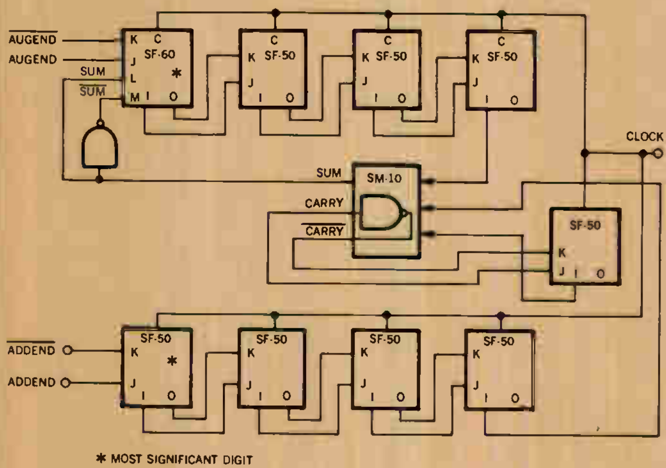
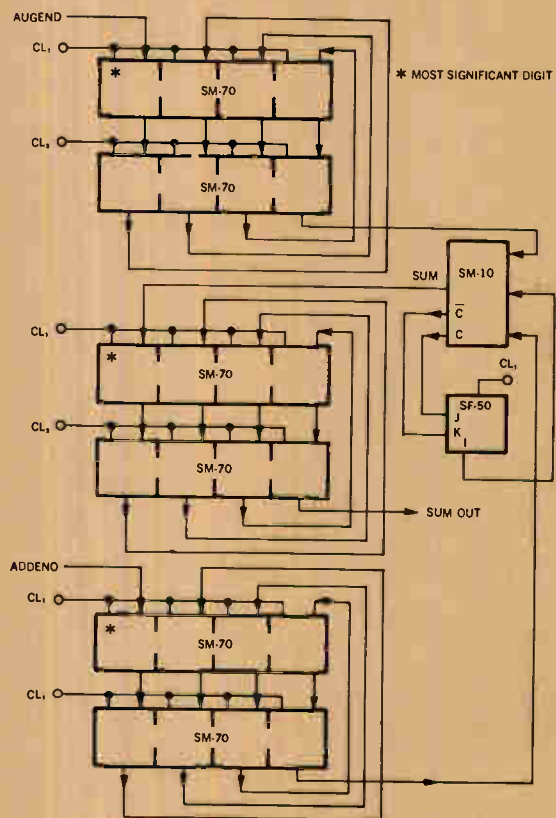
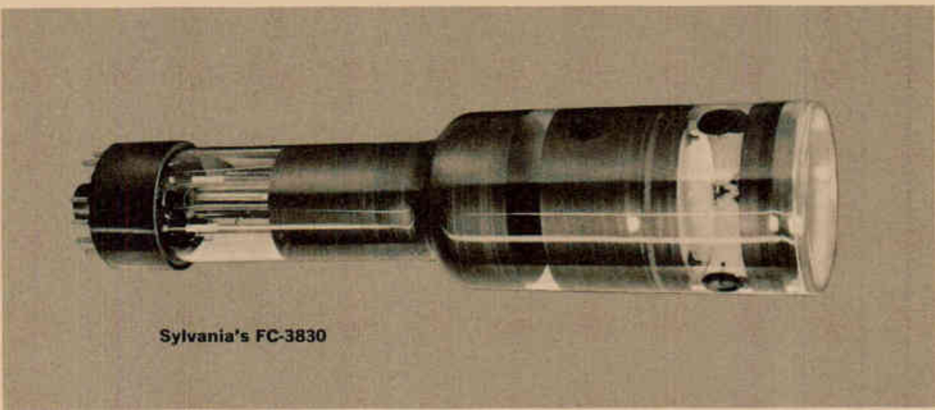


Figure 4

Serial adder, two-phase clock



Customed monoscopes and targets speed up display; add versatility



Sylvania's FC-3830

Because target configurations and general tube characteristics can be tailored to user specifications, customed monoscope CRTs from Sylvania meet many of today's display needs. Ability of these tubes to generate test patterns, alphanumeric symbols, charts, diagrams or maps at high speeds makes them ideal for a wide variety of uses. Applications include airline status boards, stock quotation systems, command control center displays, teaching machines, race track tally boards, and video test systems.

Targets in Sylvania's custom monoscopes are supplied as specified in the customer's own artwork. A typical target plate has a capability of 64 characters—A through Z, 0 to 9, punctuation marks, symbols, or just about anything needed for the specific application. These versatile displays are available in a wide selection of character fonts. They can also be supplied in a variety of black and white patterns.

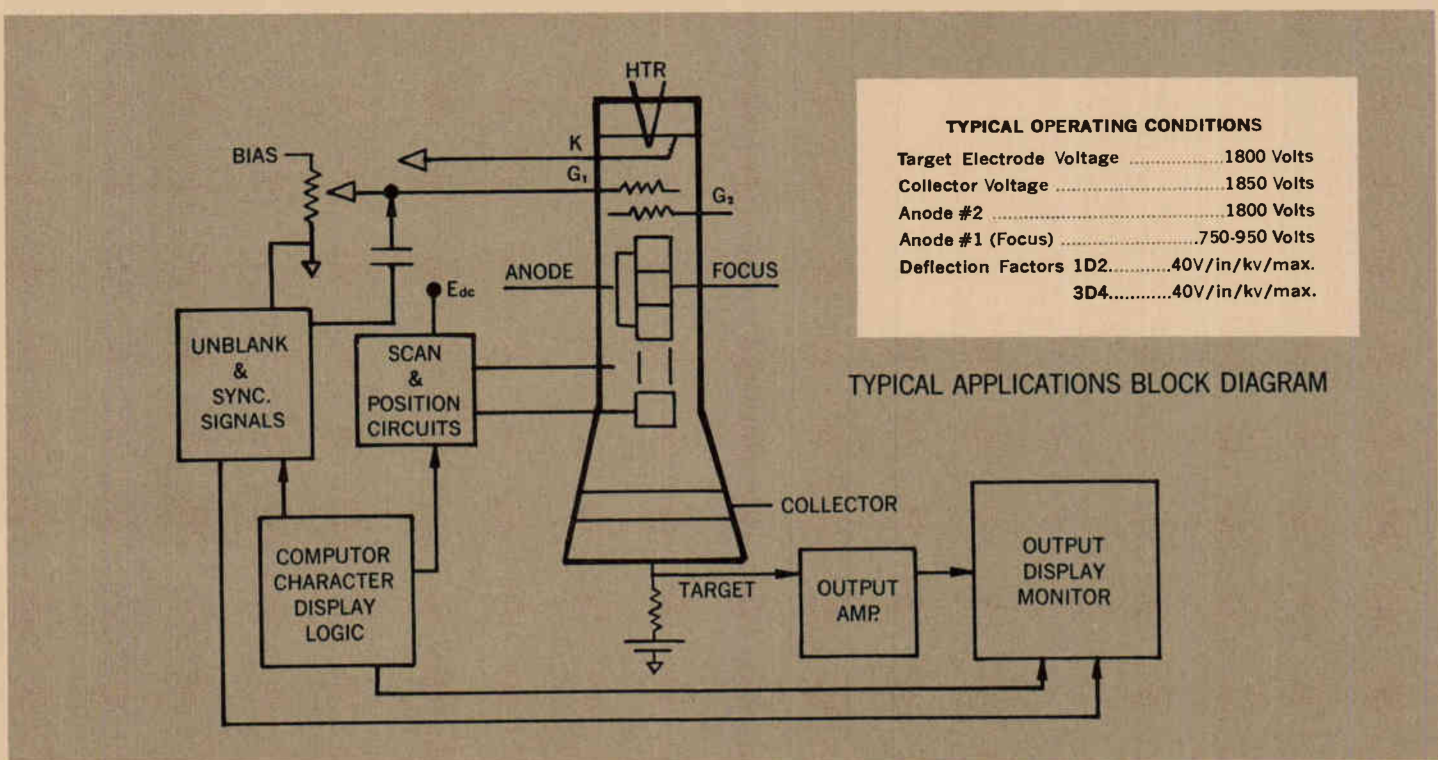
In a typical application, a computer controls the scan and positioning circuits that determine which particular character on the target is to be read out by the tube's scanning beam. Secondary electrons emitted from the target are collected on a conductive band inside the tube.

Since the non-printed portions of the pattern have a different secondary-emission ratio from the printed portions, the secondary-emission current varies as the beam scans the character. This variable target current is terminated in a load resistor. The voltage variation across the resistor now corresponds to the information printed on the target. After amplification, the information in this video signal is displayed on the output monitor in a position determined by the computer control circuits.

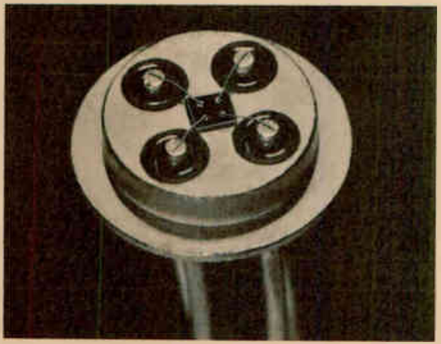
The customed monoscopes from Sylvania provide high signal output levels, good resolution and compact design. They are lightweight too. Featuring electrostatic focus and deflection, they are available with maximum ratings (with respect to cathode) of: Collector, 2500 Vdc; Target, 2500 Vdc; Focusing electrode anode, 1000 Vdc; Accelerator anode, 2500 Vdc; and Negative control grid, 200 Vdc. Peak heater-cathode voltage is 200 V with heater negative or positive with respect to cathode.

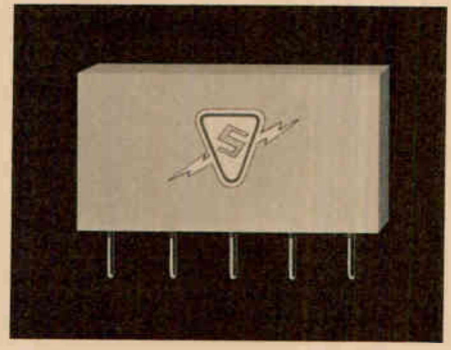
A standard line of monoscopes is also available. This means that circuit designers can use standard units with conventional target configurations during preliminary design work. Then, when final system requirements are set, the particular target and electrical characteristics needed can be incorporated into a customed monoscope meeting the specific usage.

CIRCLE NUMBER 306



How Sylvania's monolithic arrays can eliminate the need to match diodes





Chances are that any circuit requirement for matched diodes can be met by one or more units from Sylvania's broad line of monolithic diode arrays. Packaged in pairs, triples and quads with either common anodes or cathodes, these matched units have wide circuit application and offer significant advantages over conventional discrete devices.

Because these arrays consist of silicon diodes formed on a common substrate by an epitaxial planar passivated process, the individual devices exhibit remarkably similar characteristics. Thus, circuit applications requiring matched diodes are easily filled. And the excellent electrical characteristics of each diode within the array further enhance circuit performance. High forward conductance, low reverse leakage, fast recovery time, and high rectification efficiency at high frequencies characterize each device.

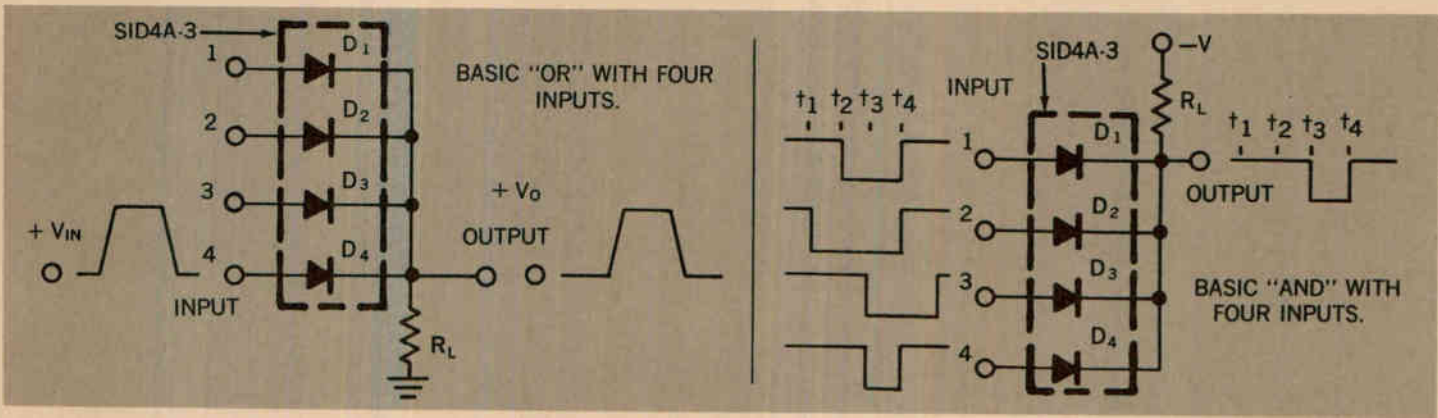
Increased reliability and reduction in assembly costs are direct results of the few external interconnections required with the multiple devices.

Typical of the units in the Sylvania line is the SID4A-3, a common cathode 4-diode array. Supplied in a 5-lead TO-46 package, this unit replaces four discrete diodes in aerospace and similar applications where space is at a premium and reliability levels must be high.

Basic OR and AND logic circuits point up the superior circuit performance of the 4-diode array. Because each diode's recovery time is short, propagation delay is reduced while pulse rise and fall times are quite small. Uniformity of forward V-I characteristics assures even current distribution between diodes under conditions of forward bias. In the reverse bias case, leakage current distribution with temperature change remains uniform.

In addition to diodes with common cathodes or anodes, Sylvania's line of epitaxial multiple diodes includes diode bridges, ring modulators and discrete all-glass hermetically sealed silicon units molded in axial-lead and plug-in epoxy packages.

CIRCLE NUMBER 307



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QUALITY CONTROL MANAGER'S CORNER

Quality can be a neuter concept

"High quality," "excellent quality," "unsurpassed quality." Great! But useless terms all, unless...

The Quality Concept is not just how well a product complies with a standard or specification. What really counts is its compliance with the needs and desires of a customer or with the market at large.

One graphic example is color picture tubes. In early 1964, industry standards were well established. By late 1964, one manufacturer, Sylvania, anticipating consumer needs, had raised these standards to new heights by following the broader, more inclusive approach to quality. Even now, two years later, this philosophy keeps *color bright 85®* tubes ahead of the field. Performance (via the Quality route) has made the big difference.

But performance cannot be realized without a strong control organization playing its role of watchdog —minute by minute, hour by hour, day by day. In our part of the electronics business, this means building each tube to the exacting standards established in Sylvania's engineering laboratories.

Where we have a particularly big quality edge is in virtually total control and evaluation of raw materials. Sylvania is among a select few component manufacturers who control their raw materials and component parts from start to finish. This includes our own parts, bases, leads, phosphors, emissive coatings, wires, tungsten and alloys. Almost everything except glass is fabricated under our own in-plant quality control systems to Sylvania's own demanding standards. And wherever we use vendors, Sylvania carefully establishes quality specifications and controls to assure the perfection of all parts.

All processes—mechanical, electromechanical, physical, and chemical—are carefully controlled and monitored. This is especially vital when sophisticated componentry like electron tubes must themselves be mass-produced, and then used in mass-produced radio, stereo and TV sets. Always bearing in mind that these devices are the brains and life's blood of an important end product, Sylvania builds in a high degree of uniformity of electrical and mechanical characteristics from tube to tube.

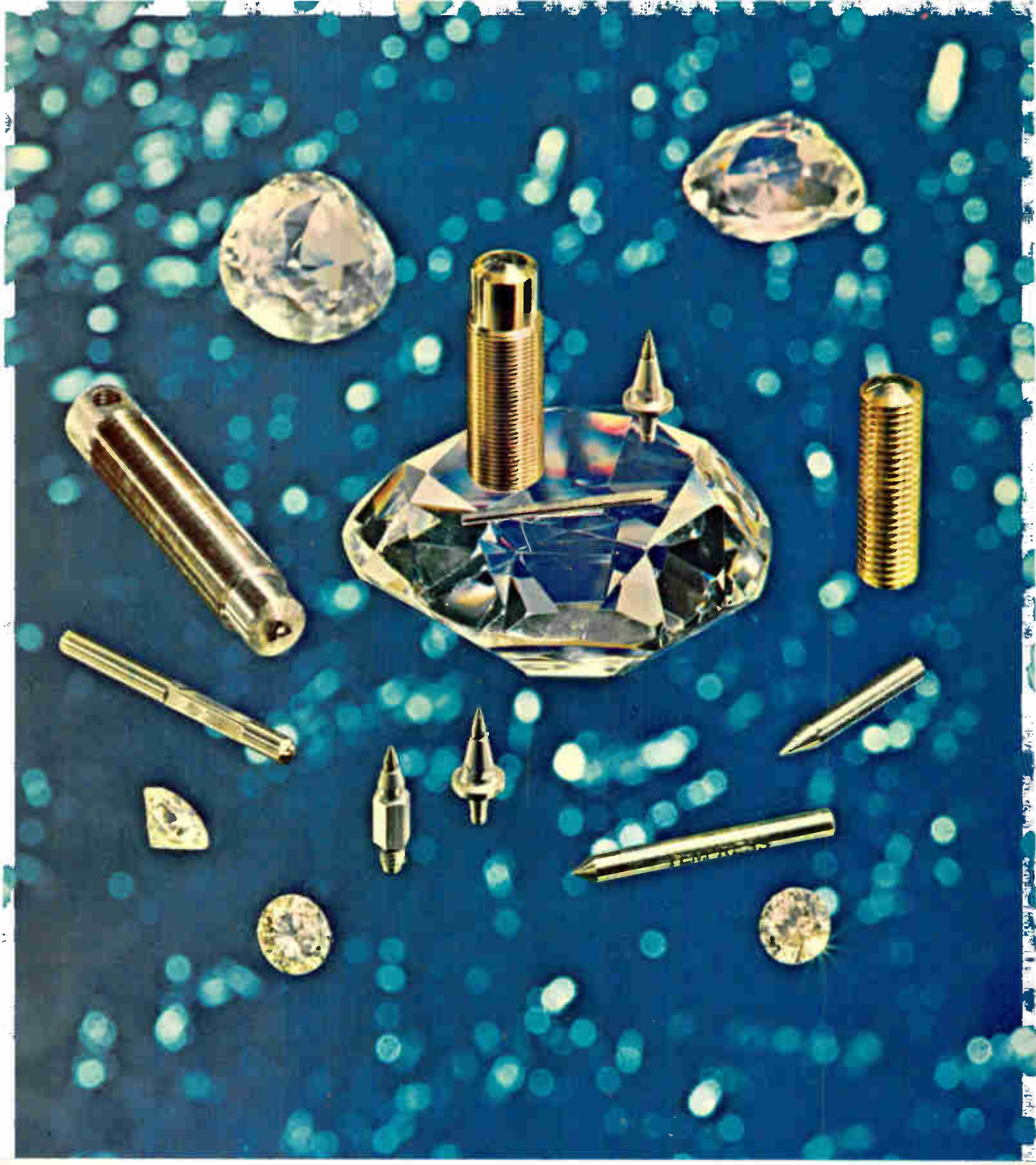
Our quality organization also performs the important functions of finished tube evaluation and the subsequent quality assurance program. In addition to 100% tests and inspections for all vital characteristics, *color bright 85* picture tubes (and other tube types) are sampled with special statistical techniques—still further assurances of compliance to specifications.

No one questions the import of long life performance. Our program through the years has included the evaluation of tubes under actual usage conditions in radio and TV sets. We conduct additional tests under more severe operating conditions to develop an accelerated evaluation of life quality. With both of these test programs, Sylvania's able to statistically evaluate life performance while providing assurance of high quality tubes—not just initially, but for life.

Our quality story is not complete without mentioning that we maintain good and effective contacts with our customers. As a supplier, it is most important to us to maintain a feedback system of information of tube performance in customer manufacturing lines. This helps us to provide engineering and quality service quickly to solve virtually any problem.

Al Heitner

A. J. HEITNER



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Prices start at $65. Every time you specify one of these supplies, instead of a comparable germanium unit, you save considerable money. If you're using commercial supplies, typical savings-per-unit are about $40. For military supplies it's much more.

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SPECIFICATIONS

	STANDARO MODEL	"A" MODEL
Total Regulation (Line and Load)	±0.5%	±0.05%. or 2 mv .
Ripple (rms. max.)	10 mv	1 mv or .003%
Temperature Coefficient	0.07%/°C	0.015%/°C

	ALL MODELS
Input	105-125 v ac, 47 to 440 cps
Temperature	75°C ambient max. 95°C base plate max.
Response Time	10 microseconds
Military Specifications	Certified to meet the environmental requirements of MIL-E-5272 and the RFI requirements of MIL-I-6181

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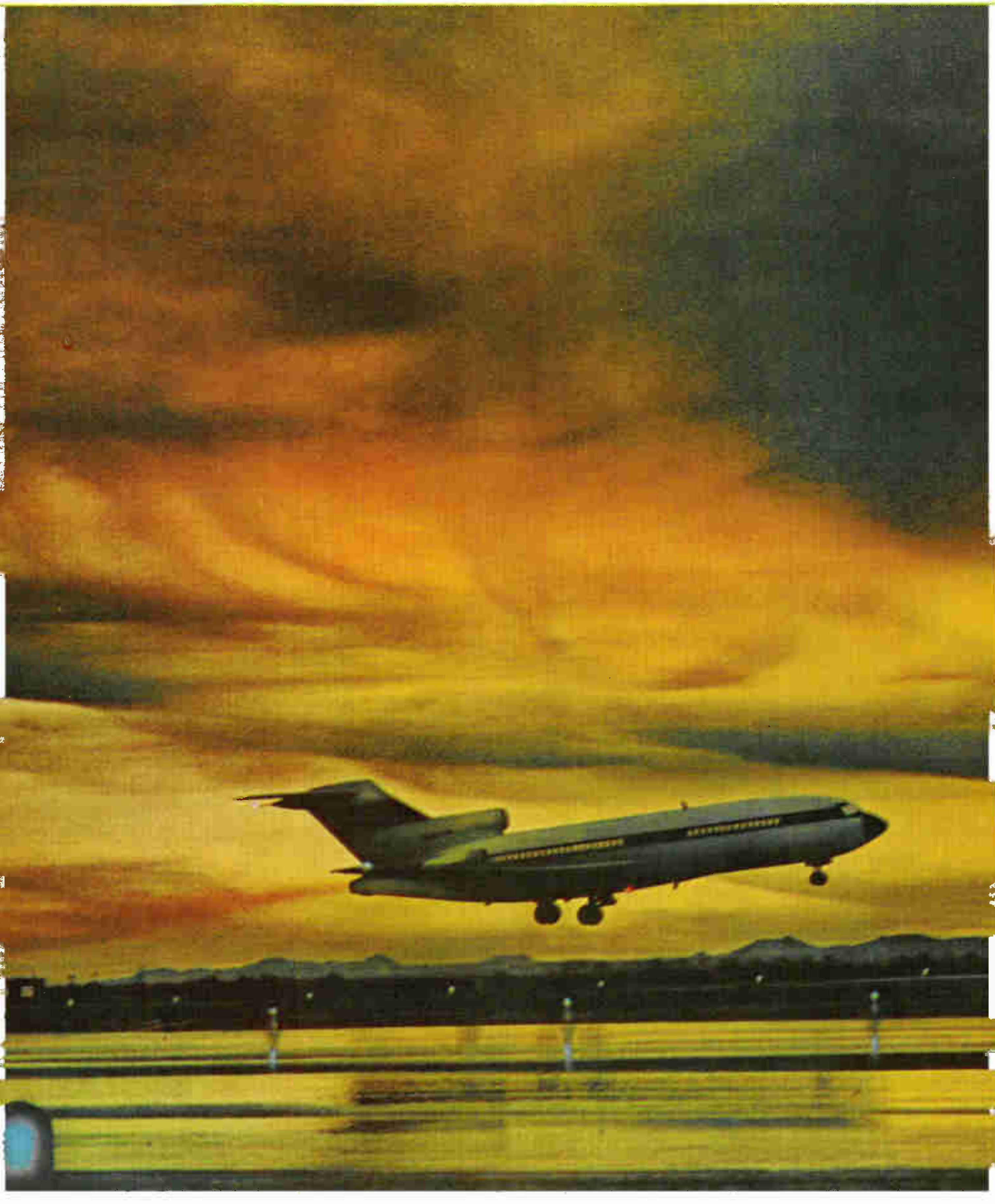

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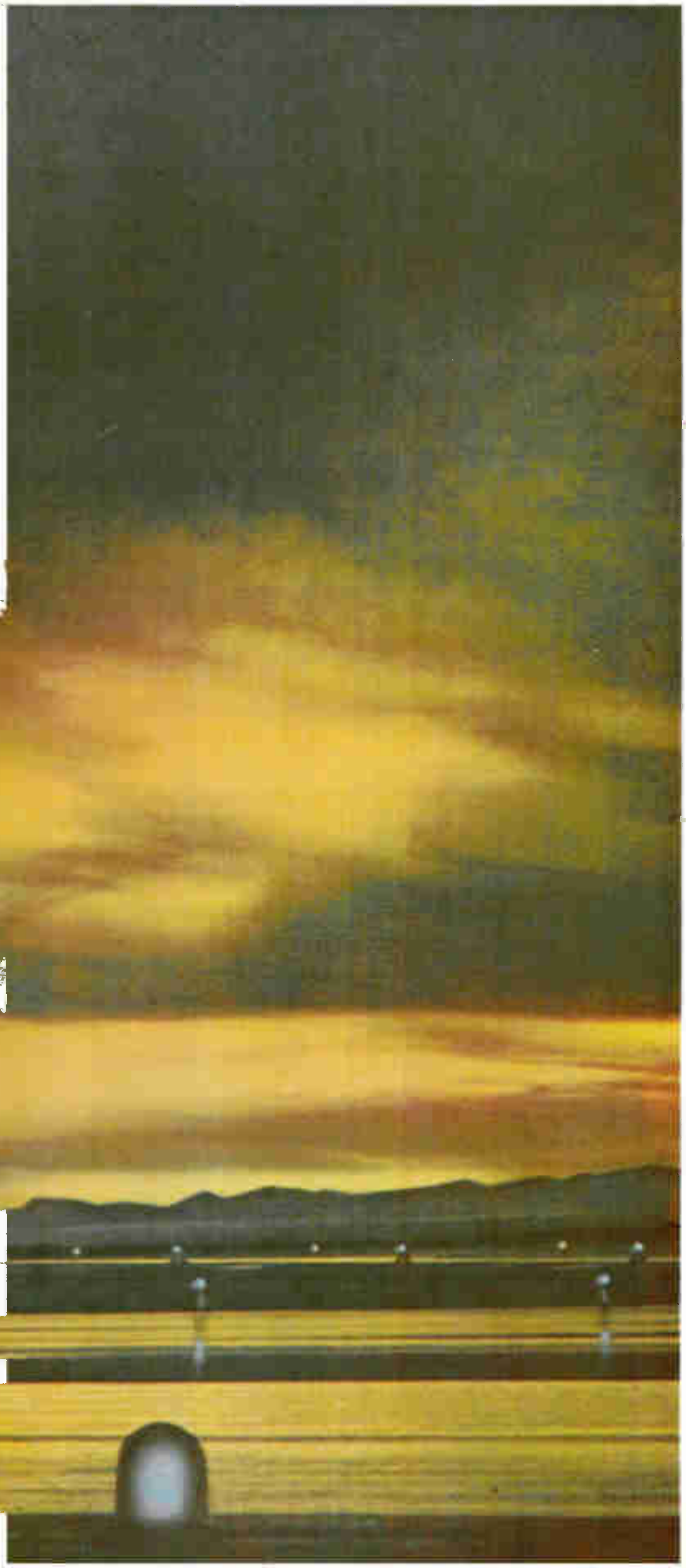

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The Switch to IC's:

The Costly Myth

Many manufacturers still believe that it is more expensive to use IC's than discrete components. The truth is that integrated circuits are much more economical to use, and will become increasingly so as time goes on. Manufacturers and design engineers who fail to recognize this fact are clinging to a myth which is costing them the very money they are trying to save.

THREE AREAS OF COST: There are three areas you should consider when you evaluate integrated circuits. First, the cost of the components — what it will cost you to buy the integrated circuit, compared with what you would pay for the discrete devices to make up an equivalent. Second, the manufacturing cost — how much it will cost to assemble your completed unit. Third, the design cost — the money you will spend on engineering the changeover. Let's look at each of these areas.

COMPONENTS COST: Many digital and linear integrated circuits for industrial applications are already lower in cost than the devices you need to build a circuit of equivalent performance and quality. More important, the price of integrated circuits is constantly going down, because new manufacturing techniques are being developed to increase the yields and lower unit costs. In discrete components most of the breakthroughs have occurred two or three years ago, and prices are likely to remain stable. If you expect your new product to remain on the market for a year or more, you can make the switch to integrated circuits with the assurance that you are paying no more now, and that you will save considerable amounts in the future.

MANUFACTURING COSTS: The real economies in integrated circuits are in manufacturing. Consider that by using IC's you reduce your components count by a factor of 10 or more. This means a reduction in the number and size of boards you have to use, resulting in savings in materials. It also means the overall equipment configuration will be considerably smaller. More material savings. And it means that you will have fewer boards to assemble, solder, clean, and inspect. Result: much lower labor costs. The savings in manpower are often so dramatic as to overshadow all other types of savings: labor reductions of up to 50% are often possible when you use integrated circuitry.

DESIGN COSTS: Finally, you have to consider the cost of engineering, prototype, design qualification, and changes in your production line. On the surface you could save all of these costs by sticking with discrete components. Don't you believe it. In the electromechanical/electronic equipment business you have to make product improvements anyway — or risk rapid obsolescence. Your engineers are working right now on some new design. They could be working on an integrated circuit design. And because of the modular, building-block nature of integrated circuits, design time is radically reduced. Moreover, you can get a lot of help in converting your designs. In return for the attached post card we'll send you information on integrated circuit design. We'll also pull information on your particular application from our files. And we'll work with you to develop the most economical and profitable method of making the switch. The important thing is to get started. Start now by returning the post card.

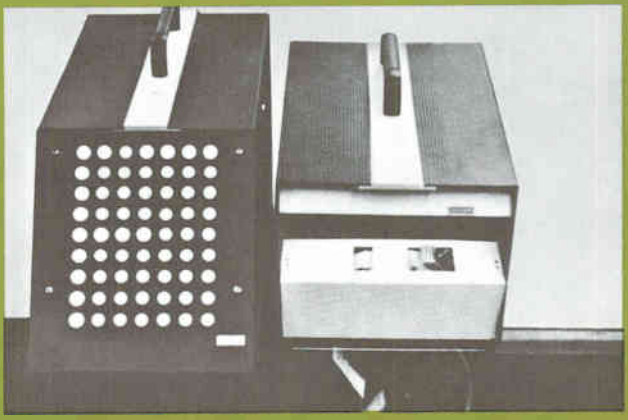
Integrated Tape Reader and Display

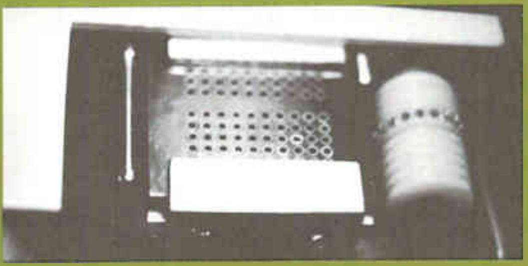
A tape reader is one of the most frequently used input devices for numerically controlled machine tools, small scale computers, and other data handling systems. We have built a tape reader and display unit at the Fairchild Applications Laboratories to demonstrate the use of integrated circuits in the control circuitry of such equipment.

DESCRIPTION: The unit is designed to read standard 1 inch, 8 channel paper tape. Ten 8-bit characters are read simultaneously and eight of the ten characters are displayed on the lamp matrix. The remaining two characters are command signals and are not displayed. A stepping motor is used to shift the tape one character position each turn. The tape moves through two loose-fitting guides which control horizontal and vertical movements.

The devices used in the read head are Fairchild FPM-100 photosensors, which combine a large photosensitive base with an optically flat window. This feature results in exceptional sensitivity without the need for critical alignment. The unit will read different colored tape with a single threshold setting by adjusting the data sensing circuit to the most sensitive tape to be used. The spectral response is from 0.4 to more than 1.1 microns and the unit can operate with daylight, tungsten, and gallium arsenide sources. 80 FPM100 devices are used for the read head, soldered into a 3/16" brass plate on 0.1-inch centers. The flat window design permits mounting flush with the wear-plate, for minimum dust accumulation, maximum tape life and minimum crosstalk.

DRIVER AND CONTROL CIRCUITS: Fairchild RTμL integrated circuits are used in the driver and control circuitry and in the data detection circuit. μL 9900 buffers are used to drive discrete transistors which in turn drive the motor windings under control of a μL 9923 J-K flip-flop operating in the toggle mode. A free-running clock comprised of half a μL 9927 gate and two RC circuits provide the timing signals. Data detection is accomplished by eight circuits on one PC board operating under control of a μL 9900 buffer. Voltage representing the data threshold from the photodevices is gated through a μL 9914 to a discrete lamp drive transistor.





Reading Head

Tape Reader and Display

CASE HISTORY: A numeric control system using Fairchild integrated circuits for control is now on the market. The unit, a multi-station drill press called Model 105, is manufactured by Machine Control Corporation of Venice, California. The machine accepts tape commands to operate up to four drill stations with two drills each. It is capable of drilling more than 50 hits (holes) per minute within .001" of one another and with a repeatability of .0003". The 105 is programmed by punching a tape while an operator manually performs the required operations on the initial run. Only seven MICROLOGIC® integrated circuit boards, and one additional PC board, are required for the controller of this unit, compared to 80 or 90 PC boards used in comparable conventional equipment.

The use of integrated circuits in this equipment has resulted, according to Machine Control Corporation, in labor cost savings of 80%, a 10 to 20% reduction in materials costs, and in an enviable reliability record of 4 million element hours without failure.

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$1.50*

2N 3773
Vceo = 140 volts
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$3.50*

SDT 1000 SERIES
Vceo = 400 volts
Ic max = 10 amp
$7.00*

Here are three new family additions to Solitron's line of High Voltage Silicon Power Transistors. New production techniques have reduced the cost of these popular devices . . . and their performance matches that of similar higher priced units now on the market. A few of the many uses of these devices, available in a TO-3 package, include TV Circuits, Audio Amplifiers, Converters, Inverters and Relay Drivers.

*Prices indicated are for quantities of 1,000 and up.

2N 3055	2N 3773	SDT 1000 SERIES
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VCE (sat) 1.1 Max @ 4A	VCE (sat) 1.4 Max @ 8A	VCE (sat) 0.8V Max @ 1.0A
VBE 1.8 max @ 4A	VBE 2.2 Max @ 8A	VBE (sat) 1.5V Max @ 1.0A
V(BR)CEX 100V Min	V(BR)CEX 160V Min	V(BR)CEX 400V Min
Power 115 watts @ 25°C	Power 150 watts @ 25°C	Power 100 watts @ 25°C

All of these devices have built-in protection against secondary breakdown and are associated with the high reliabililty standards associated with Solitron. **CONTACT US TODAY FOR COMPLETE PERFORMANCE DATA.**

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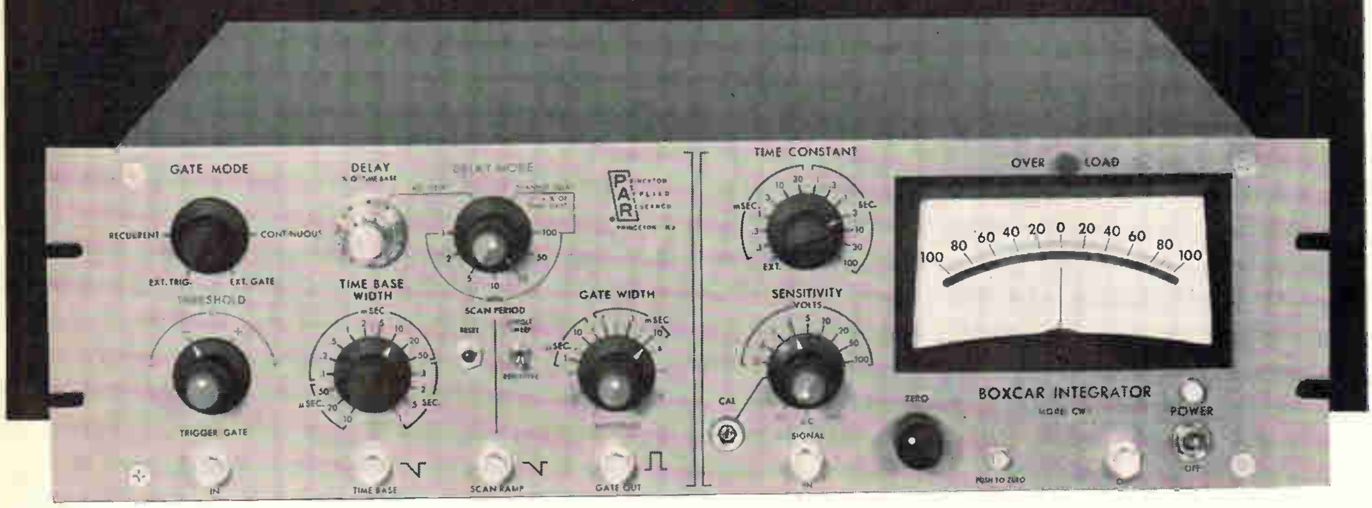
MODEL CW-1

BOXCAR INTEGRATOR



The Model CW-1 Boxcar Integrator is a gated signal averaging device useful for the recovery of either complete repetitive waveforms or incremental portions thereof from noise. The input to the Boxcar Integrator is sampled by a variable width, variable delay gate which can be fixed at any point on, or slowly scanned across, the repetitive waveform. The sampled portion of the input waveform is averaged by a variable time constant integrator, displayed on the panel meter, and made available for external recording or other use. Because the mean value of random noise is zero, the output of the integrator will asymptotically approach the average value of that portion of the input waveform being sampled at any moment, with a corresponding suppression of the accompanying noise. The Model CW-1 may be used in such widely varied applications as pulsed nuclear resonance, laser excitation decay, and biological evoked response experiments. In general, this instrument should be of value in any application where noise interferes with the recovery of repetitive waveforms.

SPECIFICATIONS

SIGNAL CHANNEL —

Input Sensitivity: ±.2 volt to ±100 volts in 1, 2, 5, sequence for ±10 volts output.

Dynamic Range: Will accept inputs 15 times full scale requirement without overloading.

Integration Time Constants: 100 microseconds to 100 seconds in 1, 3, 10 sequence.

Holding Time: At least 10^6 times integration time constant for 10% F.S. change in output, up to 10^5 sec.

Output: (a) ½% Panel Meter, ±10 volts.

(b) ±10 volts provided at front panel at an impedance of 1 K.

(c) Recorder Output — suitable for most galvanometric and servo recorders.

GATE TIMING CIRCUITS —

Operating Modes: (a) Ext. Trigger

(b) Ext. Gate

(c) Recurrent: Time Base triggered automatically and repetitively.

(d) Continuous: Gate on continuously.

Time Base Widths: 10 microseconds to 1 second in 1, 2, 5 sequence.

Gate Pulse Width: Continuously adjustable from 1 microsecond to .11 second.

Delay: (a) Manual adjustment from 0% to 100% of Time Base Width.

(b) Automatic scanning from 0% to that % of Time Base Width selected by setting the Manual Delay Dial.

Automatic Delay Scan Periods: 1, 2, 5, 10, 20, 50, and 100 minutes.

GENERAL —

Power Requirements: 105-125 volts or 210-250 volts; 50-60 Hz; approximately 15 watts.

Size: 19"W x 5"H x 14"D.

Price: $1,950.00. Export prices approximately 5 per cent higher (except Canada). Request Bulletin No. 127.

P A R **PRINCETON**
APPLIED RESEARCH CORP.
Dept. D
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September 19, 1966

Electronics Review

Volume 39
Number 19

Space electronics

Venus squeeze play

Prodded by Congress and the scientific community, the space agency has finally spelled out its plans for an ambitious program of unmanned Venus exploration. Critics in the House of Representatives had demanded a full report on the Venus plans, and top scientists meeting earlier in the year at Woods Hole, Mass., placed exploration of Venus right behind the moon and Mars in importance.

Responding to these pressures, the National Aeronautics and Space Administration this month outlined two long-range Venus programs. Venus is "an important, puzzling and paradoxical planet, meriting continued examination by space flight missions," the agency reported. This echoes the position of the National Academy of Sciences' Woods Hole conference, which urged that NASA support Venus exploration over the next 10 years on a level comparable with that proposed for Mars [see "Mars flyby drawing closer," pp. 197-199].

Looking for life. NASA told the House that Mars has been the focal point in interplanetary exploration because of the "tentative conclusion" by the scientific community that it is the most likely place to find extraterrestrial life. Hence, Mars is the main target for Voyager, the unmanned planetary exploration program in the 1970's. But the agency added that the probability of life on Venus is high enough to warrant exploration.

Of the two sets of Venus missions presented, one is based on current scientific priorities and "certain resource assumptions." This program plus Mars requires annual funding of $400 million by fiscal 1972, increasing to about $800 million by fiscal 1975 and remaining at that rate for the rest of the 1970's. Four missions would be planned to Venus through 1979 and six to Mars.

The Mariner '67 Venus flyby, an attempt with a Mariner left over from the 1964 Mars mission, would be followed in 1972 by a larger Mariner-class spacecraft carrying an atmospheric probe to obtain data on the atmosphere and surface hardness. A 1975 mission would complete the atmospheric profile of Venus prior to the initial Voyager mission to the planet in 1977.

Flexible plans. If early Venus missions indicate that more emphasis should be placed on exploring, NASA could switch to its second set of proposed Venus missions. The 1972 mission in the original program could be moved ahead to 1970. NASA says the more advanced Mariner-Mars '69 design could be adapted for a 1970 Venus shot if the money is available. The agency says it is now "considering such a possibility" since the 1967 Venus mission "may indicate the desirability of increasing NASA emphasis on Venus."

The agency also hinted that Voyager missions could go to Venus earlier than currently planned if the money is available. Under this second set of Venus plans, a mission would be scheduled for each launch opportunity—a total of six during the next 13 years.

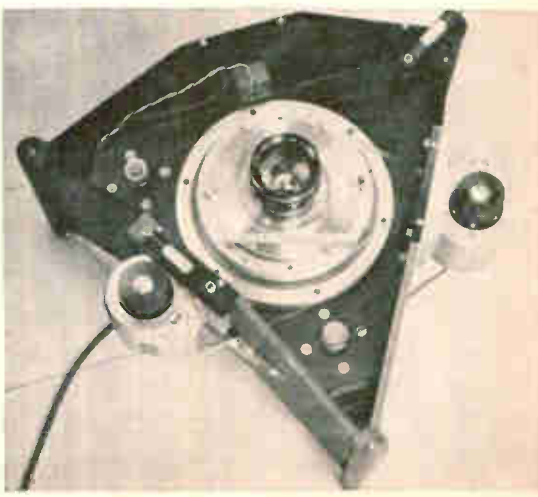
Ball bearing

An experimental navigation system has been developed to determine accurately a spacecraft's orbit around distant planets. Present star tracking techniques are accurate to about 0.1 mile in calculating earth orbits. But these techniques lack precision deep in space.

The new system will be tested aboard the third Applications Technology Satellite (ATS-C), due to be launched into a synchronous equatorial orbit early in 1968.

Instead of two star trackers that lock onto individual stars, such as Canopus, the new system developed by the Control Data Corp. for the National Aeronautics and Space Administration, uses a simple spring gun that shoots a three-inch ball at low velocity ahead of the spacecraft. The ball can be of any light-reflecting material but it must be dense enough to be unaffected by the pressure of solar radiation. (Balloons would be too light.)

A sensor on the spacecraft watches the ball's trajectory against the pattern of fixed stars, monitoring the angle of the ball's path. The spacecraft's orbit is then determined from calculations based on the gravitational constant of the moon or planet being orbited. All of these constants have been established by astronomers.



Star scanner to observe the pattern of fixed stars for spacecraft orientation is mounted on a test platform at Control Data Corporation. Lens in center of the device focuses starlight through a slit onto a photomultiplier.

Scanner. The key to the system is the optical scanner, which is now being tested at CDC. The scanner, to be mounted on a spin-stabilized spacecraft, has a lens with a two-inch aperture and a two-inch focal length. Light enters through a single slit and passes onto a photomultiplier and detector. As the image of each star crosses the slit, the detector generates a pulse that is transmitted to the computer. The timing of these pulses represents a pattern of stars that is processed by a computer to determine position and orientation of the scanner and the spacecraft.

The scanner is currently mounted on a wobbly platform that simulates the motion of a spin-stabilized spacecraft. Sitting in an open lot near Control Data's Minneapolis headquarters, the scanner watches the stars go by and transmits their position to a computer in the company's building. A pattern recognition program in the computer calculates the position of the scanner with an accuracy of one-half to two minutes of arc.

This is the first time that a scanner using pattern recognition techniques has determined position from real stars. An earlier scanner built by CDC for a nonspinning satellite did its own spinning and was tested only against a simulated star field of white spots on a black screen [Electronics, March 21, p. 115 and April 4, p. 94].

Lookout. The scanner and the spring gun will be aboard ATS-C, but the computer will be on the ground. NASA's Goddard Space Flight Center, Greenbelt, Md., which is in charge of the ATS project, has tentative plans to incorporate the scanner in other experimental satellites.

ATS-C will eject the ball and watch while it recedes several miles. The satellite will then wait one orbit to look for it again. During that time—28 to 30 hours at the satellite's 22,300-mile altitude—the ball should go out 50 or 60 miles from the satellite, then return to within 15 miles, where the scanner will see it. The difference in trajectory between the two sightings will allow the satellite's orbit to be determined within an accuracy of about 10 miles. Accuracies up to 0.1 mile are forecast.

The spring-gun technique will not attain top accuracy aboard the ATS-C, however, because the craft's fast spin and the pointing requirements for other experiments aboard will limit the choice of direction of launching the ball and scanning it. ATS-C will telemeter the star scanner output to a computer on the ground rather than use an onboard special-purpose computer to make the calculations. Control Data is working on the design of such a computer for later missions.

Orbiting yardstick

An extension to the successful geodetic satellite program is under study at the National Aeronautics and Space Administration. With two geodetic satellites up and operating—and a third due for launch toward the end of next year—NASA is trying to determine just what other geodetic information is needed and the best methods of getting it.

Parallel studies are under way at two software contractors experienced in satellite computer programing: Wolf Research & Development Co., Bladensburg, Md., and D. Brown Associates, Inc., Eau Gallie, Fla. The contracts total just under $100,000 and call for five-month studies by each company.

Jerome D. Rosenberg, manager of the program at NASA headquarters in Washington, calls the current geodetic satellites the best tracked unmanned spacecraft in history and claims that they have enabled geographers to measure the distance between points on earth to an accuracy of 10 meters. To be answered in the current round of studies is whether satellites could measure changing features such as shorelines and tidal motions.

Another possible chore is calibrating the NASA and Defense Department tracking stations around the globe. The two agencies have $150 million worth of C-band stations and they have never been calibrated so that all their electronic equipment is compatible. The Air Force had planned what it called a Calsat (Calibration Satellite), but the program never got beyond the wishful thinking stage. In a sort of trial run, NASA plans to place a C-band transponder on the next geodetic satellite, Geos B.

On the money. To emphasize the operational nature of the geodetic program, NASA moved it from the Physics and Astronomy division to the recently formed Space Applications Programs division, which also includes communications, weather, navigation and earth-resources measurement satellite programs. NASA hopes these unromantic satellites, with their potential down-to-earth payoff, will pry more dollars for space out of the Administration and Congress.

The two satellites in orbit are an active and a passive craft. Explorer 29, the active satellite called Geos A before it went into orbit last Nov. 6, carries four flashing lights to make tracking easier, four reflectors to return laser beams, doppler beacon transmitters, a range and range rate transponder and a Secor (sequential collation of range) transponder.

The passive satellite, called Pageos (Passive Geos), is a 100-foot-diameter balloon that looks like the Echo passive communications satellites. It was launched June 23 and serves as a target for tracking radars.

Except for addition of a C-band transponder, Geos B is a copy of Explorer 29. To reflect the shift to a new program office, the satellite will not get a number in the Explorer series if successfully orbited but will be called Geos 2.

To date the program has cost about $21 million, according to Rosenberg's breakdown: $7 million for the two Thor-Delta vehicles which launched the active satellites, $6.5 million for the Thor-Agena which launched Pageos, $2.5 million for the balloon and its backup and $5 million for Geos A and B and a prototype. The active spacecraft were produced by the Applied Physics Laboratory of Johns Hopkins University. Pageos was built by the G.T. Schjeldahl

Co., Northfield, Minn.

The exact configuration of the future geodetic satellites won't be known until the data requirements are established. If the decision is to proceed, NASA plans to put out a spacecraft definition contract next spring. And if there is a new geodetic satellite, Rosenberg plans to limit it to a launch vehicle no bigger than the Delta. However, there is a possibility that geodetic experiments will be carried piggyback on either the Applications Technology Satellite now being prepared by Goddard Space Flight Center, Greenbelt, Md., or the Saturn/Apollo Applications Program under study at Marshall Space Flight Center, Huntsville, Ala.

Electronic switch

A top space official with experience in running the multibillion dollar manned flight program will take over the agency's principal facility for advanced electronics research next month. James C. Elms, number two man in the National Aeronautics and Space Administration's Office of Manned Space Flight, will become director of the Electronics Research Center, Cambridge, Mass. He succeeds the center's first director, Winston E. Kock, who is returning to the Bendix Corporation in Detroit.

The controversial center was established despite congressional protests to do basic electronics research in preparation for future space missions. It is almost the only NASA center without some kind of satellite project. However, Kock said that the center might eventually have its own flight projects; the naming of Elms as director provides the experience for such activities.

Experience. Bypassed in the shuffle was Albert J. Kelley, former director of electronics and control at NASA headquarters in Washington. He once headed the task force responsible for planning the center and was considered the leading candidate for the directorship. But when the center began operation on Sept. 1, 1964, he got the second spot. The speculation was that his experience was confined to government, while Kock and Elms had industry background.

Kock's departure comes just weeks before the scheduled groundbreaking for the center's first permanent buildings. He is due to report to Bendix on Oct. 1 as chief scientist, vice president and a member of the firm's administration committee. In his previous time at Bendix he was vp for research, a lower caliber post.

Attractive. For Elms, the new job will be his third at NASA. He was second in command at the agency's Manned Spacecraft Center in Houston for a year before going to the Raytheon Company in 1964 as head of the firm's Space and Information Systems division, Sudbury, Mass. That job is currently held by NASA's first manned space flight chief, D. Brainerd Holmes.

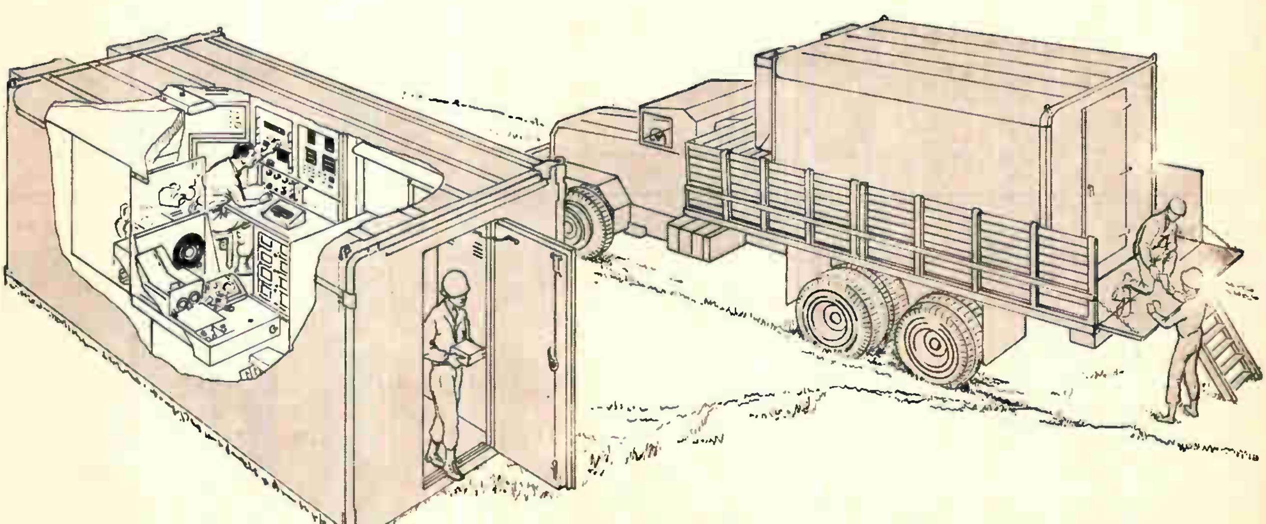
At Bendix, Kock will do well if he can attract as many top professionals as he did at ERC. In his two years there, he built up the staff from the initial task force of 70 to a group of 550, including 76 scientists with doctorates. Kock also will fill some of the gap caused when R.D. O'Neal left his job as Bendix vice president and group executive for the firm's aerospace systems to become assistant secretary of the Army for research and development.

Military electronics

Missile follower

When the Army puts three of its new tactical missiles into the battlefield, two vans of test and repair equipment will be right behind the front lines. The missiles—the Shillelagh, Lance and TOW (tube-launched, optically tracked, wire-guided)—will be supported by a movable laboratory known as the Land Combat Support System under development for the Army Missile Command at Redstone Arsenal, Huntsville, Ala.

The lab's two mobile shelters



Electronic test van (foreground) and repair shelter will support Army missiles in the field.

weigh about 7,000 pounds each and contain equipment to test, calibrate and repair electro-optical missile components. One shelter carries the test gear and the other is for repair and storage. The Radio Corp. of America's Aerospace Systems division, Burlington, Mass., has built and is testing three prototypes of each. The firm is negotiating with Redstone to produce 10 operational systems to begin the program. In production quantities the estimated cost of each is $500,000.

First clean booth. Among the novel features of the support system are an area free of contamination called a clean booth and a precision optical bench, each believed to be the first equipment of its kind designed for field use. The system is a more compact version of the automatic checkout and test equipment in maintenance depots [Electronics, Aug. 23, 1965, p. 88]. It is one of the first field systems to use integrated circuits.

Off-the-shelf integrated circuits from the Fairchild 900 series are used in the check-out and test logic, which is fundamentally the same as in larger systems using discrete-component modules. RCA project manager John F. Currier estimates that the 2,468 integrated circuit chips reduce the volume of rack-mounted equipment by 50%. They will also cut costs in production, he says.

The optical test bench, enclosed in a plastic clean booth, provides a rigid platform for alignment of optical components. Filtered air is forced out of the enclosure to prevent contamination. Access is through curtain slits.

To test infrared transmitters and trackers, the maintenance technician uses a plug-in source adapter and a detector adapter controlled by a taped program. The source adapter includes a vidicon tube that converts infrared radiation from a transmitter under test into electrical signals carrying beam pattern and boresight information. A calibrated detector measures intensity. A digital display provides readout to an operator and a paper tape gives sequencing instructions and keeps a permanent record.

For Vietnam. All three missiles for which the system was built will probably go to Vietnam. Though they were designed primarily as antitank weapons—and tanks have not been used against United States forces—the Army believes the missiles will be effective against any hard target, such as a pillbox.

The Shillelagh, an infrared-guided antitank weapon, is being produced in substantial quantities by the Philco Corp.'s Aeronutronic division and the Martin Co. Lance is built by Ling-Temco-Vought Inc.'s Michigan division using a simple inertial guidance system. TOW, produced by Hughes Aircraft Co., can be fired from the ground or a helicopter; it will be delivered and tested in the first half of 1967.

Consumer electronics

Double play

A multiplexing technique has been developed that allows two separate black-and-white television programs to be transmitted simultaneously over any single channel. Although Federal Communications Commission approval is necessary before the technique can be put into operation, its developer sees a wide variety of potential applications.

High on the list is the transmission of moneymaking programs, such as industrial training classes, by educational tv stations, which are barred from accepting advertising. Other possibilities include data retrieval from a central location by far-flung businesses and transmission of college courses over commercial tv to remote locations. The added programs would be visible only on sets fitted with special adapters and would not interfere with commercial programing.

Developed by Harold Walker, vice president of DuoVision, Inc., New York, the system employs techniques similar to those that permit black-and-white reception of broadcasts transmitted in color [Electronics, March 22, 1965, p. 97]. The signals from both programs occupy the same bandwidth. The second program modulates a subcarrier transmitted as a single-sideband suppressed carrier signal.

The DuoVision system uses a video subcarrier frequency of 4.24 megahertz rather than color tv's 3.58 Mhz. Although the bandwidth is slightly narrower than the 4.5 Mhz specified for black-and-white pictures, Walker claims the added signal's resolution will be as good as that of the regular signal.

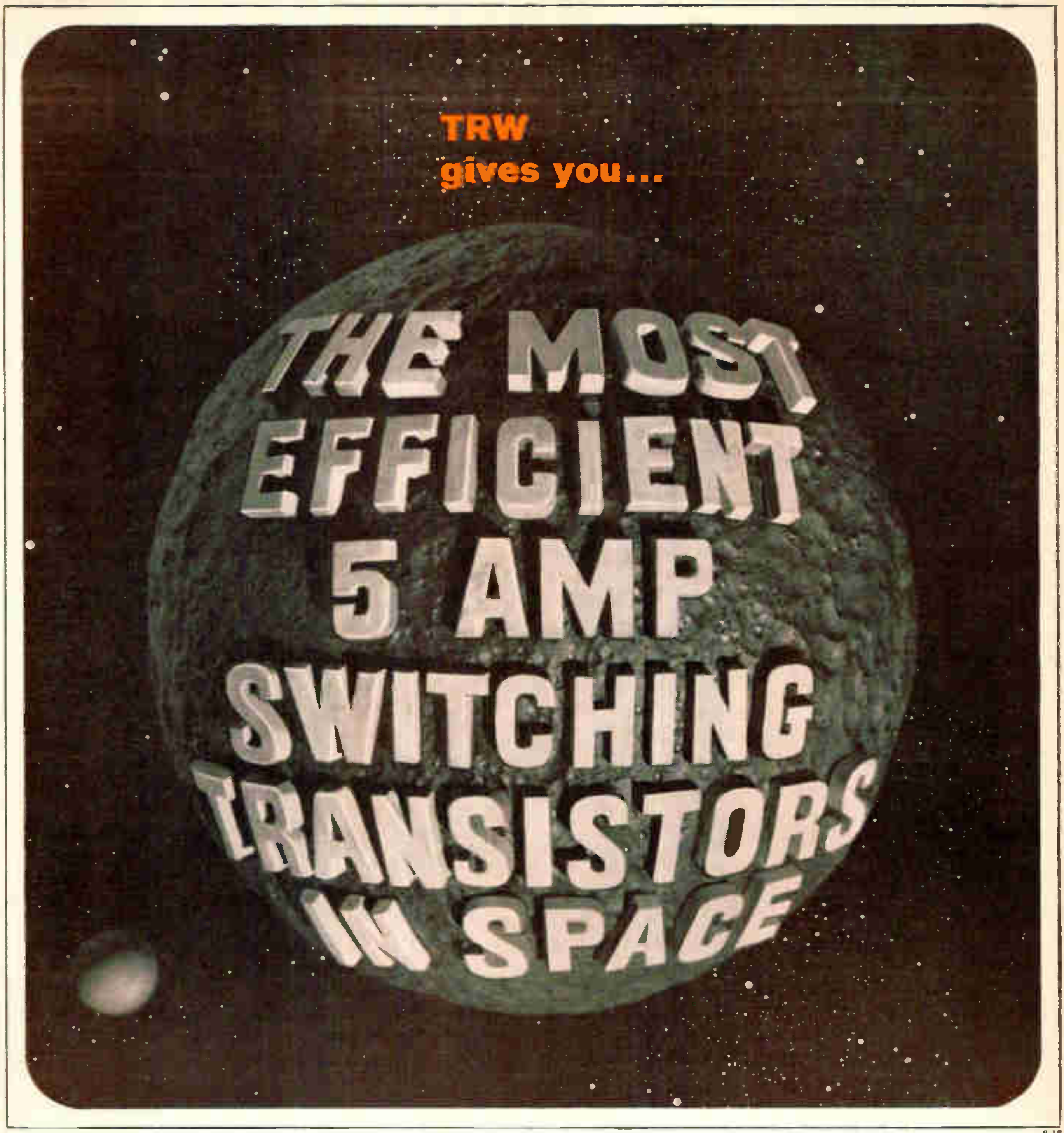
Eye averaging. DuoVision's system depends on the eye's persistence of vision or its ability to average the light intensity of a few consecutive tv frames. The light intensity changes because the phase of the added signal's subcarrier naturally reverses in every other frame—bright points on the screen in one frame become dark in the next. Consequently, the eye tends to see only the regular program because the added signal averages out to gray.

However, this phase reversal is not sufficient by itself. DuoVision's circuits perform two additional tasks to prevent the two signals from interfering with each other. First, alternate scanned lines are phase reversed. Second, the highest level harmonics in the added signal are attenuated 20 decibels to limit the amplitudes of the multiplexed signal; hence, the picture tube operates with a more linear relationship between the applied voltage and the light output, resulting in better visual cancellation.

Attenuation also insures that the added signal remains at a lower amplitude than the regular signal —even if the home viewer's set is mistuned.

Sound system. Sound for the added signal modulates onto a 31.5-khz subcarrier that is transmitted as a single-sideband suppressed signal. The signal is multiplexed on to the audio carrier using techniques of frequency-modulated stereo broadcasting.

The adapter measures about 12 by 8 by 3 inches and connects to a standard tv set's antenna terminals without rewiring. It removes



SPEED: 80MHz **GAIN: $50h_{FE}$ @ 1A** **SATURATION: 1V @ 5A**

Every characteristic the designer needs for top performance airborne inverters and switching regulators are combined in the new TRW 2N4305—2N4312 power transistors...high frequency...high gain...low collector saturation voltage.

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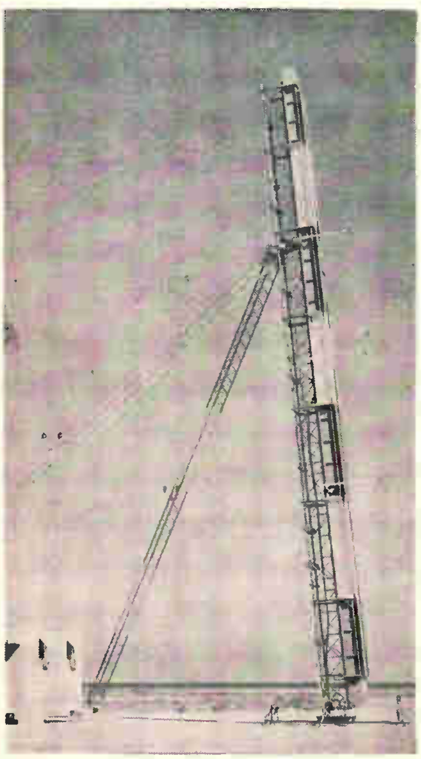
the signal from the subcarrier and puts the scanned lines into normal phase. At the same time, it phase reverses the regular signal so that the eye cancels it. Then the adapter remodulates the multiplexed signal onto a tv carrier frequency not in use in the particular reception area. Finally, the signal is fed into the set's antenna terminals.

The adapter would cost "under $150." The studio encoder, about the size of a small suitcase, should cost less than $10,000.

Although the system has been successfully tested over closed-circuit tv, tests over the air are needed to determine whether it can work without major changes in transmitting equipment approved by the Federal Communications Commission. Other unknowns are the maximum distance at which the added signal can be received and the effects of reflected signals on the added program's picture quality.

New York's educational tv station WNDT has requested permission from the FCC to test the system during the hours when the station doesn't usually broadcast. If approved, WNDT hopes to begin testing this fall.



Airport's antenna tilts . . .

Avionics

Landing on the beam

When a plane heads toward a touchdown at an airport it's usually guided by the airport's glideslope signal, generated by dipole antennas that use the half-mile or so of ground or water in front of the antennas to reflect the signals. If the ground in front of the antenna is uneven, the reflected signals are out of phase and erratic, producing an incorrect glideslope. Now a wide-aperture microwave antenna that eliminates these vagaries has been developed by Airborne Instrument Laboratory, a division of Cutler-Hammer, Inc.

Instead of using the ground to reflect the glideslope signal, the new antenna beams its signals directly at the aircraft. This means glidepath signals are consistent and the ground in front of the antenna needn't be excavated or filled—an expensive and time-consuming construction project in some areas.

Two beams. The antenna looks as if it had been installed incorrectly: it's not mounted perpendicularly to the ground but at an angle between 2½° and 3° from the perpendicular. This aims the two radiated lobes from the antenna at the necessary glideslope angle. The two lobes are fed from both the top and the bottom of the antenna and are shaped by carefully positioned slots cut in the face of the antenna wall.

The simultaneous radiation of the two beams produces a null reference-beam pattern by which a pilot steers his plane. A 330-megahertz signal in the top beam is modulated by a 90-hertz tone that indicates to the pilot that his plane is above the glideslope; the bottom beam is modulated by a 150-hz code to indicate that the plane is below the path.

Try it out. The antenna is about to be tested at New York's LaGuardia Airport, where the area in front of the approach is tidewater and changes in water level affect the glideslope as much as 0.5°. The Federal Aviation Agency has authorized LaGuardia to install one antenna at runway 422, which fronts on an inlet of Long Island Sound. At the same time, the FAA will evaluate a similar antenna at its test facilities at Atlantic City, N.J.

In addition, the Air Force will soon receive a test antenna—for use at both strategic and tactical airports. So far nine military airports are being considered for new antennas.

And in Nice, French Government aviation officials are also testing such an antenna.

Antennas

Stanford's 5 & 10

Making five antennas do the work of 10 is a new approach to radio astronomy that promises to be the simplest way yet to measure distant radio sources with very high resolution. Radio astronomers already have learned that a row of ten 60-foot-diameter dishes can do the job of one huge—and expensive—675-foot parabolic antenna.

Now Ronald N. Bracewell, pro-

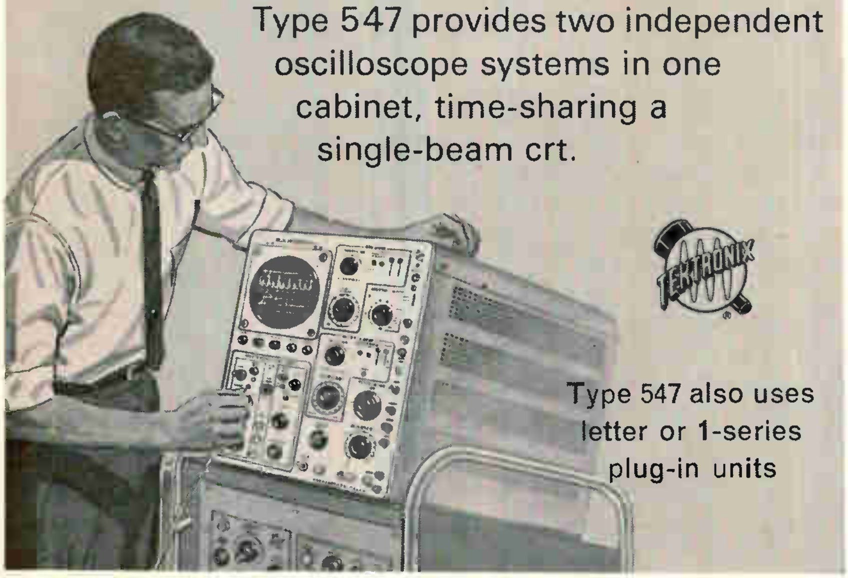
. . . and shaped slots point beam

Tektronix oscilloscope displays both time-bases separately or alternately

TYPE 547 and 1A1 UNIT

DUAL TRACE	**DC-to-50 MHz** **50 MV/CM** DC-TO-28 MHz, 5 MV/CM
SINGLE TRACE	**2 Hz-to-15 MHz** **500 μV/CM** (CHANNELS 1 AND 2 CASCADED)

With automatic display switching, the Type 547 provides two independent oscilloscope systems in one cabinet, time-sharing a single-beam crt.



Some Type 547/1A1 Unit Features

CRT (with internal graticule and controllable illumination) provides bright "no-parallax" displays of small spot size and uniform focus over the full 6-cm by 10-cm viewing area.

Calibrated Sweep Delay extends continuously from 0.1 microsecond to 50 seconds.

2 Independent Sweep Systems provide 24 calibrated time-base rates from 5 sec/cm to 0.1 μsec/cm. Three magnified positions of 2X, 5X, and 10X, are common to both sweeps—with the 10X magnifier increasing the maximum calibrated sweep rates to 10 nsec/cm.

Single Sweep Operation enables one-shot displays for photography of *either* normal or delayed sweeps, including alternate presentations.

2 Independent Triggering Systems simplify set-up procedures, provide stable displays over the full passband and to beyond 50 MHz, and include brightline automatic modes for convenience.

Type 547 Oscilloscope (without plug-in unit)	$1875
Type 1A1 Dual-Trace Unit	$ 600
Rack-Mount Model Type RM547	$1975

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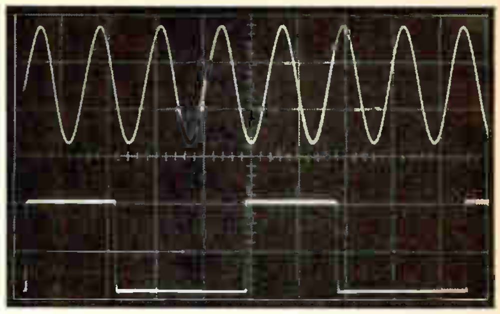


Single-exposure photograph.

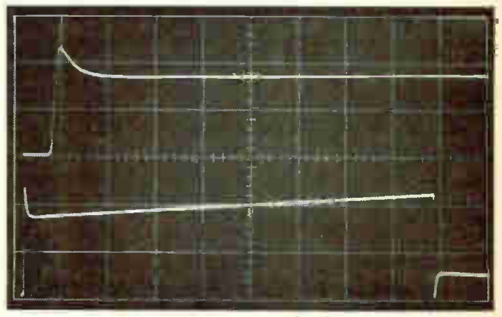
2 signals – different sweeps

Upper trace is Channel 1/A sweep, 1 μsec/cm.
Lower trace is Channel 2/B sweep, 10 μsec/cm.

Using same or different sweep rates (and sensitivities) to alternately display different signals provides equivalent dual-scope operation, in many instances.

Triggering internally (normal) permits viewing stable displays of waveforms unrelated in frequency.

Triggering internally (plug-in, Channel 1) permits viewing frequency or phase differences with respect to Channel 1.

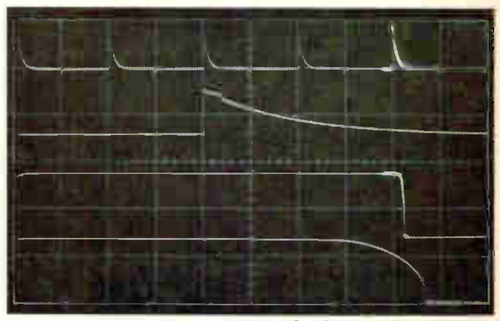


Single-exposure photograph.

same signal – different sweeps

Upper trace is Channel 1/A sweep, 0.1 μsec/cm.
Lower trace is Channel 1/B sweep, 1 μsec/cm.

Using different sweep rates to alternately display the same signal permits close analysis of waveform aberrations in different time domains.



Single-exposure photograph.

2 signals – portions of each magnified

Trace 1 is Channel 2/B sweep, 10 μsec/cm.
Trace 2 (brightened portion of Trace 1) is Channel 2/A sweep, 0.5 μsec/cm.
Trace 3 is Channel 1/B sweep, 10 μsec/cm.
Trace 4 (brightened portion of Trace 3) is Channel 1/A sweep, 0.5 μsec/cm.

Using sweep delay technique—plus automatic alternate switching of the time bases—permits displaying both signals with a selected brightened portion and the brightened portions expanded to a full 10 centimeters.

B sweep triggering internally from Channel 1 (plug-in) assures a stable time-related display without using external trigger probe.

For complete information, contact your nearby Tektronix field engineer or write:
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fessor of electrical engineering at Stanford University, has devised a way to get the same results by spacing five of the smaller antennas at strategic points and using a computer to integrate the information they gather.

Bracewell and a small band of helpers built the first of the five antennas and unveiled it last month near the university's campus at Palo Alto, Calif. They plan an array of dishes in a row 75, 150, 450 and 675 feet from this original antenna. With this arrangement, five antennas can measure all possible 75-foot increments up to 675 feet just as 10 antennas would do.

Celestial picture. The purpose of the array is to produce an energy distribution profile of a celestial radio-frequency source. Since a known r-f source can be broken down into a series of sinusoidal Fourier components, Bracewell plans to construct a profile of an unknown source by treating the output of each pair of antennas as one Fourier component. By adding them he gets the desired profile.

The spacing of the antennas determines the output signal that each pair will produce in terms of a parameter that Bracewell calls the "spatial frequency." The inverse of this parameter is a wavelength that can be expressed in minutes of arc. The nine useful pairings of the Stanford array will respond to wavelengths that range from 4.22 minutes to 23.1 seconds of an arc.

Each pair of antennas feeds a receiver that multiplies and integrates the two inputs. The result is sampled four times per second and converted to digital form by a voltage-to-frequency converter and counter. The information is put sequentially onto a tape.

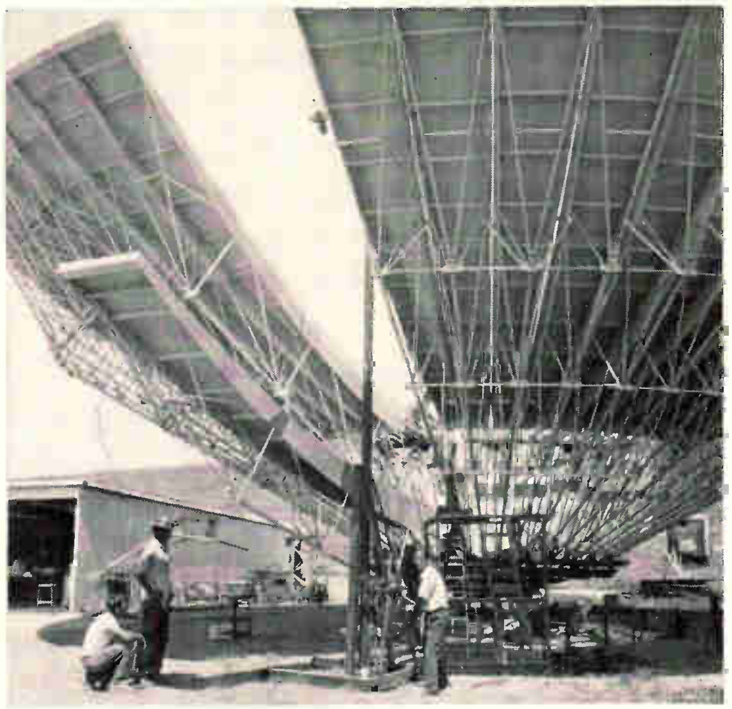
An International Business Machines Corp.'s 360/67 computer separates the information into nine channels, each of which is considered a Fourier component. The components are than added with appropriate weighting to take into account amplitude and phase shifts. The result is a profile of the energy distribution of the source.

Sharp image. When the array is completed it will have a resolution of 16 seconds of arc at X band for a source on the meridian. The array will measure 675 feet with a wavelength of 2.8 centimeters. The diameter will be equivalent to some 7,300 wavelengths, thus giving the very high resolution. The resolution is at least an order of magnitude better than the performance of present large paraboloids, some of which cost up to $5 million.

The 140-foot dish at Green Bank, W. Va., has a two-minute beamwidth. The giant 1,000-foot dish at Arecibo, Puerto Rico, operates at L band, with a wavelength of 75 centimeters and has a 10-minute beamwidth.

It will be a year or two before the Stanford array is completed, depending on how fast the money comes from the Air Force contract under which Bracewell has been working. He has been operating under a contract that gives him $250,000 a year for research in radio astronomy.

The Stanford array is expected to be particularly useful in studying quasars, those distant sources of high power radio energy. The nearest quasars appear as only about a degree of arc in width while distant quasars project a fuzzy image of two minutes of arc.



Stanford antenna is first of five in planned experimental array.

Components

A little lithium

The addition of lithium to silicon solar cells to make them more resistant to radiation is under study for the National Aeronautics and Space Administration by four electronics firms. If the method works as hoped, it could extend the life of satellites traveling through the Van Allen radiation belts or orbiting near the sun.

The concept was developed under NASA contract by the David Sarnoff Research Center of the Radio Corp. of America, Princeton, N.J. Three other companies have been asked whether they can duplicate RCA's results: the Heliotek Corp., Sylmar, Calif.; Hoffman Electronics Corp., El Monte, Calif.; and Texas Instruments Incorporated of Dallas. NASA has spent about $300,000 with the companies, more than half of it going to RCA.

The work is being done for NASA's Goddard Space Flight Center, Greenbelt, Md., which led the switch from p-on-n to n-on-p solar cells two years ago. That switch, which placed the negative layer above a cell's positive layer,

Circle 51 on reader service card→

improved radiation resistance 10 times and now all satellites carry n-on-p cells. RCA says lithium provides a 50-fold further improvement, and NASA agrees—up to a point.

Questions remain. Still unanswered, according to William Cherry, head of the space power technology branch at Goddard, is whether the lithium-doped cells will show the same radiation resistance in the vacuum of space that they do in experiments on earth. He also wants more data on whether lithium atoms will pile up at the junction between the p and n layers and whether they will damage the electrical contacts. So the center is having the companies build more lithium-doped cells. Some of them will be tortured in Goddard's radiation lab and others will be carried into space in December on the first Applications Technology Satellite.

Cherry foresees two years of such experiments before he is confident enough to recommend the lithium-doped cells. But he notes that it took three years, seven months and 20 days before the n-on-p cells were accepted. NASA first flew these cells on the Relay 2 communications satellite launched Jan. 21, 1964.

Lithium improves the radiation resistance because atoms of the element move freely in the cell and actually "heal" a rupture caused by the bombarding protons and electrons of radiation. Other elements do the same thing, but lithium was chosen because it is the most mobile, it is electrically neutral and it can easily be introduced into the solar cell material.

A limiting factor is that lithium will do its job only at room temperature, or at about 20°C. At —40°C the lithium atoms don't move at all and near 100°C they damage the cell by moving so fast they break up the structure. The problem is not as serious as it appears, Cherry points out, since the thermal control system of a spacecraft keeps the solar cells at room temperature even in the extreme cold of space.

Back to p-on-n. A side effect of the use of lithium, if it is accepted, will be a return to the p-on-n solar cells. In silicon solar cells, boron is used for the p layer and phosphorous for the n. Lithium can only work with phosphorous. Since the bottom layer provides 75% of the electrical current and logically is the one to protect from radiation, the p, or boron-diffused, layer will have to go on top. Lithium-doped cells will be a dull black instead of the bright blue of current solar cells.

RCA began work under the NASA contract in January, 1964, and used very conventional solar cells 1 by 2 centimeters with an efficiency of 10%. Both lithium-doped and undoped cells were subjected to the same amounts of radiation. The doped cells recovered after each radiation dose, reaching nearly the power output they exhibited beforehand. The undoped cells degraded along an almost linear curve.

Industrial electronics

Transit tie-up

The San Francisco Bay Area Rapid Transit District (BARTD) has decided to simplify requirements for its automatic train control and communications system. The decision means that bids will not be opened before January instead of the original target date, Dec. 6.

The main change is a relaxation of stopping accuracy from 1 foot to 15 feet. BARTD will also relax some of its demands for guarantees and reliability testing, which one potential supplier says would have upped the cost by several million of dollars more.

With the changes, says engineer Benne Aboudara, BARTD has been assured that its target figure of $25 million to $30 million is realistic. Some manufacturers had been talking of bids in the area of $45 million if the specs were as tight as those originally outlined [Electronics, Aug. 8, 1966, p. 195].

More time. The extra time will give the Philco Corp.'s Western Development Laboratories a chance to revise its train control plans. Philco, a subsidiary of the Ford Motor Co., had tested a system using aluminum pickets that interrupted a microwave signal, but BARTD shot it down on grounds that it did not provide continuous monitoring of the train.

Philco considers the difficulty a matter of defining the word "continuous." The BARTD action "put a transient in our planning," according to R.W. Porter, manager of ground instrumentation subsystems. The company is considering two other methods. One takes a track transmission approach similar to that of the Western Electric Co.; the company declines to discuss the other until BARTD decides whether to use a-c or d-c in the propulsion system.

Communications

Home tv from space

Although satellites won't beam television directly to home receivers for several years, the technology has reached a point where community and educational receiving terminals appear to be economically feasible.

This conclusion can be drawn from a study just completed for the National Aeronautics and Space Administration by Atlantic Research Corp.'s Jansky & Bailey Systems Engineering department, Alexandria, Va. The report investigated factors that would affect the cost and quality of reception of television transmitted via stationary satellites through 1970. The satellites themselves were not studied.

Satellites now lack the effective radiated power needed to get television home receiver modification costs down to a price the owner would pay. In the lower satellite power ranges, however, ground terminals can be modified at costs within the reach of community antenna television and educational television operators.

Low cost. Jansky & Bailey calculated that home receiver modification costs on a mass production basis (1 million units) could be as little as $15 per set if satellite power could be increased to 90 decibels above one watt (dbw). But this signal strength is far above what can be achieved now or in the immediate future. By contrast, the Communications Satellite Corp.'s operating Early Bird communication satellite has an effective radiated power of 10 dbw.

At the more realistic satellite output of 40 dbw, receiver modification costs would run about $180—too much for the average home receiver owner but within the range of the institutional user.

Jansky & Bailey studied signal power between 30 dbw and 90 dbw and projected cost and quality of all the trade-offs among frequency. background noise and effective radiated power. After studying a frequency range from 200 megahertz to 12,000 Mhz, the investigators decided the best frequencies from a cost standpoint are from 800 to 1,000 Mhz.

The study revealed that equipment costs generally increased sharply below 600 Mhz because atmospheric, man-made and cosmic noise levels are high in this range, necessitating a larger antenna. Above 1 Ghz, receiving equipment becomes very expensive because of the complex components needed for those frequencies. In the preferred range present ultrahigh frequency tuner techniques are applicable.

High level. For the study, the investigators used a 40 db signal-to-noise ratio at the receiver output since this is considered to provide a high quality tv picture with the standard 4-Mhz bandwidth used for television transmission in the United States.

A.M. Greg Andrus, NASA's communications director, says that the $50,000 report was ordered because of confusion about the problems in direct satellite broadcasting—particularly signal-to-noise problems in urban areas. Andrus said the next step is to examine the spaceborne link of such a system. He said that the space agency plans to seek industry proposals for this study in about two months.

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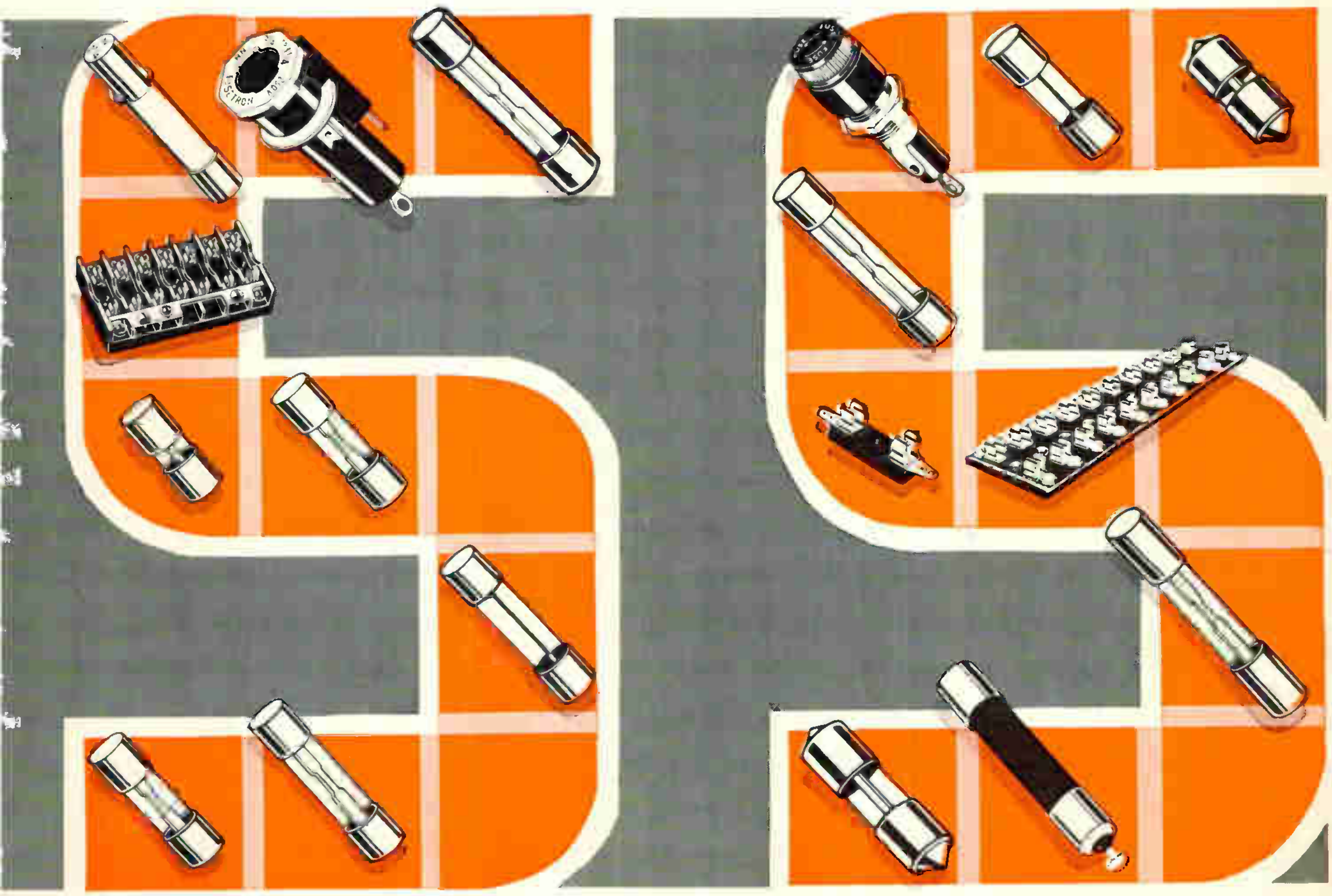

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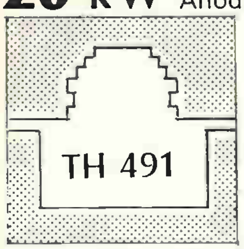
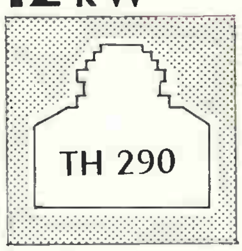
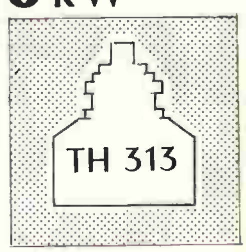


12 kW



New

6 kW



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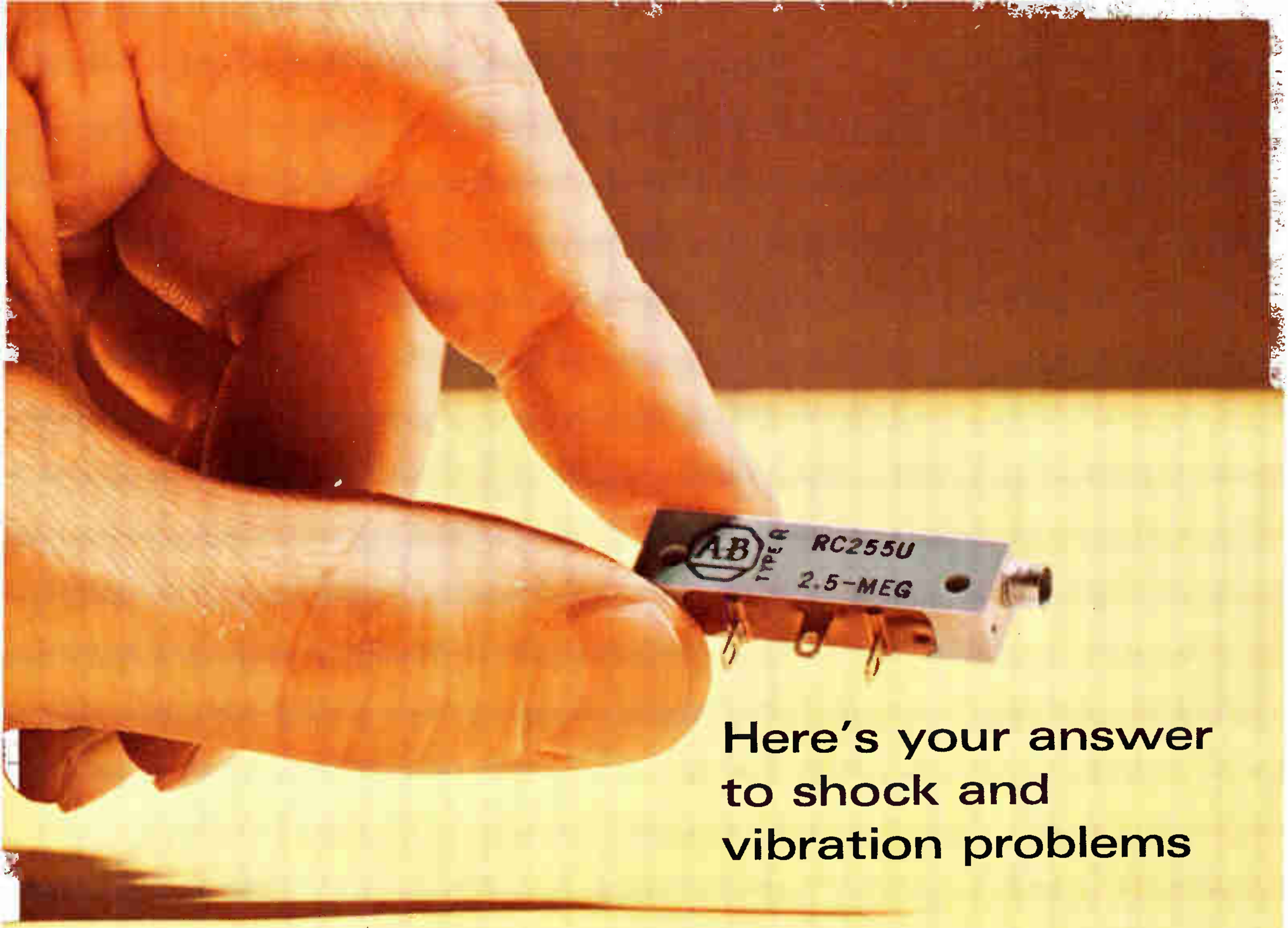

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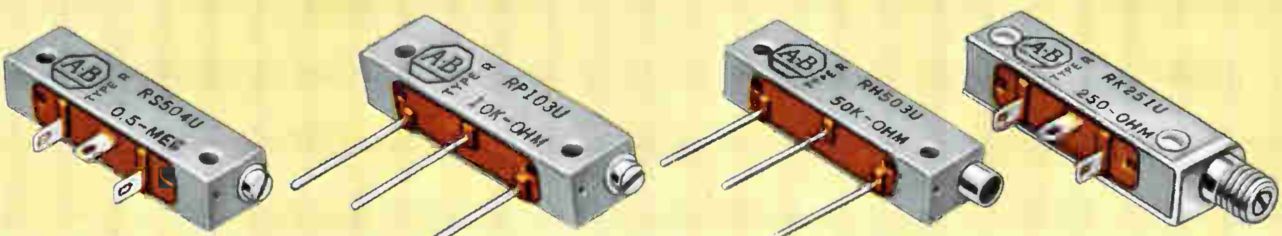
The solid resistance track assures such smooth control that it approaches infinite resolution. Its smoothness cannot be compared with the abrupt wire-wound turn-to-turn resistance changes which may cause circuit transients. Since Type R controls are essentially non-inductive and have low distributed capacity, they can be applied in high frequency circuits where wire-wound controls are impractical. The Type R molded enclosures are both dustproof and watertight, permitting encapsulation after adjustment.

Allen-Bradley Type R controls are suitable for use from −55°C to +125°C and are rated ¼ watt at 70°C, 300 volts max. RMS. Available as standard in total resistance values from 100 ohms to 2.5 megohms with tolerances of ±10% or ±20%. As special, can be furnished down to 50 ohms. Technical Bulletin B5205 contains complete specifications. Please send for your copy today: Allen-Bradley Co., 222 W. Greenfield Ave., Milwaukee, Wisconsin 53204. In Canada: Allen-Bradley Canada Limited. Export Office: 630 Third Ave., New York, New York, U.S.A. 10017.

Allen-Bradley Type R Adjustable Fixed Resistors—Shown actual size



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ITT is licensed to build all DTL integrated circuits from the 930 series. Quantity production is a reality in ITT Semiconductors' facility in West Palm Beach, Florida.

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It's easy to recognize the DTL circuits that come from ITT in West Palm Beach. They're the ones you don't have to wait for.

ITT Semiconductors is a division of International Telephone and Telegraph Corporation, 3301 Electronics Way, West Palm Beach, Florida.

Type Number	Circuit Function
MIC930	Dual 4-input Gate with Expander
MIC932	Dual 4-input Buffer
MIC933	Dual 4-input Expander
MIC944	Dual 4-input Power Gate
MIC945	R-S or J-K Flip-Flop
MIC946	Quad 2-input Gate
MIC948	R-S or J-K Flip-Flop
MIC949	Fast Quad 2-input Gate
MIC950	Pulse-triggered Binary

ITT

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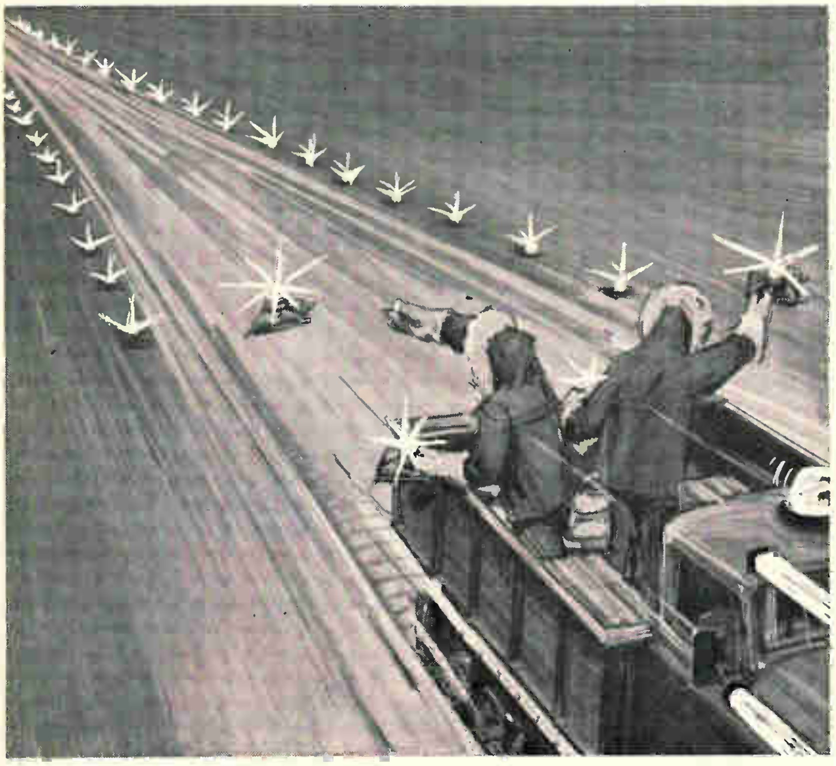
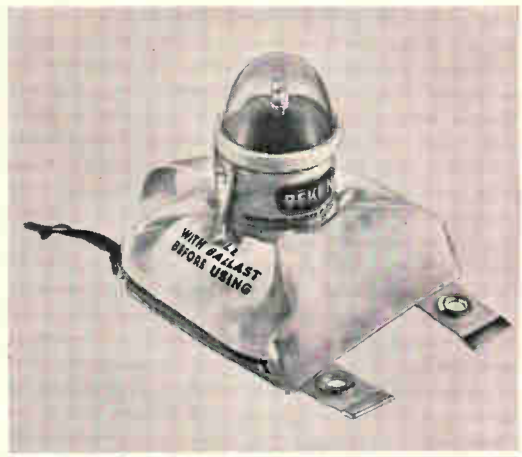
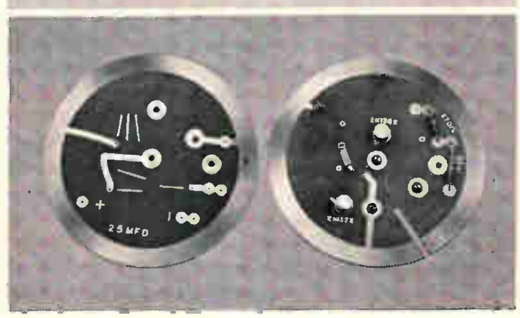
FACTORIES IN WEST PALM BEACH FLORIDA PALO ALTO, CALIFORNIA LAWRENCE, MASSACHUSETTS, HARLOW AND FOOTSCRAY ENGLAND FREIBURG AND NURENBERG GERMANY

It has a circuit of dependable FORMICA® brand copper clad . . .

They designed an emergency landing light knowing it couldn't be babied in Arctic snow or jungle rainstorm.







Power failure puts an airfield out of business—or rather it used to. Today, airfields throughout the world depend on Bekon* lights for such emergencies. These rugged little life-savers, thrown quickly from moving trucks, to serve as emergency runway markers, keep working in any climate, under any weather condition. The Bekon Light nerve center is a printed circuit, made of a FORMICA® brand copper clad laminate. If the dependability of the p. c. in your product is also important, write Dept. ID-6 for data on FORMICA® brand copper clad laminates. Look for the FORMICA® brand, your assurance of quality.

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MIC948	R-S or J-K Flip-Flop
MIC949	Fast Quad 2-input Gate
MIC950	Pulse-triggered Binary

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It has a circuit of dependable FORMICA® brand copper clad . . .

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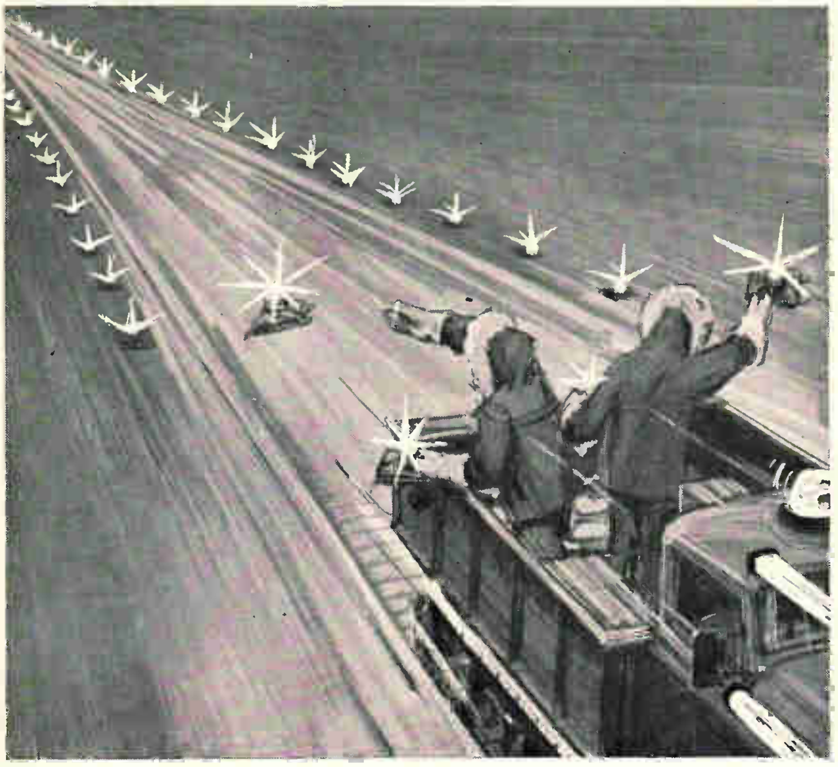

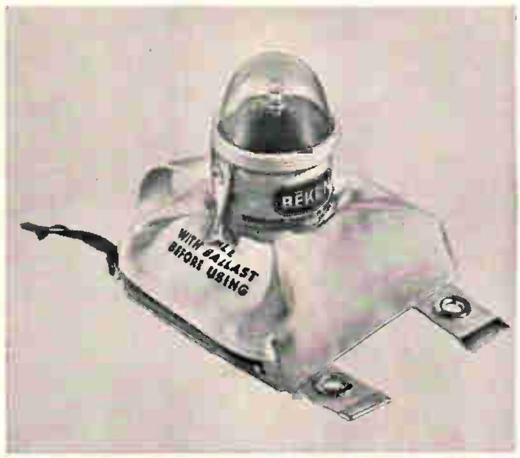

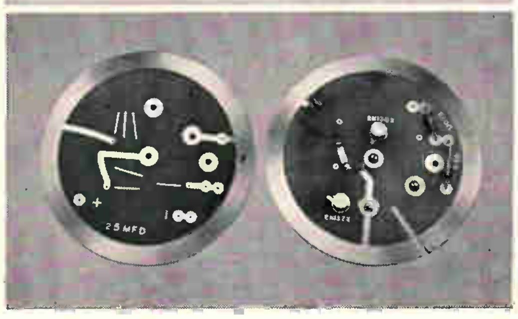

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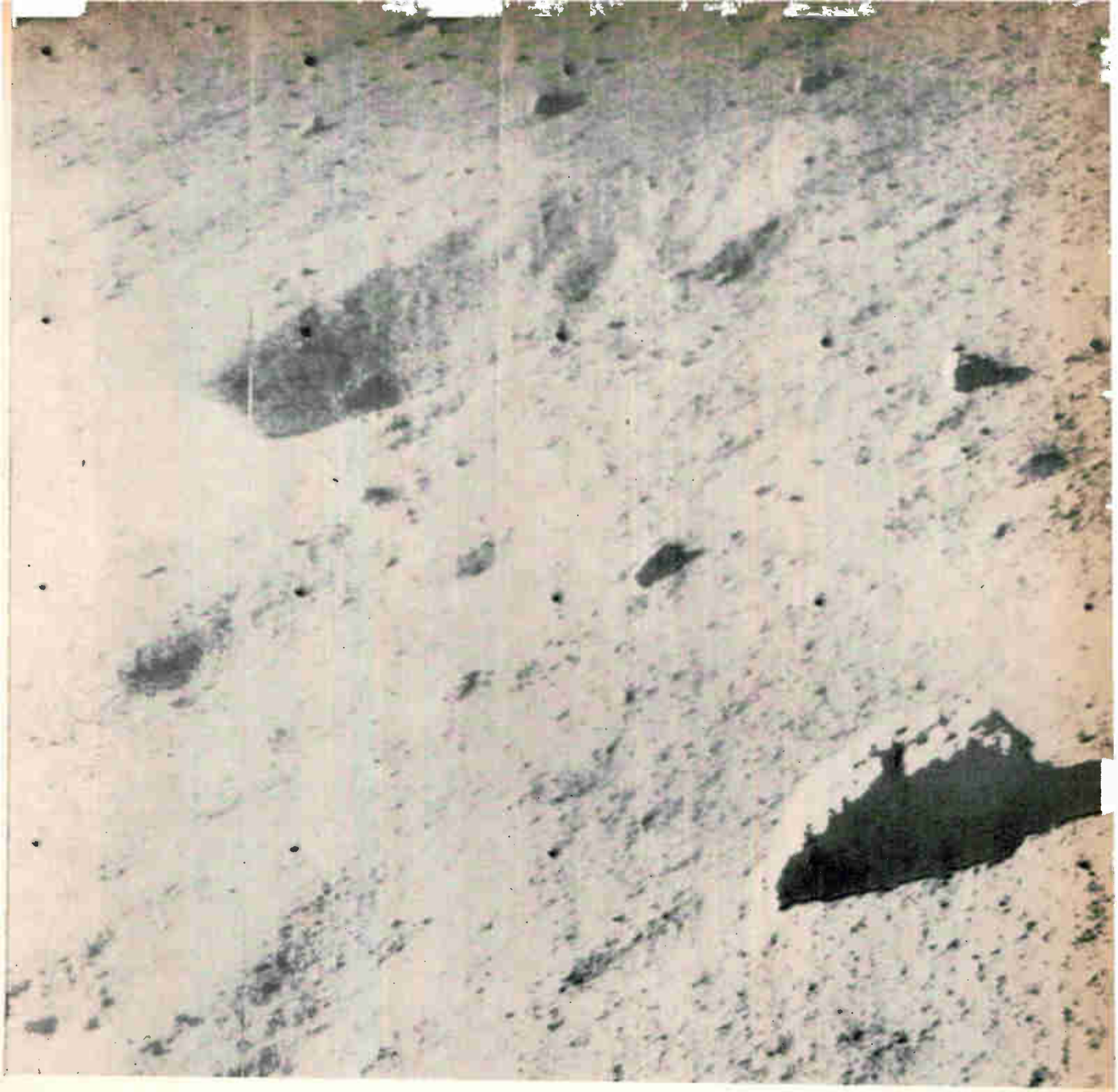

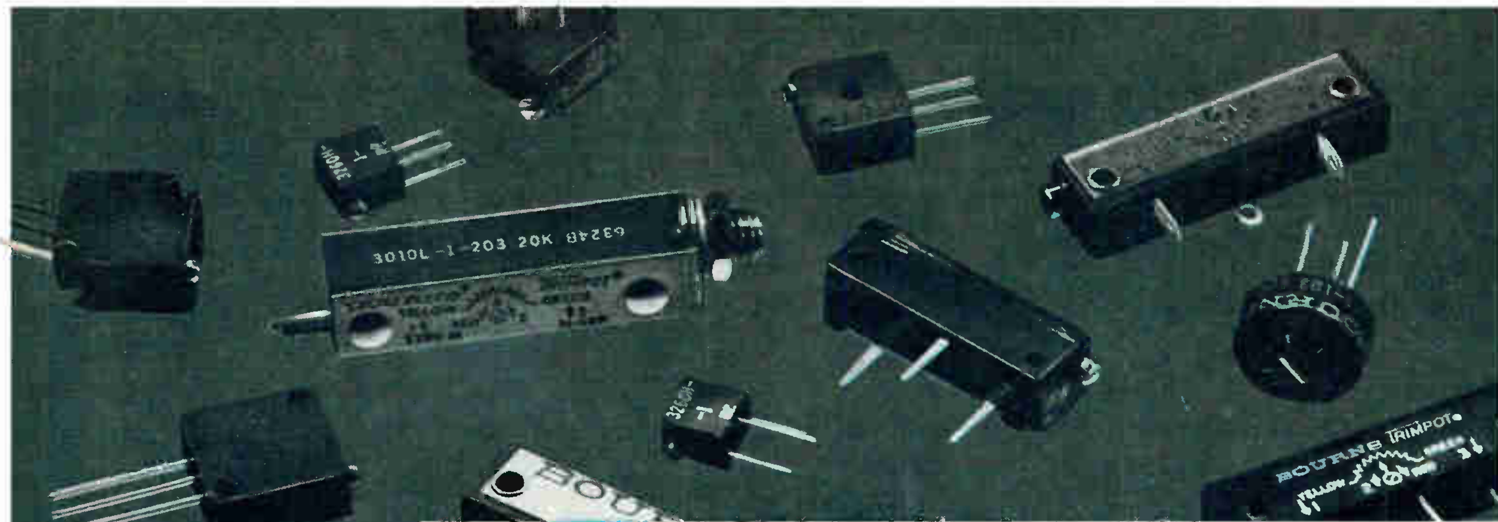

Model	Element	Trade† Name	Terminals*	Tolerance (%)	Power Rating (Watt)	Max. Operating Temp. (°C)	Adj. Turns	Humidity Proof (Mil Spec)	Size (Inches) H	W	L	Standard Resistances (Ohms)
200	Wirewound	TRIMPOT	L, S, P	±10	0.50	125	25	Steady State Only	5/16	1/4	1-1/4	10-100K
215	Carbon	TRIMPOT	L, S, P	±20	0.25	125	22	Steady State Only	5/16	1/4	1-1/4	5K-5 Meg
260	Wirewound	TRIMPOT	L, S, P	±10	1.00	175	25	Steady State Only	5/16	1/4	1-1/4	10-100K
235	Carbon	TRIMPOT	L, S, P	±20	0.25	125	22	Yes	23/64	19/64	1-11/32	5K-5 Meg
236	Wirewound	TRIMPOT	L, S, P	±10	0.80	135	25	Yes	23/64	19/64	1-11/32	10-100K
220	Wirewound	TRIMPOT	L, W	± 5	1.00	175	15	Yes	5/16	3/16	1	10-30K
224	Wirewound	TRIMPOT	L, S, P	± 5	1.00	175	22	Yes	5/16	3/16	1-1/4	10-100K
3000	Wirewound	TRIMPOT	P	±10	0.50	175	15	Yes	5/16	5/32	3/4	50-20K
3001	Carbon	TRIMPOT	P	±20	0.20	150	15	Yes	5/16	5/32	3/4	20K-1 Meg
3010	Wirewound	TRIMPOT	L, P	± 5	1.00	175	25	Yes	5/16	9/32	1-1/4	10-100K
3011	Carbon	TRIMPOT	L, P	±20	0.25	150	22	Yes	5/16	9/32	1-1/4	5K-5 Meg
3012	Cermet	TRIMPOT	L, P	±10	1.00	175	25	Yes	5/16	9/32	1-1/4	500Ω-1 Meg
3051	Carbon	TRIMPOT	L, S, P	±20	0.25	150	22	Yes	5/16	3/16	1-1/4	5K-5 Meg
3052	Cermet	TRIMPOT	L, S, P	±10	1.00	175	25	Yes	5/16	3/16	1-1/4	500Ω-1 Meg
3053	Cermet	TRIMPOT	L / P, S	±10	0.50	175	25	Yes	5/16	3/16	1-1/4	20-200 / 2-200
3070	Wirewound	TRIMPOT	H, P, S, L	± 5	1.50	175	10	Yes	5/16	5/16	1-1/16	100-50K
3250	Wirewound	TRIMPOT	L / P, W	± 5	1.00	175	25	Yes	3/16 / 7/32	1/2 / 1/2	1/2 / 1/2	10-50K
3251	Carbon	TRIMPOT	L / P, W	±20	0.50	150	25	Yes	3/16 / 7/32	1/2 / 1/2	1/2 / 1/2	20K-1 Meg
3260	Wirewound	TRIMPOT	H	± 5	0.2	175	11	Yes	11/64	1/4	1/4	10-20K

*Key to terminal types: L=Insulated stranded leads. S=Solder lugs (includes panel mount bushings on Models 3300S, 3301S, 3367S, 3368S only). P=Printed circuit pins (flat mounting). W=Printed circuit pins (edge mounting). Additional worm gear terminal clarification: W=Printed circuit pins (edge mounting—top adjust). H=Printed circuit pins (edge mounting—side adjust).
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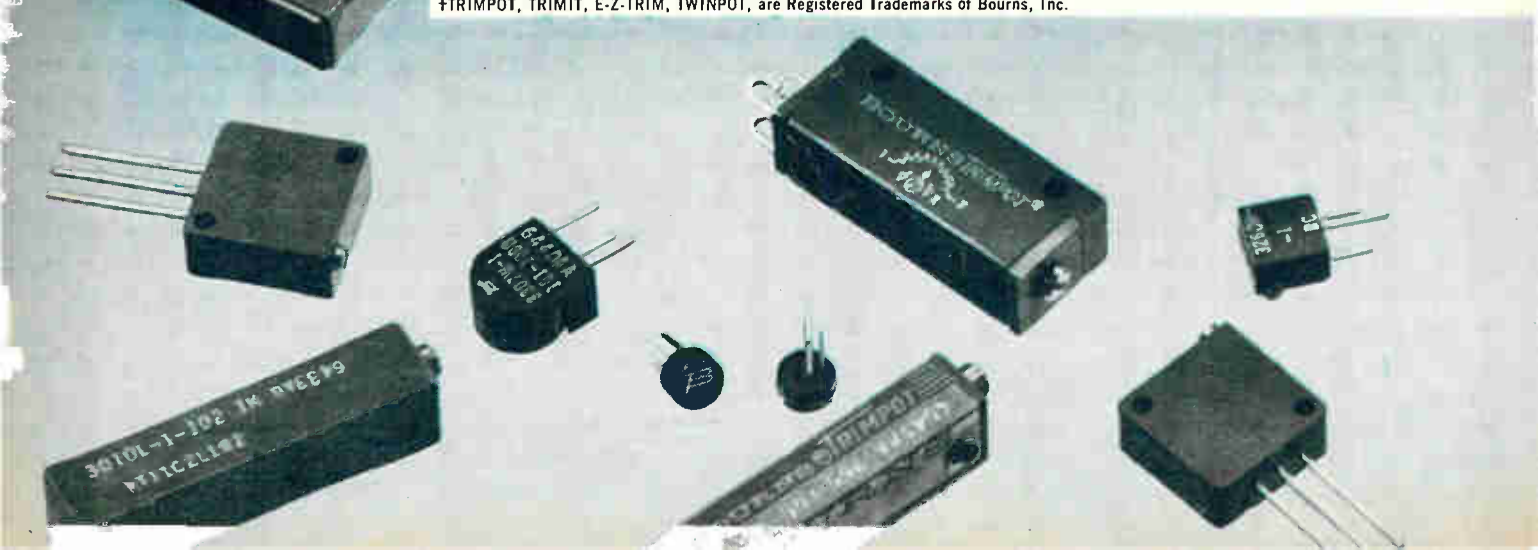

BOURNS TRIMPOT® ADJUSTMENT POTENTIOMETERS

Model	Element	Tradet Name	Terminals*	Tolerance (%)	Power Rating (Watt)	Max. Operating Temp. (°C)	Adj. Turns	Humidity Proof (Mil Spec)	Size (Inches) H	W	L	Standard Resistances (Ohms)
3280	Wirewound	TRIMPOT	L, P, W	± 5	1.00	175	25	Yes	13/64	3/8	3/8	10-50K
3281	Carbon	TRIMPOT	L, P, W	±20	0.5	150	25	Yes	13/64	3/8	3/8	20K-1 Meg
3282	Cermet	TRIMPOT	L, P, W, H	±10	1.00	175	25	Yes		3/8 x 13/64 x 3/8		2K-1 Meg
3300	Wirewound	TRIMPOT	W P S	± 5	0.50	175	1	Yes		3/8 x 1/4 x 5/16 5/16 dia. x 3/16 5/16 dia. x 15/32		10-20K
3301	Carbon	TRIMPOT	W P S	±20	0.25	150	1	Yes		3/8 x 1/4 x 5/16 5/16 dia. x 3/16 5/16 dia. x 15/32		10K-1 Meg
3307	Wirewound	TRIMPOT	W P	± 5	0.5	150	1	Steady State Only		3/8 x 1/4 x 5/16 5/16 dia. x 3/16		50-20K
3317	Wirewound	TRIMPOT	W P	±10	0.2	105	1	No		3/16 x 1/4 x 5/32		20 to 5K
3367	Wirewound	TRIMPOT	P S	± 5	0.50	105	1	Steady State Only		1/2 dia. x 15/64 1/2 dia. x 35/64		10-20K
3368	Carbon	TRIMPOT	P S	±20	0.25	105	1	Steady State Only		1/2 dia. x 15/64 1/2 dia. x 35/64		20K-1 Meg
3257	Wirewound	TRIMPOT	L, P, W	±10	0.5	105	25	No	7/32	1/2	1/2	10-20K
271 273 275	Wirewound	TRIMIT	L S P	±10	0.50	105	25	No	5/16	1/4	1-1/4	10-20K
272 274 276	Carbon	TRIMIT	L S P	±20	0.20	105	25	No	5/16	1/4	1-1/4	5K-5 Meg
3067	Wirewound	E-Z-TRIM	S, P	±10	0.50	85	15	No	23/64	9/32	1	50-20K
3068	Carbon	E-Z-TRIM	S, P	±20	0.20	85	15	No	23/64	9/32	1	20K-1 Meg
207	Wirewound	TRIMPOT	L	±10	2.00	175	25	No	13/16	9/32	1-1/4	100-100K
3020	Wirewound	TRIMPOT	L	± 5	5.0	200	25	Yes	21/64	1/4	1-1/4	100-50K
209	Wirewound	TWINPOT	L	±10	0.5 (each element)	135	25	No	5/16	1/2	1-1/4	10-50K

Circle 67 on Reader Service Card

BOURNS

BOURNS, INC., TRIMPOT DIVISION
1200 COLUMBIA AVE., RIVERSIDE, CALIF.
PHONE (714) 684-1700 · TWX: 714-682 9582
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TRIMPOT® AND PRECISION POTENTIOMETERS — RELAYS — MICROCOMPONENTS: TRANSFORMERS, INDUCTORS, RESISTORS AND CAPACITORS

CASE FOR THE MAN FROM E.A.G.L.E.

UNDERCOVER OPERATOR

22AP Plug-in General Purpose Relay

. . . the epitome of relay craftsmanship and design. Versatile to the Nth degree on loads to 10 amps. Available in 8- and 11-pin styles for AC, DC and plate circuit requirements. Features include: forms to 3PDT plus specials on request; standard units have gold-plated contacts for longer shelf life; lower pull-in voltages (DC: 70% of nominal, AC: 75% of nominal); AC operating voltages 0.5 to 250, DC 0.2 to 130 in current ranges from .005 to 10 amp. Complete information is in our new relay bulletin. For your copy, use Reader Service Card, circle number 484.

SPECIFICATIONS

- *Contacts: SPDT, DPDT, 3PDT*
- *Contact Rating: 5 and 10 amps.*
- *Pull-in: 22 milliseconds average*
- *Drop-out Speed: 12 milliseconds average*
- *Size: $1\frac{3}{8}$" x $2\frac{1}{8}$" x $1\frac{3}{8}$"*
- *Weight: 3 ounces*

POWERFUL PARTNER

25PS Medium Power Relay

. . . toss your toughest medium-power-handling assignments to this workhorse. 25PS types carry loads to 20 amps. on a fast duty cycle in a breeze. UL listed. Features include: rugged ⅜" diameter silver cadmium oxide alloy contact; lower pull-in voltages (DC: 75% of nominal, AC: 76% of nominal); AC operating voltages 4 to 250, DC 1 to 130 in current ranges from .02 to 10 amp. For full technical information on this and other Eagle Signal general purpose and medium power relays, use the Reader Service Card, and circle number 485.

SPECIFICATIONS

- *Contacts: SPDT*
- *Contact Rating: 20 amps. 115/230 VAC 60 cycle resistive • 1 HP @ 115/230 VAC motor-inductive*
- *Pull-in: 50 milliseconds max.*
- *Drop-out Speed: 30 milliseconds max.*
- *Size: $2\frac{1}{4}$" x $1\frac{9}{32}$" x $1\frac{13}{16}$"*
- *Weight: 3 ounces*

RELAY DESIGNERS' RELAY

25AA Open Frame General Purpose Relay

. . . and boy what a relay it is! Versatile, dependable, economical. You'll find hundreds of uses for these 5 or 10 amps., UL listed high-reliability types. Standard units have gold-plated contacts which permit longer shelf life. Other significant features include: lower pull-in voltages (DC: 70% of nominal, AC: 75% of nominal). AC operating voltages 0.5 to 250, DC 0.2 to 130 in current ranges from .005 to 10 amp. Detailed specifications on these and other Eagle Signal general purpose relays are given in a new technical bulletin. For your copy, use Reader Service Card, circle number 486.

SPECIFICATIONS

- *Contacts: SPDT, DPDT, 3PDT*
- *Contact Rating: 5A and 10A @ 115 VAC•5A-1/10 HP @ 115 VAC, 1/6 HP @ 230 VAC•10A-1/6 HP @ 115 VAC, 1/3 HP @ 230 VAC*
- *Pull-in: 22 milliseconds average*
- *Drop-out Speed: 12 milliseconds average*
- *Size: $1\frac{7}{8}$" x $1\frac{9}{32}$" x $1\frac{1}{2}$"*
- *Weight: 2 ounces*

Ask the man from E.A.G.L.E. to open his "showcase" of ideas for you. Many can help solve your process control problems. Want our complete catalog? Use the handy Reader Service Card, circle number 487, or write: Eagle Signal Division, E. W. Bliss Company, Federal Street, Davenport, Iowa 52803.

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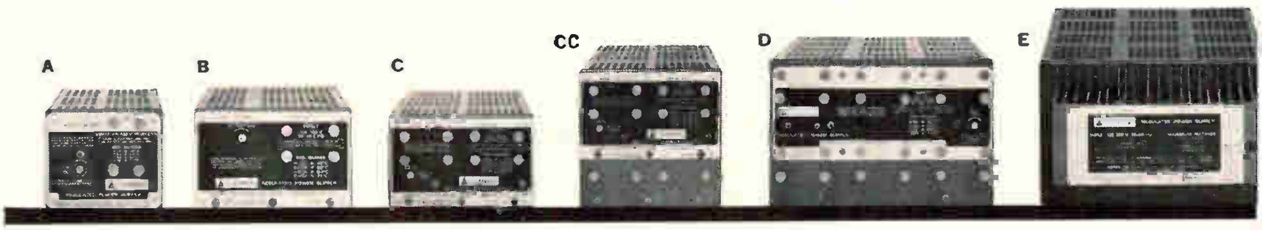
A DIVISION OF THE E. W. BLISS COMPANY

Meet any programable or fixed voltage need

Up to 150 volts • Up to 95 amps

5 Year Guarantee



FEATURES and DATA

Full line of accessories and options to meet your system needs. Meet Mil. Environment Specs. **RFI**—MIL-I-16910: **Vibration:** MIL-T-4807A: **Shock:** MIL-E-4970A • Proc. 1 & 2: **Humidity:** MIL-STD-810 • Meth. 507: **Temp. Shock:** MIL-E-5272C • (ASG) Proc. 1: **Altitude:** MIL-E-4970A • (ASG) Proc. 1: **Marking:** MIL-STD-130: **Quality:** MIL-Q-9858: **Fungus Proofing** (optional) all models available with MIL-V-173 varnish for all nutrient components.

Convection cooled—no heat sinking or forced air required

Wide input voltage and frequency range—105-132 VAC, (200-250 VAC, optional at no extra charge) 45-440 cps

Regulation (line) 0.05% plus 4MV **(load)** 0.03% plus 3MV: **Ripple and Noise**—1 MV rms, 3MV p to p

Overvoltage protection available for all models up to 70 VDC

High Performance Option—All models available with these specifications for $25.00 extra: **Line regulation**—.01% + 1MV; **Load regulation**—.02% + 2MV: **Ripple and Noise**—½MV rms; 1½MV p to p: **Temp. Coef.**—.01%°C

ACCESSORIES and OPTIONS

System Rack Adapters

LRA-5 • 3½" height by 2⅞" depth. Price $35.00

LRA-4 • 3½" height by 14" depth. (For use with chassis slides) Price $55.00

LRA-5 and **LRA-4** mount the following combinations of LM models: up to 4 A package sizes • 3 B or 3 C package sizes • 2 A and 1 B or 1 C package sizes

LRA-3 • 5¼" height by 2⅞" depth. Price $35.00

LRA-6 • 5¼" height by 14" depth. (For use with chassis slides) Price $60.00

LRA-3 and **LRA-6** mount the following combinations of LM models: up to 4 A, B or C package sizes • 3 CC package sizes • 2 D or 2 E package sizes • 2 A, B or C and 1 CC or 1 D or 1 E package sizes • 1 CC and 1 D or 1 E package sizes • 1 D and 1 E package sizes

Metered Panels • 3½" Metered panel MP-3 is used with rack adapters LRA-4, LRA-5 and packages A, B and C. Price $40.00

5¼" Metered panel MP-5 is used with rack adapters LRA-6, LRA-3 and packages A, B, C, CC, D and E. Price $40.00

To order these accessory metered panels, specify panel number which MUST BE FOLLOWED BY the MODEL NUMBER of the power supply with which it will be used.

F and G LM Packages are full rack power supplies available metered or non-metered. For metered models, add suffix M to the Model No. and $30 to the non-metered price.

Other Options • Also available are Overvoltage Protectors, Fungus Proofing, and High Performance Options at moderate surcharges.

WIDE VOLTAGE RANGE

PROGRAMABLE LM SERIES MODELS

PACKAGE A 3⁹⁄₁₆"x3¾"x6½"	ADJ. VOLT. RANGE VDC	*MAX. AMPS AT AMBIENT OF:				Price**
		40 C	50 C	60 C	71 C	
LM 251	0-7	0.35	0.31	0.29	0.27	$ 69
LM 201	0-7	0.85	0.75	0.70	0.55	79
LM 202	0-7	1.7	1.5	1.4	1.1	89
LM 252	0-7	2.0	1.8	1.4	1.1	99
LM 257	0-14	0.27	0.24	0.23	0.22	69
LM 203	0-14	0.45	0.40	0.38	0.28	79
LM 204	0-14	0.90	0.80	0.75	0.55	89
LM 258	0-14	1.2	1.1	1.0	0.80	99
LM 259	0-24	0.18	0.16	0.15	0.14	69
LM 260	0-24	0.35	0.30	0.25	0.20	79
LM 261	0-24	0.70	0.65	0.60	0.45	89
LM 262	0-24	0.80	0.75	0.70	0.60	99
LM 263	0-32	0.14	0.12	0.11	0.10	69
LM 205	0-32	0.25	0.23	0.20	0.15	79
LM 206	0-32	0.50	0.45	0.40	0.30	89
LM 264	0-32	0.66	0.60	0.50	0.32	99
LM 265	0-60	0.08	0.07	0.07	0.06	79
LM 207	0-60	0.13	0.12	0.11	0.08	89
LM 208	0-60	0.25	0.23	0.21	0.16	99
LM 266	0-60	0.35	0.31	0.28	0.25	109
LM 267	0-120	0.10	0.09	0.08	0.07	109
LM 268	0-120	0.13	0.12	0.10	0.09	119

PACKAGE B 3⁹⁄₁₆"x4⁵⁄₁₆"x6½"	ADJ. VOLT. RANGE VDC	*MAX. AMPS AT AMBIENT OF:				Price**
		40 C	50 C	60 C	71 C	
LMB-0-7	0-7	2.8	2.6	2.3	1.5	$109
LMB-0-14	0-14	1.6	1.5	1.3	1.2	109
LMB-0-32	0-32	0.80	0.70	0.60	0.5	109
LMB-0-60	0-60	0.45	0.40	0.35	0.3	109
LM-217	8.5-14	2.1	1.9	1.7	1.3	119
LM-218	13-23	1.5	1.3	1.2	1.0	119
LM-219	22-32	1.2	1.1	1.0	0.80	119
LM-220	30-60	0.70	0.65	0.60	0.45	129

PACKAGE C 3⁹⁄₁₆"x4¹⁵⁄₁₆"x9⅜"	ADJ. VOLT. RANGE VDC	MAX. AMPS AT AMBIENT OF:				Price**
		40 C	50 C	60 C	71 C	
LM-225	0-7	4.0	3.6	3.0	2.4	$139
LMC-0-14	0-14	2.2	2.0	1.8	1.5	139
LMC-0-32	0-32	1.1	1.0	0.90	0.80	139
LMC-0-60	0-60	0.60	0.55	0.50	0.45	139
LM-226	8.5-14	3.3	3.0	2.5	2.0	139
LM-227	13-23	2.3	2.1	1.7	1.4	139
LM-228	22-32	2.0	1.8	1.5	1.2	139
LM-229	30-60	1.1	1.0	0.80	0.60	149

PACKAGE D 4¹⁵⁄₁₆"x7½"x9⅜"	ADJ. VOLT. RANGE VDC	MAX. AMPS AT AMBIENT OF:				Price**
		40 C	50 C	60 C	71 C	
LM-234	0-7	8.3	7.3	6.5	5.5	$199
LMD-0-14	0-14	4.9	4.2	3.4	2.7	199
LMD-0-32	0-32	2.5	2.1	1.7	1.3	180
LMD-0-60	0-60	1.3	1.1	0.95	0.75	239
LM-235	8.5-14	7.7	6.8	6.0	4.8	199
LM-236	13-23	5.8	5.1	4.5	3.6	209
LM-237	22-32	5.0	4.4	3.9	3.1	219
LM-238	30-60	2.6	2.3	2.0	1.6	239

PACKAGE E 4¹⁵⁄₁₆"x7½"x11⅜"	ADJ. VOLT. RANGE VDC	*MAX. AMPS AT AMBIENT OF:				Price**
		40 C	50 C	60 C	71 C	
LME-0-7	0-7	12.0	10.5	8.5	6.8	$249
LME-0-14	0-14	7.4	6.4	5.2	4.1	249
LME-0-32	0-32	3.7	3.2	2.6	2.1	249
LME-0-60	0-60	2.1	1.7	1.4	1.1	249

PACKAGE F 3½"x19"x16½"	ADJ. VOLT. RANGE VDC	*MAX. AMPS AT AMBIENT OF:				Price**
		40 C	50 C	60 C	71 C	
LMF-0-7	0-7	25.0	21.0	17.0	14.0	$425

PACKAGE G 5¼"x19"x16½"	ADJ. VOLT. RANGE VDC	*MAX. AMPS AT AMBIENT OF:				Price**
		40 C	50 C	60 C	71 C	
LMG-0-7	0-7	35.0	29.0	24.0	20.0	$575

with Lambda Modular Power Supply Systems

F

G

5 Year Guarantee

FIXED VOLTAGE RANGE

LM SERIES MODELS

PACKAGE B 3[illegible] x4[illegible] x6[illegible]	ADJ. VOLT RANGE VDC	MAX AMPS AT AMBIENT OF: 40 C	50 C	60 C	71 C	Price**
LM B3	3 ±5%	1.8	[illegible]	[illegible]	1.6	$119
LM B3P3	3.3 ±5%	1.8	[illegible]	[illegible]	1.6	119
LM B3P6	3.6 ±5%	1.8	[illegible]	[illegible]	1.6	119
LM B4	4 ±5%	1.8	[illegible]	[illegible]	[illegible]	119
LM B4P5	4.5 ±5%	1.7	[illegible]	[illegible]	1.5	119
LM B5	5 ±5%	1.7	[illegible]	[illegible]	1.5	119
LM B6	6 ±5%	[illegible]	[illegible]	[illegible]	1.4	119
LM B8	8 ±5%	[illegible]	[illegible]	[illegible]	[illegible]	119
LM B10	10 ±5%	[illegible]	[illegible]	[illegible]	1.4	119
LM B12	[illegible] ±5%	[illegible]	[illegible]	[illegible]	1.3	119
LM B15	15 ±5%	[illegible]	[illegible]	1.8	1.3	119
LM B18	18 ±5%	[illegible]	1.8	[illegible]	[illegible]	119
LM B20	20 ±5%	1.8	1.6	[illegible]	[illegible]	119
LM B24	24 ±5%	1.4	[illegible]	[illegible]	1.1	119
LM B28	28 ±5%	[illegible]	[illegible]	1.1	1.0	119
LM B36	36 ±5%	1.1	1.0	0.90	0.85	129
LM B48	48 ±5%	[illegible]	0.85	[illegible]	0.75	129
LM B60	60 ±5%	[illegible]	0.65	[illegible]	0.54	129
LM B100	100 ±5%	[illegible]	0.34	[illegible]	0.28	139
LM B120	120 ±5%	0.30	0.28	0.25	0.23	139
LM B150	150 ±5%	0.25	0.23	0.20	0.19	149

PACKAGE C 3[illegible] x4[illegible] x9[illegible]	ADJ VOLT. RANGE VDC	*MAX. AMPS AT AMBIENT OF: 40 C	50 C	60 C	71 C	Price**
LM C3	3 ±5%	5.3	4.6	3.7	2.5	$139
LM C4	4 ±5%	5.2	4.5	3.6	2.5	139
LM C4P5	4.5 ±5%	5.1	4.4	3.5	2.4	139
LM C5	5 ±5%	5.1	4.3	3.4	2.4	139
LM C6	6 ±5%	4.8	4.1	3.3	2.4	139
LM C12	12 ±5%	4.0	3.5	2.9	1.9	139
LM C15	15 ±5%	3.5	3.2	2.8	1.9	139
LM C20	20 ±5%	3.1	2.9	2.6	1.8	139
LM C24	24 ±5%	2.5	2.4	2.2	1.5	139
LM C28	28 ±5%	2.3	2.1	2.0	1.4	139
LM C48	48 ±5%	1.6	1.4	1.3	1.0	149
LM C150	150 ±5%	0.39	0.36	0.33	0.30	169

NEW PACKAGE CC 4[illegible] x4[illegible] x9[illegible]	ADJ. VOLT. RANGE VDC	*MAX. AMPS AT AMBIENT OF: 40 C	50 C	60 C	71 C	Price**
LM CC3	3 ±5%	11.0	9.4	8.2	5.5	$179
LM CC4	4 ±5%	11.0	9.4	8.2	5.5	179
LM CC4P5	4.5 ±5%	10.5	9.0	8.0	5.5	179
LM CC5	5 ±5%	10.5	9.0	8.0	5.5	179
LM CC6	6 ±5%	9.0	8.4	7.7	5.5	179
LM CC12	12 ±5%	7.3	6.8	5.9	4.7	169
LM CC15	15 ±5%	6.0	5.6	5.1	4.3	169
LM CC20	20 ±5%	5.0	4.6	4.2	3.6	169
LM CC24	24 ±5%	4.0	3.7	3.4	3.0	169
LM CC28	28 ±5%	3.5	3.4	3.1	2.8	169
LM CC48	48 ±5%	2.5	2.4	2.2	1.9	189
LM CC150	150 ±5%	0.7	0.67	0.62	0.55	199

PACKAGE D 4[illegible]"x7½"x9½"	ADJ. VOLT. RANGE VDC	MAX. AMPS AT AMBIENT OF: 40 C	50 C	60 C	71 C	Price**
LM D3	3 ±5%	13.1	11.3	9.2	6.2	$199
LM D4	4 ±5%	13.1	11.3	9.2	6.2	199
LM D4P5	4.5 ±5%	13.1	11.3	9.2	6.2	199
LM D5	5 ±5%	12.6	10.8	9.2	6.1	199
LM D6	6 ±5%	12.4	10.6	8.9	6.0	199
LM D12	12 ±5%	10.0	9.2	8.3	5.7	199
LM D15	15 ±5%	9.0	8.4	7.9	5.3	209
LM D20	20 ±5%	7.4	6.9	6.5	4.9	209
LM D24	24 ±5%	6.7	6.3	5.8	4.8	219
LM D28	28 ±5%	6.0	5.6	5.2	4.7	219
LM D48	48 ±5%	4.1	3.9	3.6	3.1	239
LM D150	150 ±5%	1.1	1.0	0.90	0.80	254

PACKAGE E 4[illegible] x7[illegible] x11½	ADJ. VOLT. RANGE VDC	*MAX. AMPS AT AMBIENT OF: 40 C	50 C	60 C	71 C	Price**
LM E3	3 ±5%	22.0	20.0	16.5	10.0	$269
LM E4	4 ±5%	21.0	19.0	16.5	10.0	269
LM E4P5	4.5 ±5%	20.0	18.0	16.4	10.0	269
LM E5	5 ±5%	20.0	18.0	16.4	10.0	269
LM E6	6 ±5%	19.0	17.3	15.6	10.0	269
LM E12	12 ±5%	15.0	13.6	12.3	9.5	269
LM E15	15 ±5%	14.0	12.7	11.5	8.6	269
LM E20	20 ±5%	12.0	10.9	9.8	8.5	269
LM E24	24 ±5%	11.0	10.0	9.0	7.6	269
LM E28	28 ±5%	10.0	9.0	8.0	7.1	269
LM E48	48 ±5%	6.0	5.4	4.9	4.3	299
LM E150	150 ±5%	1.4	1.3	1.2	1.0	299

PACKAGE F 3½"x19"x16½"	ADJ. VOLT. RANGE VDC	*MAX. AMPS AT AMBIENT OF: 40 C	50 C	60 C	71 C	Price**
LM FA3	3 ±5%	31.5	28.5	24.0	18.0	$375
LM FA4	4 ±5%	31.5	28.5	24.0	18.0	375
LM FA4P5	4.5 ±5%	31.5	28.5	24.0	18.0	375
LM FA5	5 ±5%	31.5	27.7	23.7	18.0	375
LM FA6	6 ±5%	30.5	26.0	22.0	18.0	375
LM FA12	12 ±5%	22.0	19.0	16.2	13.2	375
LM FA15	15 ±5%	19.4	18.3	15.2	12.6	375
LM FA20	20 ±5%	16.0	14.7	12.6	10.5	350
LM FA24	24 ±5%	14.0	13.0	11.4	9.0	350
LM FA28	28 ±5%	13.5	12.0	10.4	8.5	350
LM FA48	48 ±5%	8.1	7.5	6.5	5.4	375
LM FA150	150 ±5%	2.4	2.1	1.8	1.4	410
LM F3	3 ±5%	48.0	42.0	34.0	25.0	425
LM F4	4 ±5%	48.0	42.0	34.0	25.0	425
LM F4P5	4.5 ±5%	48.0	42.0	34.0	25.0	425
LM F5	5 ±5%	48.0	41.0	33.0	25.0	425
LM F6	6 ±5%	47.0	40.0	32.0	24.0	425
LM F12	12 ±5%	33.0	28.0	22.0	17.0	425
LM F15	15 ±5%	28.0	24.0	19.0	16.0	425
LM F20	20 ±5%	23.0	20.0	17.0	13.0	395
LM F24	24 ±5%	20.0	17.0	14.0	11.0	380
LM F28	28 ±5%	19.0	16.0	13.0	10.0	380
LM F48	48 ±5%	10.0	9.0	7.5	6.0	425
LM F150	150 ±5%	3.1	2.6	2.1	1.6	460

PACKAGE G 5¼"x19"x16½"	ADJ. VOLT. RANGE VDC	*MAX. AMPS AT AMBIENT OF: 40 C	50 C	60 C	71 C	Price**
LM G3	3 ±5%	95.0	80.0	62.0	45.0	$575
LM G4	4 ±5%	85.0	80.0	62.0	45.0	575
LM G4P5	4.5 ±5%	85.0	80.0	62.0	45.0	575
LM G5	5 ±5%	80.0	75.0	62.0	45.0	575
LM G6	6 ±5%	80.0	75.0	62.0	45.0	525
LM G12	12 ±5%	56.0	46.0	37.0	29.0	525
LM G15	15 ±5%	45.0	42.0	36.0	28.0	525
LM G20	20 ±5%	35.0	32.0	28.0	21.0	525
LM G24	24 ±5%	32.0	26.0	21.0	16.0	480
LM G28	28 ±5%	28.0	25.0	21.0	16.0	480
LM G48	48 ±5%	17.0	14.0	12.0	9.0	575
LM G150	150 ±5%	5.5	5.2	4.5	3.7	675

NOTE:
Space does not permit listing all LM Series fixed-voltage power supplies. In every package size there are models for each voltage range listed under the B package. Call or write for data and prices.

* Current rating is from zero to I max. at ambient. Current rating applies over entire output voltage range.

Current rating applies for input voltage 105-132 VAC 55-65 cps.

For operation at 45-55 cps derate current rating 10%.

For operation at 360-440 cps consult factory for ratings and specifications.

** Prices F.O.B. Factory, Melville, N. Y. All specifications and prices subject to change without notice.

SEND FOR NEW CATALOG ON FIXED VOLTAGE AND WIDE RANGE MODULAR POWER SUPPLIES

LAMBDA ELECTRONICS CORP. A Veeco SUBSIDIARY
515 BROAD HOLLOW ROAD · MELVILLE, L. I., NEW YORK · 516 MYRTLE 4-4200

Now you can throw out less versatile storage techniques. A Ferroxcube core memory costs as little as $1,190.

We haven't been a leading core memory manufacturer all these years for nothing. We learned how to mass produce core memories and thereby sell them to you at prices competitive with less reliable, less versatile storage techniques.

Aside from price (we'll get back to that in a moment), consider the advantages of core memory systems. Speed. Random access. Non-dissipative. And they're non-volatile. We could go on and on. We won't because you've probably always wanted to design your system around core storage anyway. Only the cost stopped you.

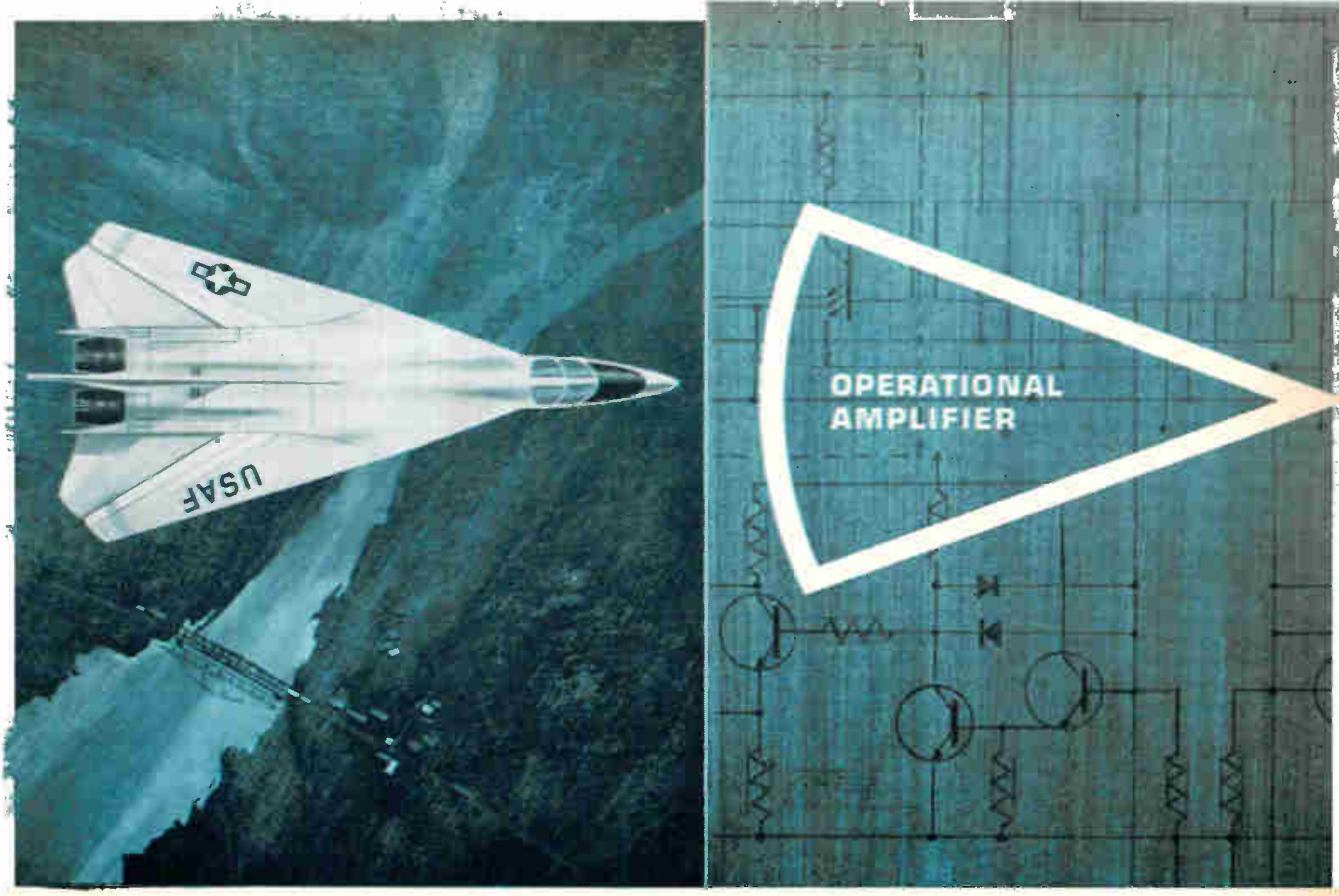
Now you can buy a Ferroxcube 128 x 8 core memory system complete with stack electronics, data register and timing for a paltry $1,190. That's our FX-12. Its capacity ranges up to 512 x 8. The FX-14 picks up there and goes on to 4,096 x 32. Prices are comparably low. Moreover, the FX-14 is available with almost any choice of interfacing elements. Buy only what you need to interface with what you already have.

In brief, Ferroxcube core memories make both functional and economic sense. Write or call for Bulletin M661.

Ferroxcube

FERROXCUBE CORPORATION OF AMERICA

Englewood, Colorado 303-771-2000 | Boston 617-899-3110 | Chicago 312-261-7880 | Dallas 214-255-0441 | Los Angeles 213-837-1484 | Minneapolis 612-888-4681 | New York Area 201-267-5888 | Phoenix 602-265-1792 | Philadelphia 215-927-6262 | Washington, D.C. 703-893-4900



USAF
OPERATIONAL
AMPLIFIER

MARRIAGE OF CONVENIENCE

How Sperry blends the best of two technologies into a superior microwave source

A V band Sperry klystron with matching solid-state power supply.

System designers who want to capitalize on the obvious advantages of solid-state without enduring the crippling power and frequency limitations are discovering a new solution: the packaged power supply/klystron oscillator combination from Sperry Electronic Tube Division.

Sperry now offers single low-voltage (28 volts) DC-to-microwave frequency sources which combine the best features of solid-state circuitry and klystron oscillators. The source consists of an all solid-state power supply, a reflex klystron, and (if required) a stalo cavity and an isolator.

For many applications, Sperry has already proved that such a combination can equal the size and weight of an all solid-state source and show considerable improvement in reliability, power handling capability, noise and other characteristics.

The Sperry designs are based on existing hardware and technologies. Tubes, power supplies and stalos already in production require only minor modifications to become usable components in packaged source combinations. Because no development work is required, you can expect peak reliability from the first unit – the "learning curve" stage is completely eliminated.

Precise prediction of the interaction between microwave and solid-state elements requires in-depth understanding of both technologies. Such understanding is the principle ingredient in Sperry's "Storehouse of Knowledge." Put our understanding to work for you today.

Sperry delivers the source in a compact, integrated package . . . for a typical X band application it may be as small as 100 cubic inches and weigh as little as four pounds. While power supply maintenance should be conducted at depot level, the tube and stalo may be replaced, at any level, thanks to the fixed reflector voltage feature of Sperry reflex klystrons.

In packaging the units, Sperry pays particular attention to environmental requirements, mounting requirements and optimum RFI shielding.

If you're concerned with the performance and reliability of an all solid-state source to meet your specifications, or if you want to avoid the agony of matching a klystron to its power supply, get more information about Sperry's packaged source capability. For your free copy of a new technical paper, ask your Cain & Co. man or write Sperry, Gainesville, Fla.

SPERRY

DIVISION OF SPERRY RAND CORPORATION

SPERRY ELECTRONIC TUBE DIVISION, Gainesville, Fla.

National Representatives: Cain & Co., Los Angeles, 783-4700; Boston, 665-8600; Arlington Heights, 253-3578; Dallas, 369-2897; Dayton, 228-2433; Eastchester, 337-3445; Philadelphia, 828-3861; San Francisco, 948-6533; Syracuse, 463-0462; Washington, 296-8265; South Amboy, 727-1900; Huntsville, 534-7955; Dade City, 422-3460; Montreal, 844-0089.

Washington Newsletter

September 19, 1966

The high cost of expansion

The proposed suspension of the 7% investment tax credit may not slow electronics as much as other industries. There is serious concern the war effort may be hindered if expansion of the electronics and other key industries are hampered. **Thus, to fill military orders, some expansion, even at the more costly rates, may still be necessary.** Also, electronics firms have shown more restraint in their expansion plans than the rest of the economy.

President Johnson has sent his proposed legislation to Capitol Hill, where hearings have already begun in the House Ways and Means Committee. The bill, which seems assured of passage, would make expansion more costly and cause companies to defer such expansions until the credit is reestablished—probably in January, 1968. The President proposed that the credit suspension be made retroactive to Sept. 1.

Commerce Department figures forecast electronics expansion for the rest of this year at 2.4% above the previous quarter, compared to a 3% rise for all industries. Investment in new plant and equipment by the electronics industry—paced by the communications segment—was $6.09 billion for the year's first three months, went to $6.27 billion for the second quarter and $6.53 billion in the third. **Investment is expected to climb another $6.7 billion between now and year's end.**

Components manufacturers account for $575 million of the projected fourth-quarter total, computer firms another $206 million, and the communications giants are planning a $5.9 billion growth. Computer firms cut their expansion plans to a level below the last quarter's, but the communications companies more than made up the difference.

Congress fears antisub slowdown . . .

L. Mendel Rivers (D., S.C.), chairman of the House Armed Services Committte, wants to make sure that Pentagon concern with the war in Vietnam doesn't shortchange the Navy's antisubmarine warfare program. **He has asked Samuel S. Stratton (D., N.Y.) to find out whether antisubmarine defense against a potential Soviet threat is being sacrificed to the land war in Southeast Asia.**

Stratton, who headed the congressional subcommittee that visited Vietnam in April, has had some preliminary interviews with Vice Adm. Charles B. Martell, director of the Navy antisubmarine program; hearings are planned before the full committee.

. . . while Navy goes ahead with Autec . . .

Despite the fears of Rivers and his committee, progress is reported in one area of antisubmarine warfare research. The Navy's Atlantic Undersea Test and Evaluation Center (Autec) is ready to begin limited operations and a three-year, $10.8-million contract has gone to the Radio Corp. of America to manage and maintain the ocean test bed off the Bahamas.

None if by land

Returning Gemini and Apollo spacecraft will continue to splash down in the ocean, but dry landings may be possible for early flights in the Apollo Applications Program now under study by the National Aeronautics and Space Administration. **John Kiker, head of landing techniques at NASA's Manned Spacecraft Center in Houston, says that** budget problems are delaying ground landings as much as the technical difficulties. Spending for Vietnam cut into funds that NASA engineers had hoped to use for the limping land landing program for Apollo [Electronics, Aug. 8, 1966, p. 48].

Air Force tests emergency network for communications

A system that worked well during the East Coast blackout last Nov. 9 may provide the Defense Department with an emergency communications network; when the lights went out stations switched to standby power and continued both commercial and emergency teletypewriter broadcasting over a-m broadcast facilities.

The teletypewriter system—under test by the Air Force—operates at 100 words a minute. Messages are squeezed onto the broadcasting bands along with commercial programs—without interference—by shifting carrier-wave signals 18 hertz. Twelve stations in the northeastern United States have been equipped for the tests.

The system is compatible with digital air-to-ground communications equipment at high frequencies and with low-frequency systems used to contact submarines and underground command posts.

Westinghouse seeks better sonar for rescue sub

The Navy has ordered development of a sonar for its deep submergence rescue vehicle (DSRV) that will sound out and display small parts of a disabled submarine. The Westinghouse Electric Corp.'s Underseas division, Baltimore, is designing the sonar with a display resolution of one foot for an object 15 feet away. This difficult-to-obtain resolution is vital if the rescue vessel is to find and latch onto the hatch of crippled subs when the water is too turbid for visual observations.

To obtain the desired resolution, Westinghouse shortened the pulse rate to 20 microseconds and narrowed the beam to one degree. Power is held to less than 50 watts, and the external transducer and scan package can be no larger than 4 by 4 by 10 inches. Westinghouse has a $150,000 contract to build two systems for the DSRV program. Delivery is scheduled for mid-March.

California share of spending drops

California is receiving a smaller share of a bigger defense procurement budget and Texas is getting a bigger share, but otherwise the state-by-state breakdown of defense contract dollars looks like business as usual. However, California still holds a 2-to-1 lead over runner-up New York.

In fiscal year 1966, which ended June 30, California firms received $5.8 billion in prime contracts, or 18.3% of the $35.7 billion total defense procurement. In the previous year, California companies got $5.1 billion —22.1 of the $26.6 billion spent.

Trailing California in 1966 were New York with 8.9%, Texas with 7.2%, Connecticut with 6.5% and Pennsylvania at 5.3%.

Essa 3 comes to the rescue

The third in the series of operational weather satellites and the first of its kind to carry a one-inch vidicon camera system will be launched for the Environmental Science Services Administration on Sept. 21. Essa 3 will resume the global cloud picture coverage interrupted by the failure last month of one of Essa 1's two half-inch vidicon systems and the tape recorder that stored pictures for Nimbus 2's one-inch vidicon system. Earlier Essa satellites carried half-inch vidicons.

What increased chemical cleaning production 20% and cut solvent costs in half?

ITT says: FREON® solvents and Branson Ultrasonics.

At ITT's Electron Tube Plant in Easton, Pa., components are now cleaned in a Branson ultrasonic system using FREON TF solvent. Standard degreasing just couldn't do the job as efficiently. Time and money were lost through recleaning.

Now, FREON leaves components microscopically clean—the first time through. With its low surface tension it reaches into the smallest pores and crevices. With its high density, FREON carries off all traces of dirt, cutting oils and other contaminants. It dries quickly, leaving no residue.

The result: chemical cleaning production up 20% . . . solvent costs down 52% from $100 to $48 per week.

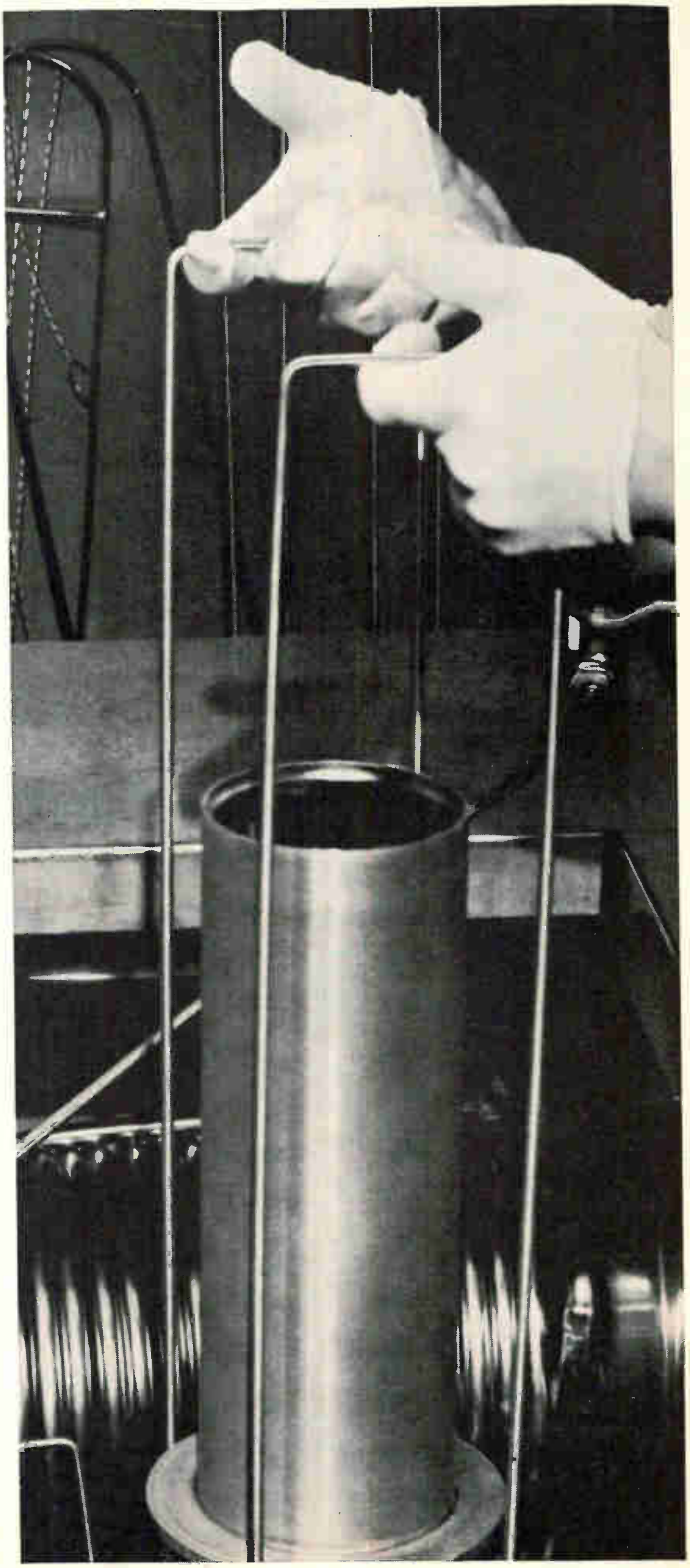
And, because FREON is nonexplosive and relatively nontoxic, no special exhaust system is needed. Its high stability permits recovery and reuse after simple distillation.

FREON solvents could be the answer to your cleaning problems. For more information, write Du Pont Co., Room 4342, Wilmington, Delaware 19898. (In Europe, write: Du Pont de Nemours International S.A., "FREON" Products Div., 81 Route de l'Aire, CH 1211 Geneva 24, Switzerland.)

DU PONT FREON Fluorocarbon SOLVENTS

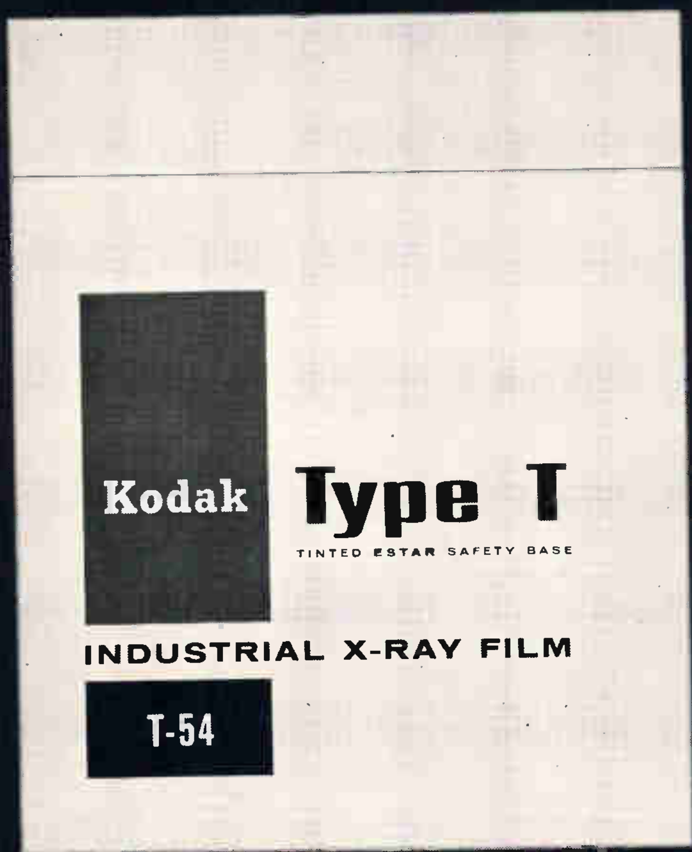
Better Things for Better Living
. . . through Chemistry

DU PONT



Circle 77 on reader service card

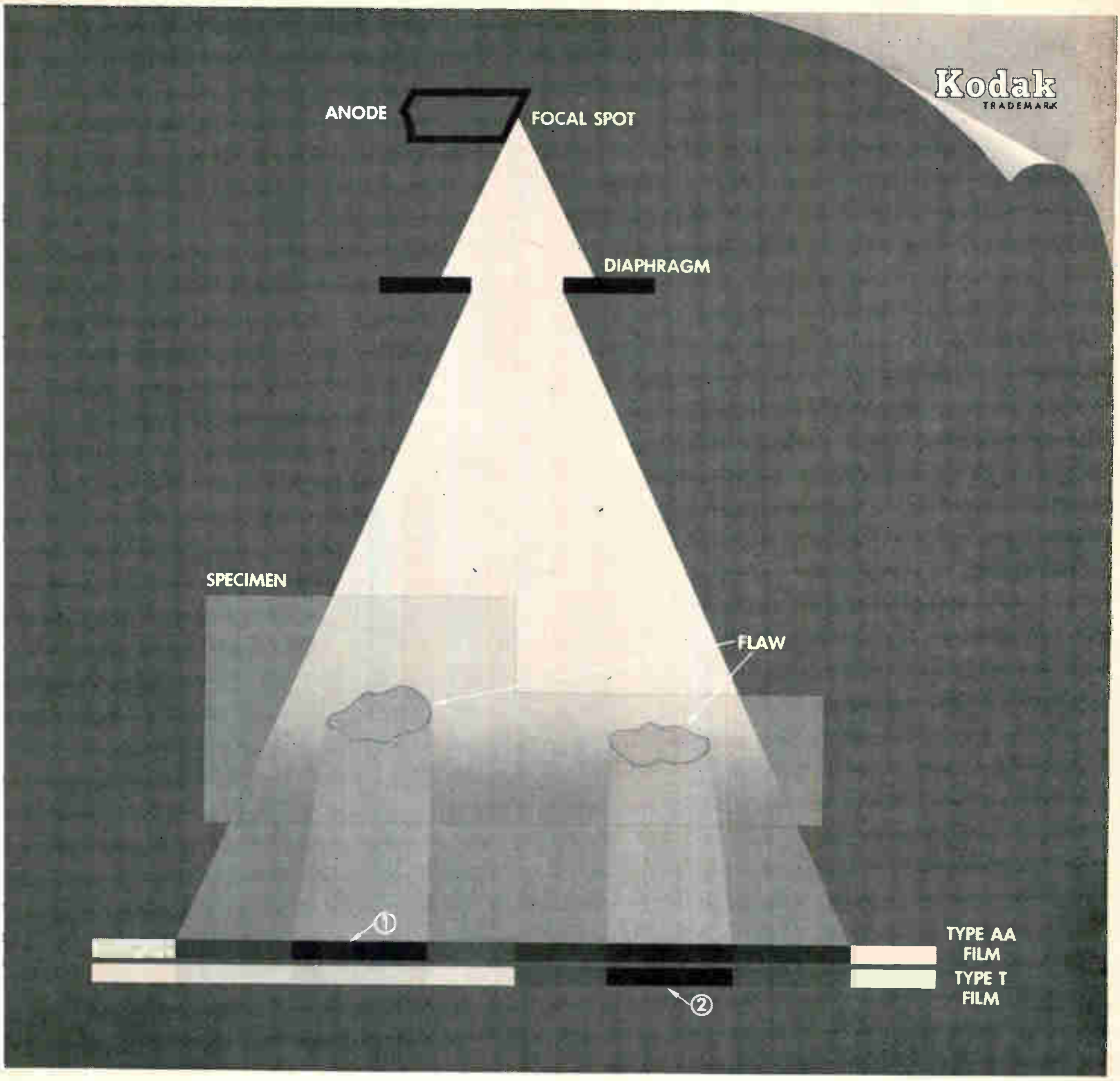
NEW FROM KODAK: INDUSTRIAL X-RAY FILM, TYPE T (ESTAR Base)



Now just apply a factor of 2, and you can establish a technique to rely on.

New KODAK Industrial X-ray Film, Type T (ESTAR Base), completes the most comprehensive line of industrial x-ray emulsions available; the five most popular Kodak films increase in speed by an approximate factor of 2. This means no more complicated calculation in selecting a film for a particular job. All you have to do is remember the factor of 2—then apply it.

Type T fits halfway between Type M and Type AA. It's the fastest extra-fine-grain film Kodak makes. It's specially



In the above illustration, (1) and (2) are the diagnostically significant images. KODAK Industrial X-ray Film, Type AA (ESTAR Base), is twice as fast as KODAK Industrial X-ray Film, Type T (ESTAR Base).

designed to do a number of critical jobs better than they could ever be done before. For instance, if specs call for an extra-fine-grain emulsion, but you need shorter exposures for higher production, you want new Type T: it has twice the speed of M, half the speed of AA.

Kodak's comprehensive line of industrial x-ray film emulsions means greater versatility and less mathematics in multiple-film exposure techniques. Now multiple-film exposures using Kodak films can be applied to a greater range of casting thicknesses, even extremely thick- and thinwall specimens.

Use the table on the right to choose the best combination of films for your needs.

Want to know more about KODAK Industrial X-ray Film, Type T (ESTAR Base), and how the factor of 2 table can make life simpler? Contact your Kodak x-ray dealer or write us to have a representative call from Kodak's Radiography Markets Division.

FACTOR OF 2 TABLE

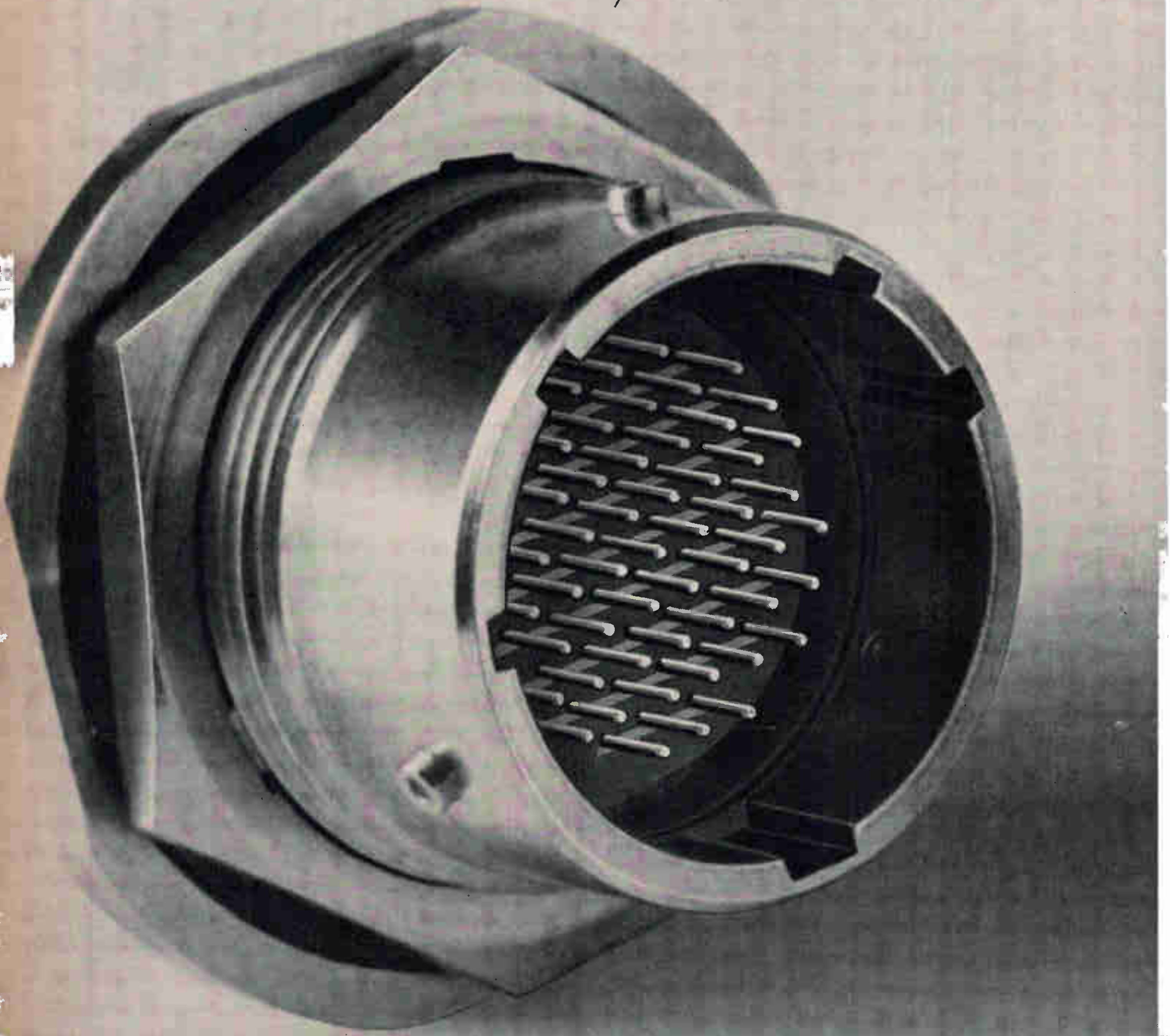
Type of Film	Approximate Relative Speed*
R (Single-Coated)	1
R	2
M	4
T	8
AA	16

*at 200 kv

EASTMAN KODAK COMPANY
Radiography Markets Division
ROCHESTER, N.Y. 14650

Circle 80 on reader service card→

NEW ASTRO/348



Illustrated: 16-55 Astro/348 subminiature

raises the limit on reliability

AMPHENOL HIGH-DENSITY SUBMINIATURE PROVIDES:

1. Maximum of 85 #22 contacts in size 18 shell.
2. Improved contact retention design eliminating metal retention clip, permitting .021″ minimum dielectric separation on .085″ contact centers.
3. Environmental performance to MIL-C-26500/38300 except temperature range −55 C to 150 C.
4. Elimination of damage to receptacle male pins during blind mating.
5. Optional assembly of contacts into retention disc outside of connector shell. (For visual assurance that contacts are installed properly.)

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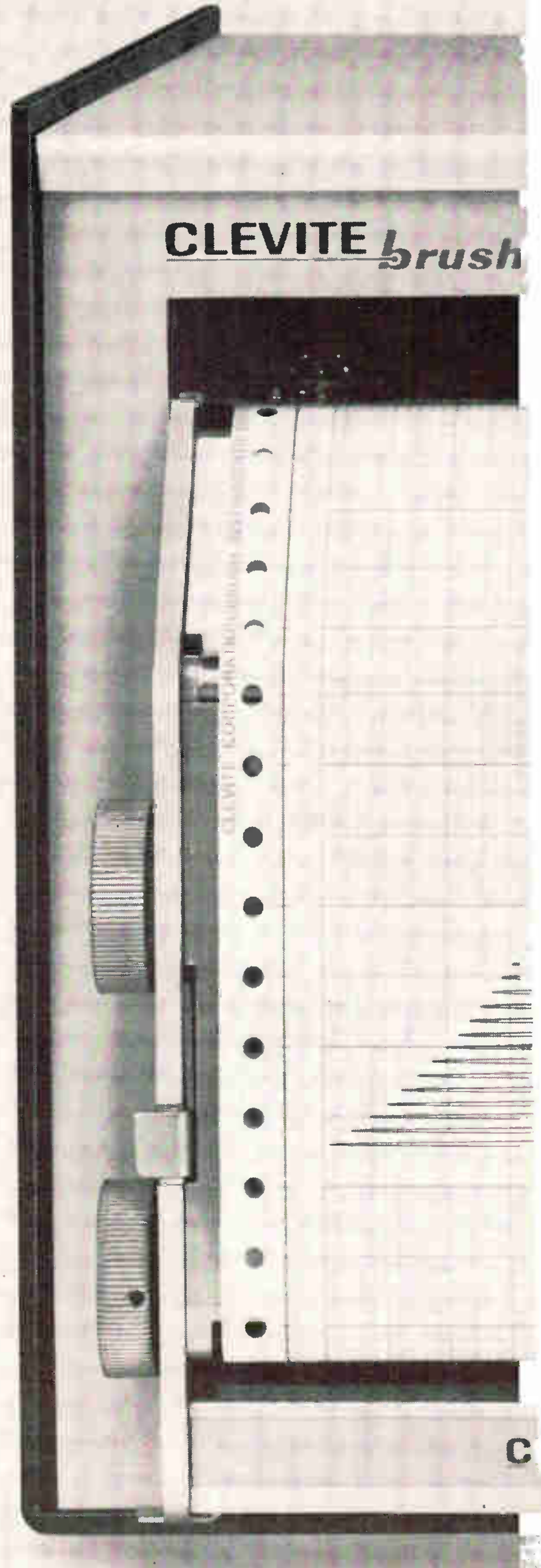
AMPHENOL CORPORATION

TM

Specify Amphenol . . . the leading name in cable, connectors, assemblies, RF switches, potentiometers, motors, microelectronics

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



Shown approx. 76% of actual size with 1 μv preamplifier RD 4215-70; event markers optional.

Meet the fastest, most accurate strip chart recorder on record: The new Brush Mark 250. When you read about all the features you'll know why we call it the first recorder for the perfectionists of the world!

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

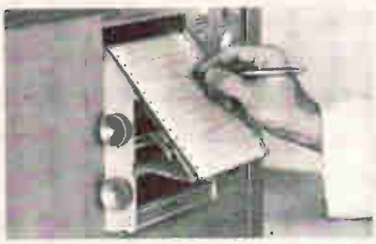
2 Wide selection of signal conditioners. Choose from 21 interchangeable preamps. Use one today; plug in a different one when your recording requirements change.

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

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

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

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

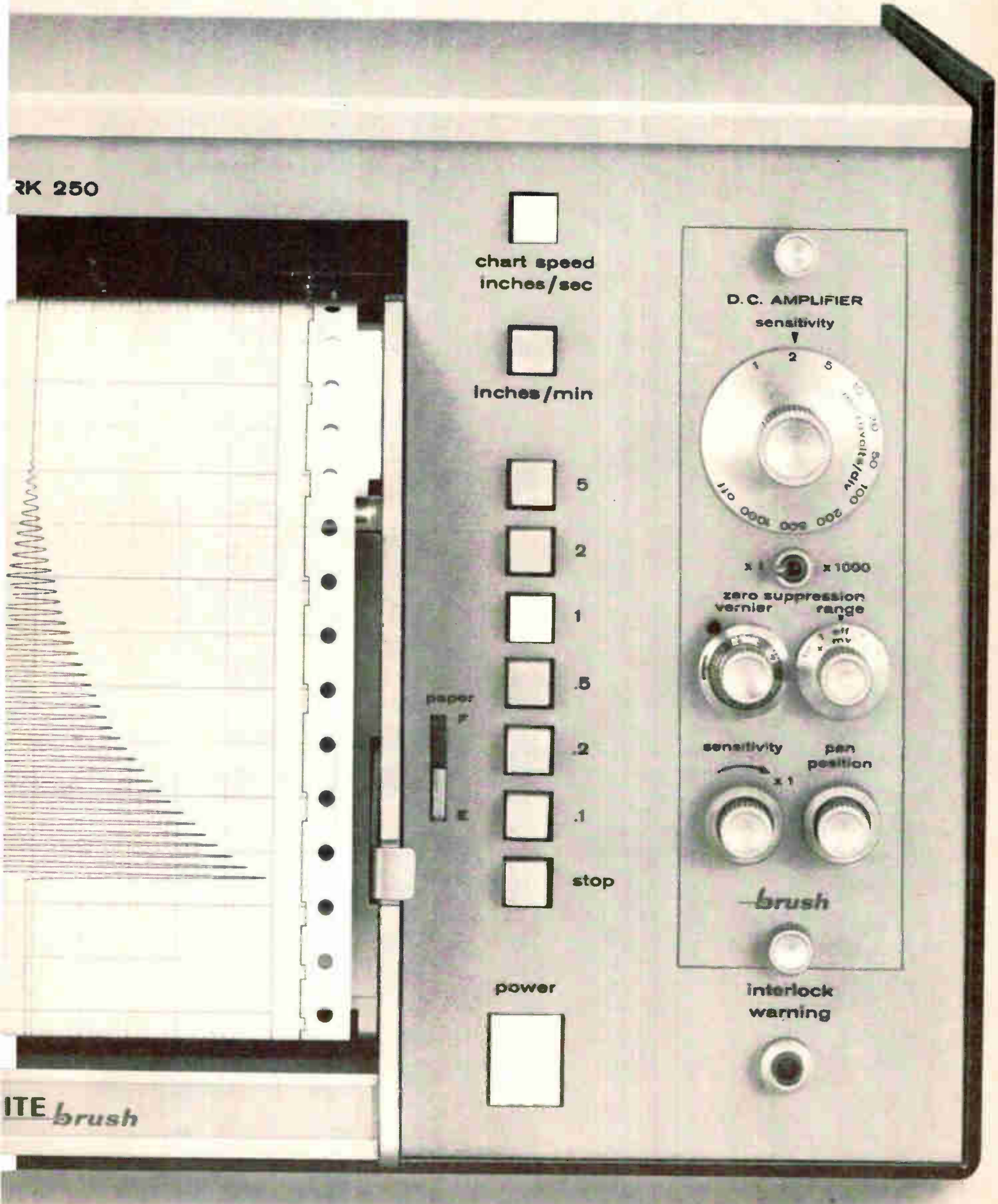


7 Removable chart paper magazine. Great for desk top record reviews. Man-sized manual winding knobs let you roll chart forward *and* back. Chart reloading is a cinch.

See what we mean? The Mark 250 is for the perfectionists of the world. Ask your Brush Sales Engineer for a demonstration. Or, write for chart sample and specifications. Clevite Corporation, Brush Instruments Division, 3633 Perkins Ave., Cleveland, Ohio 44114.

CLEVITE
brush INSTRUMENTS DIVISION

Circle 493 on reader service card



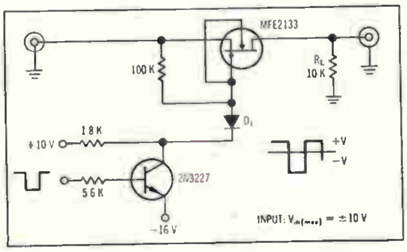
RK 250
chart speed
inches/sec
inches/min
5
2
1
.5
.2
.1
stop
paper
power
D.C. AMPLIFIER
sensitivity
x 1000
zero suppression
vernier
range
sensitivity
pen
position
brush
interlock
warning
ITE brush

NEW FET CHOPPER-MFE2133
FOR MILITARY/INDUSTRIAL DESIGNS

. . . featuring low r_{ds} "on" — 60 ohms (max)

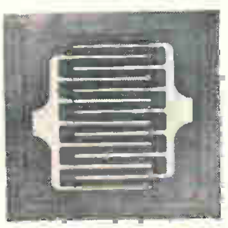
Here is *one* high-impedance device that can dissipate 1.5 watts. In addition, Motorola's TO-39 package — with low thermal resistance (6.7 mW/°C) — keeps the junction relatively free of troublesome temperature swings. The MFE2133 also offers low transfer capacitance (5 pF) in proportion to the low drain-source resistance. And, the combination makes for better all-around switching performance.

The MFE2133 is suitable for large gate voltage swings as a chopper. The circuit as shown allows input voltages of 10 volts. No transformer is required. The result, of course, is circuit simplicity and savings in component costs.



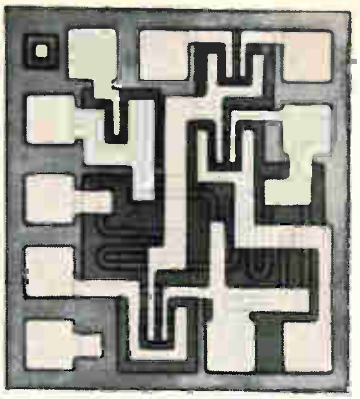
MEDIUM-POWER AMPLIFIER JFETs
FOR INDUSTRIAL & CONSUMER USES

The industry's first medium-power, high-gain, economical JFETs are Motorola types MFE2097 & MFE2098. Because of their natural high impedances, combined with a medium-power capability, you can often eliminate one transformer as well as large coupling and bypass capacitors in most designs. Even greater savings result from the low 100-up price of $4.90 — *less than half the price of comparable devices!* While these new FETs are ideal for driver stages of audio amplifiers and other audio communications equipment, they are also well-suited for use in analog control systems.



- Medium-power capability results from large geometry with many current paths.
- I_{DSS} ranges from 15 to 50 mA — MFE2097
  40 — 100 mA — MFE2098
- $|y_{fs}|$ = 10,000 μmhos (min) — MFE2097
  14,000 μmhos (min) — MFE2098
  . . . for extremely high gain.
- High-dissipation package — TO-39 with 1½" leads.

MAKE YOUR MOVE TO FETs WITH ANY ONE OF FIVE NEW PIECES FROM MOTOROLA



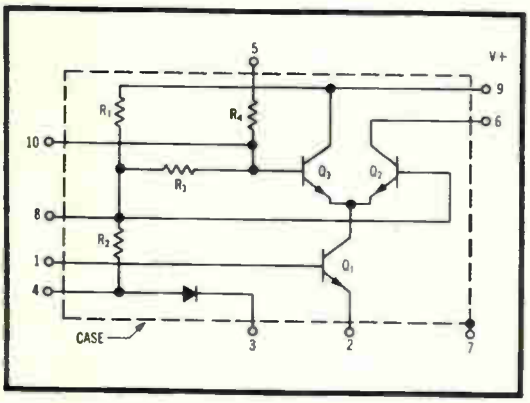
RF-IF CASCODE AMPLIFIER

TYPE MC1550

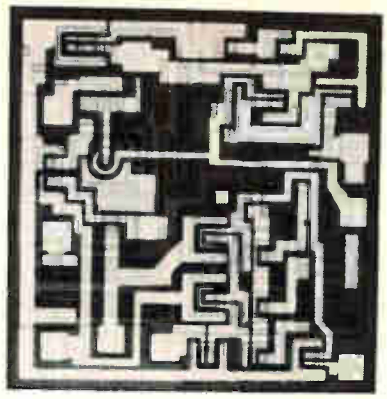
. . . with excellent AGC performance!

Typical performance:

- Very low internal feedback (y12<.001 mmhos) – for easy alignment and high stability
- High power gain — 25 dB@ 60 MHz
- Constant input impedance over entire AGC range
- Low noise figure — 5 dB@ 60 MHz



. . . ideal for your newest communication equipment designs.



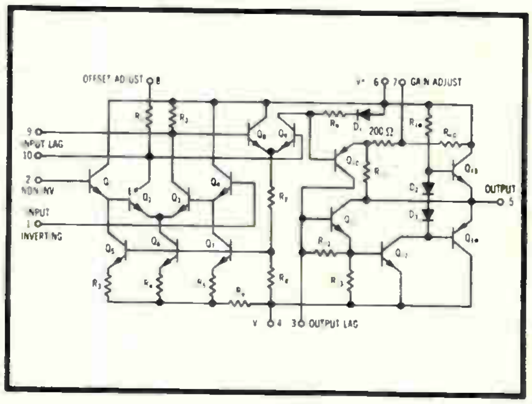
HIGH-GAIN OPERATIONAL AMPLIFIER

TYPE MC1533

. . . with extremely low drift (±3 μV/°C)

Typical performance:

- Open loop gain — 60,000
- High-input impedance — Z_{in} = 1 megohm
- Adjustable input offset (set V_{off} = 0 volts for minimum possible error signal)
- Large-output voltage swing — 13 volts (± V = 15 volts) with 2 K load



. . . for application in all types of low-level sensing equipment and analog computation systems.

Units for immediate evaluation are in stock at your nearest Motorola franchised semiconductor distributor. For complete technical details and/or application assistance in designing with these new integrated circuit amplifiers, contact your nearest Motorola field representative. Or write: Motorola Semiconductor Products Inc., Technical Information Center, Box 955, Phoenix, Arizona 85001.

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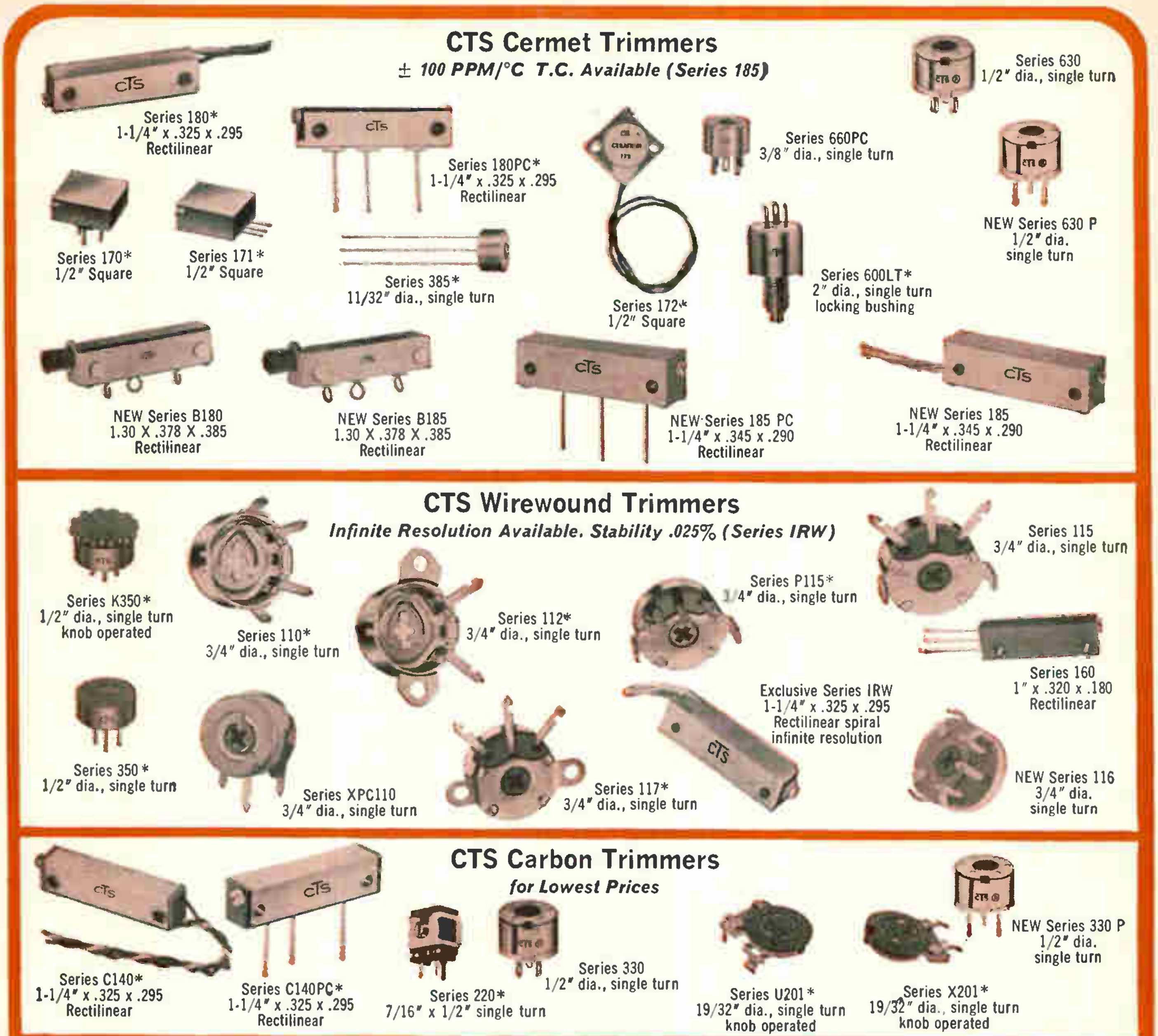

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Series 180* 1-1/4" x .325 x .295 Rectilinear
Series 180PC* 1-1/4" x .325 x .295 Rectilinear
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Series 630 1/2" dia., single turn
NEW Series 630 P 1/2" dia. single turn
Series 170* 1/2" Square
Series 171* 1/2" Square
Series 385* 11/32" dia., single turn
Series 172* 1/2" Square
Series 600LT* 2" dia., single turn locking bushing
NEW Series B180 1.30 X .378 X .385 Rectilinear
NEW Series B185 1.30 X .378 X .385 Rectilinear
NEW Series 185 PC 1-1/4" x .345 x .290 Rectilinear
NEW Series 185 1-1/4" x .345 x .290 Rectilinear
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Infinite Resolution Available. Stability .025% (Series IRW)
Series K350* 1/2" dia., single turn knob operated
Series 110* 3/4" dia., single turn
Series 112* 3/4" dia., single turn
Series P115* 3/4" dia., single turn
Series 115 3/4" dia., single turn
Series 160 1" x .320 x .180 Rectilinear
Exclusive Series IRW 1-1/4" x .325 x .295 Rectilinear spiral infinite resolution
Series 350* 1/2" dia., single turn
Series XPC110 3/4" dia., single turn
Series 117* 3/4" dia., single turn
NEW Series 116 3/4" dia. single turn
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for Lowest Prices
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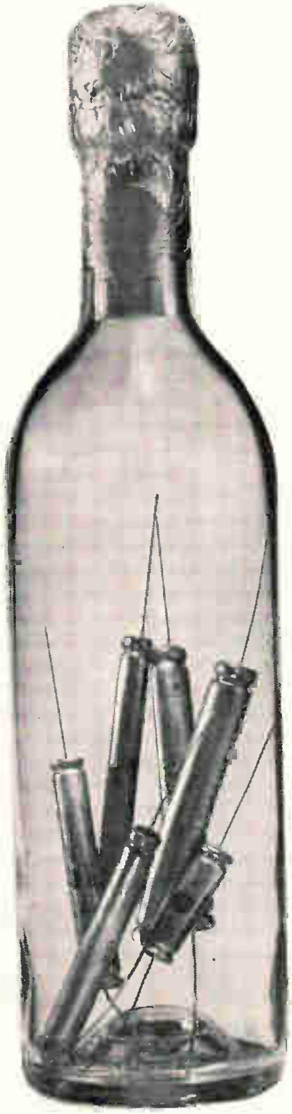
Series U201* 19/32" dia., single turn knob operated
Series X201* 19/32" dia., single turn knob operated
NEW Series 330 P 1/2" dia. single turn

ELECTRONIC INNOVATIONS IN ACTION

Vintage 1952



That's 14 years at 25C . . . with capacitance change less than 5%. The bouquet's still there! And long shelf life is only one reason for using G-E tantalum foil capacitors. Here are 3 others:

PROVED OPERATING LIFE: Our 85C tantalum foil has been on continuous test for over 50,000 hours, our 125C for more than 40,000 hours . . . with no capacitance change significant enough to affect performance. And with General Electric's Minuteman-proved true hermetic seal (now offered on most foil units for a small additional charge), life can be extended indefinitely.

REVERSE VOLTAGE STRENGTH: G-E tantalum foil capacitors are designed to withstand unsuspected reversals.

SELF HEALING: Forget about low impedance circuit problems and catastrophic failures. G-E tantalum foil capacitors are self-healing.

G-E tantalum foil capacitors are available in ratings up to 450VDC, 0.15 to 3500uf, —55 to 85 or 125C.

We've been proving—and improving—them for 17 years. They're virtually risk-proof. And may cost a bit more. But don't the best grapes make the best vintage?

For all the facts on G-E tantalum foil reliability, write for Reliability Report, Section 430-27, General Electric Co., Schenectady, N. Y. 12305

14 years proved shelf life is just one more reason for G-E tantalum foil

ELECTRONIC COMPONENTS DIVISION

GENERAL ELECTRIC

Circle 89 on reader service card→

 Circle 88 on reader service card

This year, you'll buy more than 2000 POLARAD modular microwave signal instruments ...40% more than last year.

Why?

Turn the page...

If card has been used, please circle reader inquiry card.

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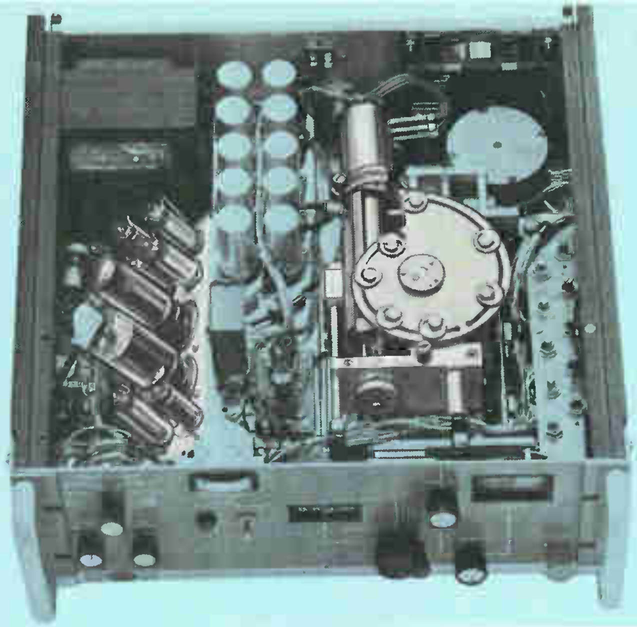


Here are 10 of the reasons!

1. Lowest Cost—yet highest quality, widest range, greatest flexibility. *Always* your best buy—and we can prove it!

2. True Modular Compatibility—buy only what you need, and add new capabilities as required—without wasteful overlap or performance compromise!

3. Highest Inherent Reliability—due to exclusive rock-solid ceramic klystron, ultra-rigid castings, advanced thermal design, and the most generous operating margins ever provided in this class of instruments.

4. Full Mechanical Flexibility—rack or stack these modern, attractive packages, in any combination—easiest instruments to use, to convert, to "build-in"!

5. Over 100 Useful Combinations—from only 11 basic modules; and that means capital-budget economy for the small laboratory or production-test facility!

6. Most Compact in their Class—more range, more function per cubic inch, per panel inch, per lb, per dollar—than is offered by any other precise microwave signal instrumentation.

7. ±0.5% Accurate Digital Frequency Readout—programmable by rear tuning shaft extension, too.

8. Ultra-Stable, Ultra-Pure—extremely-well-regulated power supplies, low thermal gradients, bimetallic cavity stabilization, and advanced shielding/filtering/isolating design ensure lowest drift, lowest incident AM and FM, greatest freedom from spurio signals.

9. Full Phase-Lock Compatibility—all models designed to accept phase-lock frequency stabilization from the Polarad Model 3815—the highest-performance master-crystal stabilizer you can buy.

10. In-Stock Availability—in small quantities, we ship from continually-replenished stock; larger quantities are scheduled on a 15-45 day cycle, currently. *(Demos? Overnight by air!)*

Yes,

IT'S TRUE—more engineers standardize on POLARAD Modular Microwave Signal Instrumentation *every year*... won't use any other kind, in fact. The card below will bring you *all* the reasons for PEI's popularity—by return mail!

Gentlemen:

☐ I want to see and try a Polarad Signal Generator. Have my local Polarad Field Engineer call me at once to arrange for a demonstration.

☐ I may have a requirement soon. Send me Bulletin EIS-663 by return mail, and have my local Polarad Field Engineer get in touch with me shortly thereafter, to discuss my requirements.

☐ I have no immediate requirement, but I want the complete new Polarad Signal Generator Catalog for

My application is __________

The frequency range of interest to me is __________

Name __________

Title __________

Company __________

Address __________

City __________

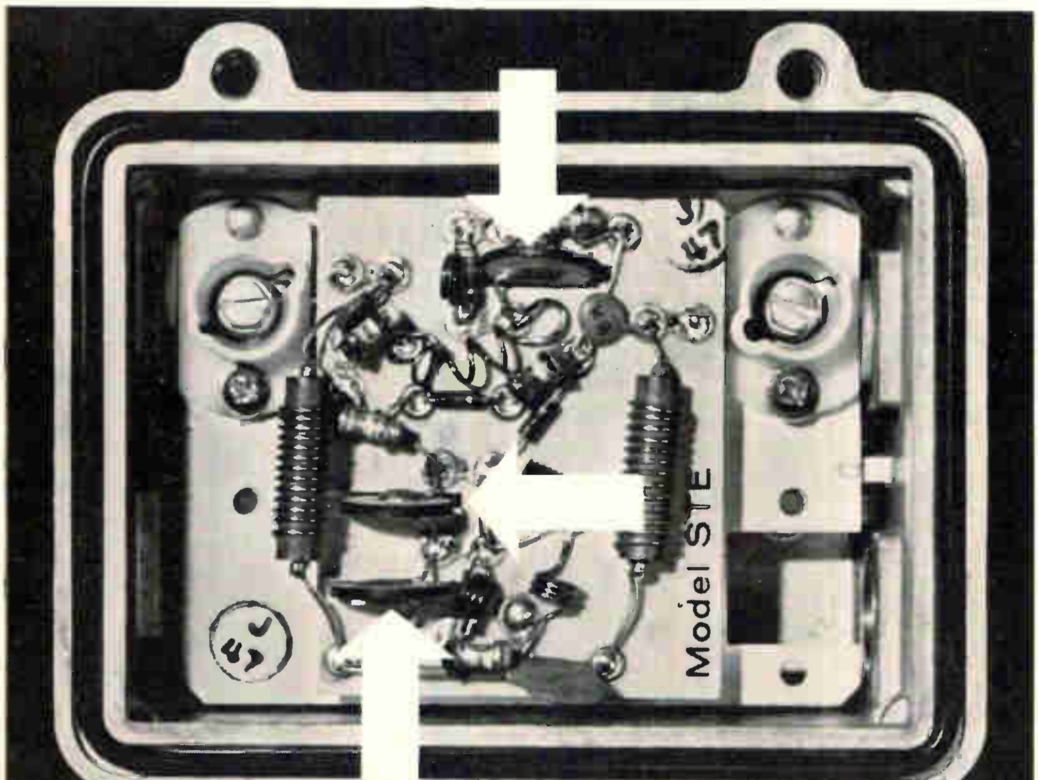
State __________ Zip __________

Send for this brand-new, comprehensive guide to the best in Microwave Signal Instrumentation . . . just off the press—Bulletin EIS—663

Use this card for Fast, Direct Actio

Keystone Thermistors ...very much part of the picture for Jerrold CATV

An essential element in the constant picture quality provided by Jerrold Electronics Corporation's Starline all-band solid state CATV distribution system are thermal equalizers employing Keystone disc type thermistors (see arrows).



Stationed at every third trunk amplifier location, each of these units, controlled by our thermistors, equalizes for 17db of cable at 216 mc at 70°F and compensates for temperature changes for 60 db of cable from a wintry low of —40°F to a summer high of 120°F. ■ We make thermistors that measure and control temperatures, provide power surge protection, sense liquid levels, etc., in over 400 standard types! Resistance values, temperature coefficients and physical sizes range widely to meet your needs. Let us have your inquiry. KEYSTONE CARBON COMPANY, St. Marys, Pa. 15857

Keystone *leads*
in versatile thermistor design

For any capacitor requirement ...fixed or variable... glass, quartz, air or ceramic dielectrics

Write

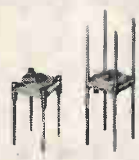
JFD ELECTRONICS CO. / COMPONENTS DIVISION
15th Ave. at 62nd St.
Brooklyn, N. Y. 11219

VAM

Please send me
VAM Air Variable Capacitor Bulletin VAM-65

Name__________
Title__________
Company__________
Address__________

JFD ELECTRONICS CO. / COMPONENTS DIVISION
15th Ave. at 62nd St.
Brooklyn, N. Y. 11219



MODUTRIM

Please send me Modutrim Ceramic
Variable Capacitor Bulletin MT-66

Name__________
Title__________
Company__________
Address__________

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15th Ave. at 62nd St.
Brooklyn, N. Y. 11219

UNICERAM

Please send me Uniceram Ceramic
Fixed Capacitor Bulletin UNM-65-2

Name__________
Title__________
Company__________
Address__________

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Brooklyn, N. Y. 11219

STANGARD

Please send me Stangard Ceramic
Variable Capacitor Bulletin STD-65

Name__________
Title__________
Company__________
Address__________

JFD VAM air variable capacitors maintain highest Q at high frequencies, offer ultra stability, smallest size. Request Bulletin VAM-65.

Modutrim *ceramic* variable capacitors feature wide △ 'C in extremely small and ultra stable circuits. Now 9 models in 4 configurations. Request Bulletin MT-66.

Uniceram High-Q Ceramic Fixed Capacitors combine exceptional stability, small size with minimum Q of 5000. Send for Bulletin UNM-65-2.

Low-cost Stangard miniature ceramic variable series for commercial and industrial applications provide 8 wide △ 'C in 4 versatile configurations. Write for Bulletin STD-65.

And remember JFD also offers industry's widest line of piston trimmer capacitors... over 3500 standard and special panel-mount and printed-circuit units. They're available with glass, quartz, air and ceramic dielectrics, with a wide variety of drive mechanisms for every requirement. Here are two examples.

For tuning and trimming applications, JFD's Super Max-C Extended Range EMC series offers unusually wide △ 'Cs—as wide as 1.5 to 300 pf with a single standard unit.

If space is highly limited, the miniature 950 series offers capacitance ranges as wide as 1.2 to 16 pf in a unit only 5/16" long.

These and many others are fully described in Catalog C-66. To obtain a copy, just add "and C-66" to any of the coupons above.

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

JFD

JFD ELECTRONICS CO. / COMPONENTS DIVISION • 15th Avenue at 62nd Street • Brooklyn, New York 11219 / Phone 212-331-1000
Sales Offices — Arcadia, California / Chicago, Illinois / Baltimore, Maryland / Saxonville, Massachusetts / Brooklyn, New York
New Hartford, New York / Cincinnati, Ohio / Philadelphia, Pennsylvania / Pittsburgh, Pennsylvania / Paris, France / Azor, Israel

Fast, convenient direct reading measurements of impedance and phase angle 500 kHz to 108 MHz...

THE 4815A RF VECTOR IMPEDANCE METER

This new Vector Impedance Meter is a versatile instrument that provides fast, direct reading measurements of impedance and phase angle over the frequency range from 500 kHz to 108 MHz. It is continuous tuning over this frequency range, and does not require balancing or data interpretation. Thus, it is an extremely useful tool for the evaluation of the complex impedance of both active circuits and components. The convenience of probe measurement, ease of operation, and direct reading features make the instrument equally useful for laboratory, receiving inspection or production line measurements.

The 4815A is a convenient and powerful measuring tool for any application involving measurements over a band of frequencies or in-circuit measurements. It may be used to determine the self-resonance point of capacitors, the series and parallel resonance points of crystals, or the characteristics of high frequency transformers and transducers. Price: $2650 f.o.b. factory. For complete specifications, contact your local Hewlett-Packard field engineer or write Hewlett-Packard, Rockaway Division, Green Pond Road, Rockaway, N. J. 07866; Europe: 54 Route des Acacias, Geneva.

Advantages:

Fast, continuous tuning from 500 kHz to 108 MHz

Provides data directly in impedance and phase angle, 1 ohm to 100K ohms 0 to 360°

Convenient probe for in-circuit measurements

Analog outputs permit permanent data recording

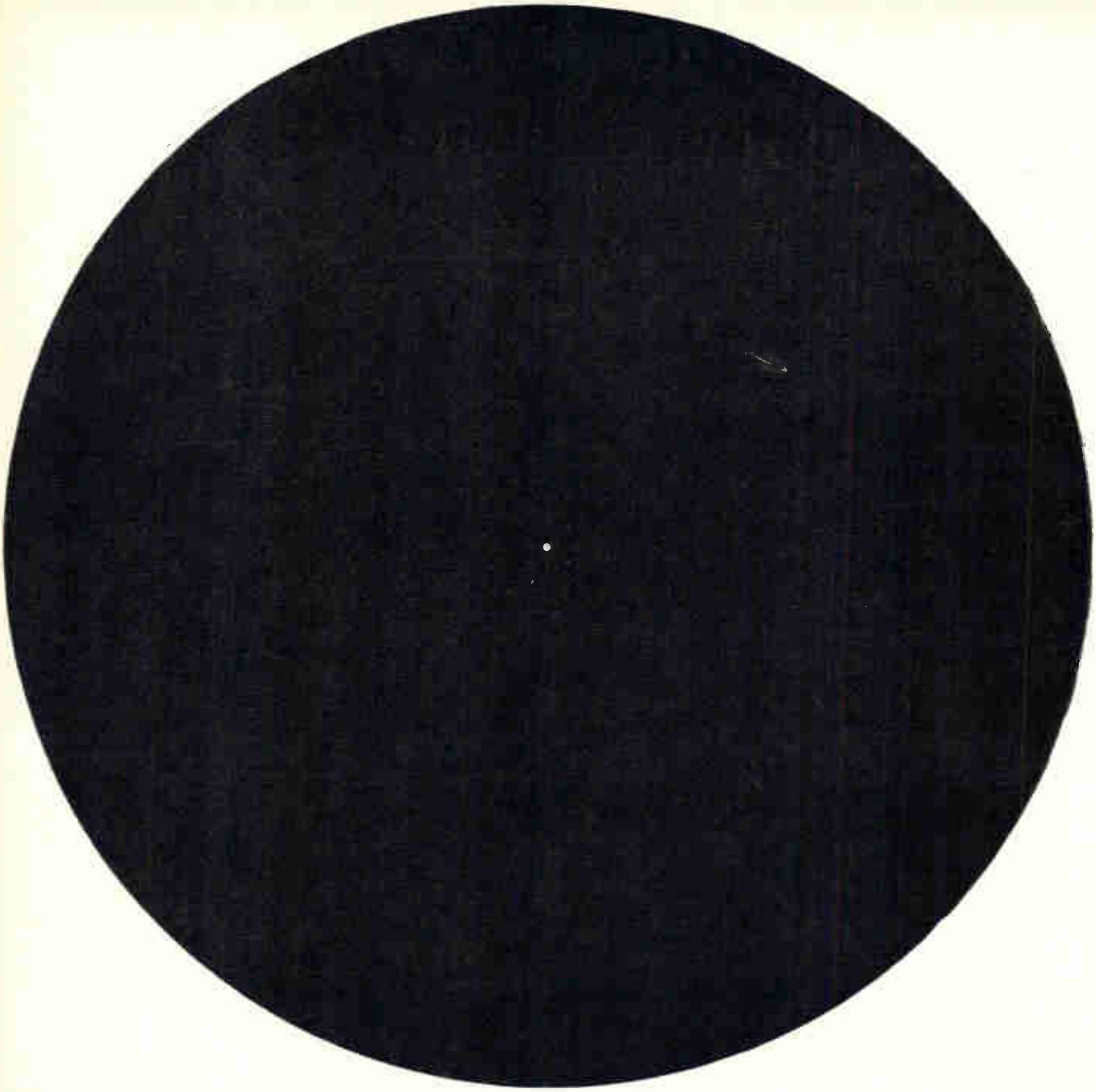
Self calibration check provides measurement confidence

Low-level test signal minimizes circuit disturbance

HEWLETT hp PACKARD

An extra measure of quality

Circle 93 on reader service card



The small pin hole in the center of this circle is more then enough light for MTI Image Orthicon Television Cameras.

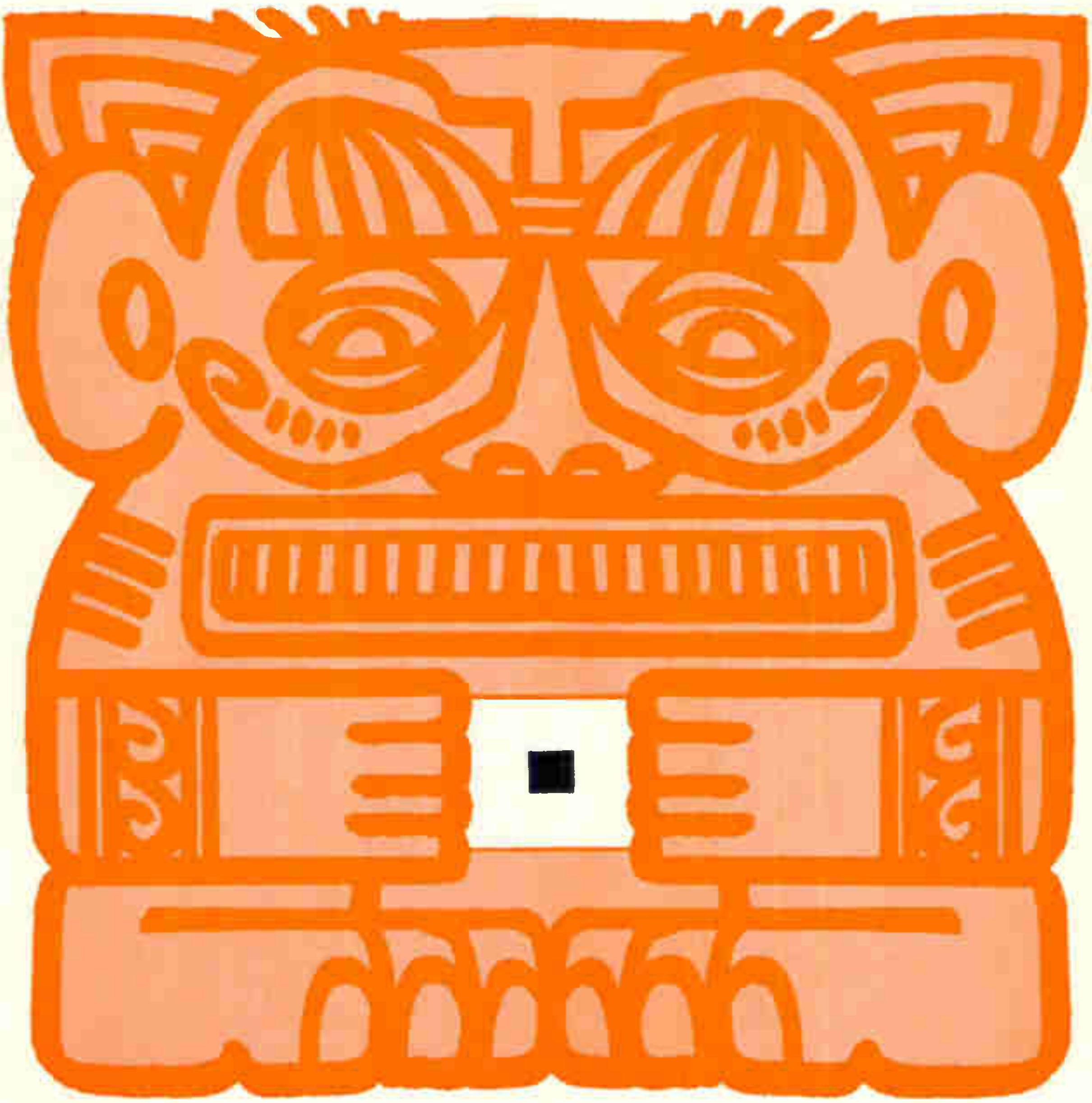
MTI is the world's largest manufacturer of low light level TV systems. This simply means that low light levels are our specialty. Specifically, at 1×10^{-5} foot candles of ambient light (approaching total darkness) MTI image Orthicon TV cameras will produce high resolution pictures. So the amount of light illustrated by the pin hole is more than enough.

There are hundreds of applications for MTI low light level equipment. Here are just a few: viewing nocturnal animals performing tasks, observing stars, examining small components such as transistors, diodes, capacitors and relays for minute flaws, and so on. In any application where low light levels are of prime importance, MTI can solve your problems.

Seven different line scan frequencies are available "off the shelf". Specific details available on request. If you have an application problem, call us. We can help.

mti MARYLAND TELECOMMUNICATIONS, INC.
York & Video Roads, Cockeysville, Maryland / Area code 301, 666-2727
WORLD'S LARGEST MANUFACTURER of low light level image Orthicon cameras

What brings a silicon chip like you to Taiwan, anyhow?



Low-cost packaging, what else?

Our new Taiwan production facility packages a complete line of transistors and integrated circuits at the most competitive prices around. And available, *now*.

FOR EXAMPLE: IMMEDIATE DELIVERY ON PLANAR AND PLANAR EPITAXIAL SILICON TRANSISTORS.
PNP: General-purpose amplifier medium-speed switch.
NPN: AM-FM receivers, 400 kc IF amplifier, 10.7 Mc IF amplifier, RF and video amplifier, low-noise high-gain amplifiers at low-level operation, UHF/VHF oscillator RF amplifier, general-purpose amplifier medium-speed switch, high-speed switching saturated-logic circuits.

Call for the name of your nearest distributor. **Philco Microelectronics Division Sales Offices:** 2920 San Ysidro Way, Santa Clara, California (408-245-2966) 999 North Sepulveda, El Segundo, California (213-772-6226) 594 Marrett Road, Lexington, Mass (617-862-6000) Benson Manor, Suite 114B, Washington Lane, Jenkintown, Pa (215-885-0430) 314 South Missouri Avenue, Suite 212, Clearwater, Florida (813-446-0124) 815 Connecticut Avenue N. W., Washington, D. C. (202-965-0903).

Microelectronics Division | **PHILCO**

SANTA CLARA, CALIF. • LANSDALE, PA • SPRING CITY, PA. | A SUBSIDIARY OF Ford Motor Company

Sometimes we worry about Jim becoming a Narcissist.

It all started with Celanar Polyester Film. We go to extremes to make it the cleanest, strongest, smoothest film available. Then challenge Jim, and our quality control experts, to find a flaw in it. But stare as he may, it's a rare day when Jim finds a wrinkle, a cross-buckle or other visual defect to mar his own reflection on a roll of Celanar. Which is enough to turn anyone into a narcissist.

The cleanliness of Celanar starts in our "White Room" production area at Greer, S.C., where air filtration systems trap dirt specks as tiny as 0.3 micron. But *clean* just begins to describe Celanar. It's stronger than the other polyester film. Retains its strength at elevated temperatures. Its gauge thickness is more uniform. We assure its uniformity by radioactively inspecting every foot of every roll before it's shipped. And Celanar film has excellent aging characteristics, resists embrittlement.

What's more, we go a long way to supply Celanar in the roll lengths, widths, and gauges most convenient to you. Even guard it during shipment with temperature recording flags. Or impact recorders, when necessary.

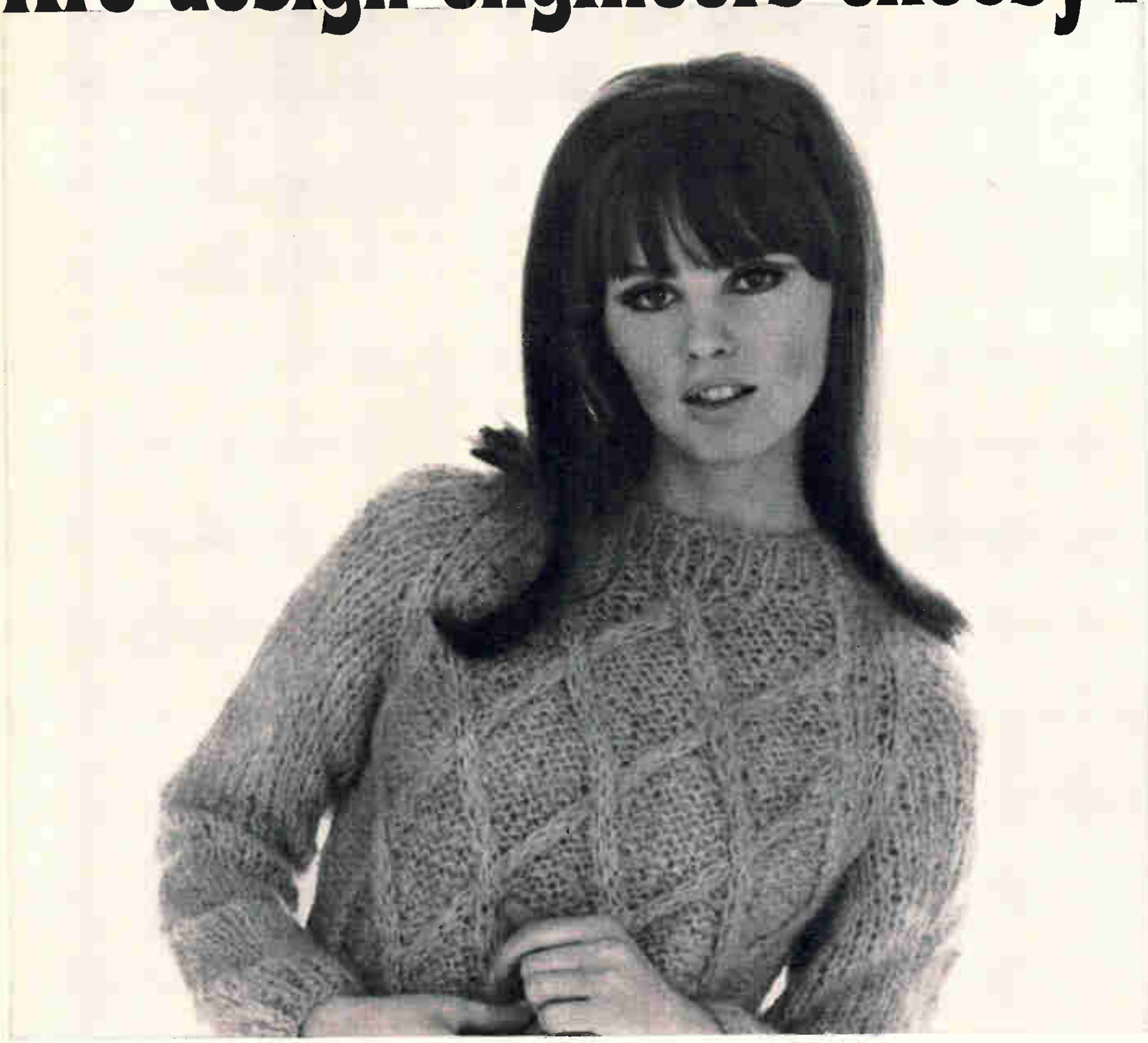
Send for complete details about Celanar Polyester Film—and how we can help you make the best use of it. Celanese Plastics Company, Dept. 133-C, 744 Broad Street, Newark, N. J.

Celanese Plastics Company is a division of Celanese Corporation of America. Celanese® Celanar®

CELANESE

Circle 97 on reader service card

Are design engineers choosy?



You bet they are! And the more discerning they are the better we like it.

That's why CAMBION® RF chokes molded with epoxy resins offer triple the advantages of competitive chokes. They provide greater resistance to external contaminants, cooler operating temperatures and tighter electrical tolerances. They are five times more water resistant, have 50% more dielectric strength and develop only half the heat of chokes encapsulated with alkyd resins.

Because they run cooler, CAMBION chokes last longer . . . achieve greater reliability. And by radiating less heat to neighboring components, these chokes improve the total reliability of your circuit assemblies.

CAMBION quality is a tangible thing. Special techniques, new equipment and our quality control program assure precise winding and careful handling of epoxy resins.

Seals are stronger, too. There is a more uniform bond between the epoxy, the windings and the terminal leads. Our molded RF chokes are rugged . . . built to take rough treatment both in production and in the field.

What's more, CAMBION advanced techniques in epoxy molding permit winding with larger diameter wire to give you reduced d-c resistance and high Q.

And you can specify tolerances to 5% or 10%. Standard CAMBION RF chokes combine consistency and uniformity in a variety of values, styles and sizes. There's a CAMBION choke built to meet your particular requirements, ready for immediate delivery off the shelf. We also produce many popular styles of RF chokes in conformance with Military Specifications. All CAMBION chokes are guaranteed for quality regardless of quantity.

Contact your nearest CAMBION distributor. Be choosy — there are 18 styles of CAMBION RF chokes in over 500 different inductance ratings, stocked and ready for shipment. For complete technical data, write Cambridge Thermionic Corporation, 401 Concord Avenue, Cambridge, Massachusetts 02138. In Los Angeles, at 8703 La Tijera Boulevard, 90045.

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CAMBRIDGE THERMIONIC CORPORATION

CAMBION®

Standardize on CAMBION . . . 21,541 guaranteed electronic components

AE's dry-reed switches are soggybobbinproof

On our PC Correeds, we soggy-proof the bobbins by molding them from a fiberglass-reinforced nylon. This strong material is marvelously low in moisture absorption. It keeps its shape even when humidity stays at the saturation point.

That's good to know if you're designing AE Correeds into a piece of remote equipment that must work in a Louisiana bayou. Or anywhere that is exposed to moist atmospheres.

Enough about bobbins. Let's take a look at the "business end" of a PC Correed. We separated the leads from the terminals – to eliminate strain. We *welded* the terminals, for a better electrical connection than possible with solder.

And for high-density packaging, we have designed low profiles, magnetic shielding and standard printed-circuit terminal spacing (multiples of 0.200").

You can get PC Correeds with 1, 2, 3 and 5 reedcapsules. In contact forms A, B, C and magnetic latching. Many of these modules are available directly from stock. Soggy-proof bobbin and all.

Could you use some helpful new design information? Ask your nearby AE representative for Circular 1070-B.

Or write to the Director, Electronic Control Equipment Sales, Automatic Electric Company, Northlake, Ill. 60164.

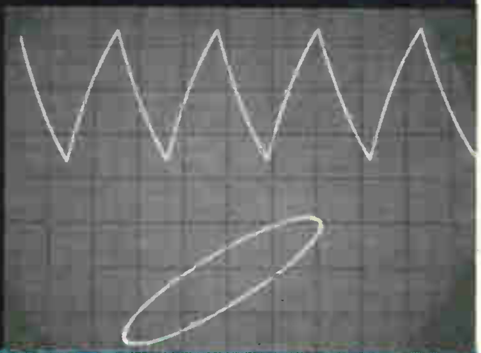
AUTOMATIC ELECTRIC

SUBSIDIARY OF GENERAL TELEPHONE & ELECTRONICS GT&E

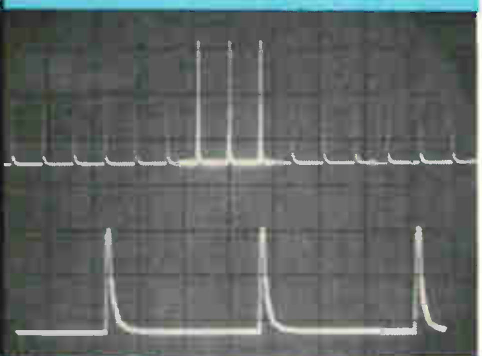
Circle 99 on reader service card

DUAL BEAMS DOUBLE SCOPE VERSATILITY!

Two Completely Independent Traces In One Display Make Comparisons Easier!

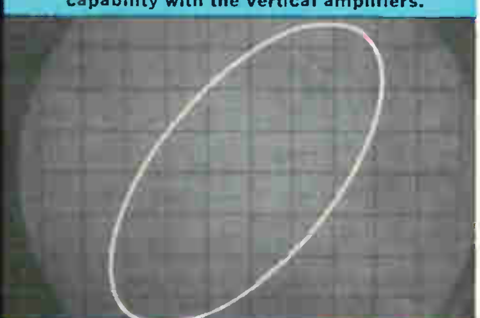


Two completely independent beams permit simultaneous X-Y and time plots.



Same signal can be shown at two different sweep speeds. Intensified portion is magnified.

Many different X-Y measurements are possible using the 5 mv/cm, 300 kHz horizontal capability with the vertical amplifiers.



50 kHz X-Y displays are possible at 100 μv/cm sensitivity, because phase shift between amplifiers is less than 2°.

Capability of many different displays through two independent CRT beams easily doubles versatility of the hp Model 132A Dual Beam Oscilloscope. This two-in-one scope allows simultaneous comparisons of two different traces—quantitatively and qualitatively!

Waveforms look the same from range to range with the Model 132A because the high sensitivity, stable vertical amplifiers retain full bandwidth of 500 kHz at all sensitivities from 1 mv/cm through 20 v/cm. At the most sensitive range, 100 μv/cm, bandwidth becomes 200 kHz.

Stability of the two vertical amplifiers is provided through use of Nuvistor tubes in an aluminum shock-mounted block. This heat sink keeps Nuvistor temperatures identical, which gives the scope excellent DC drift stability. When DC coupling is not needed, drift can be eliminated entirely by using the AC amplifier coupling switch.

Internal time base may be applied through one or both horizontal amplifiers, thereby allowing two different sweep speeds or a simultaneous X-Y and Y vs. time display.

Compare these and additional features such as outputs from each vertical amplifier for monitoring and recording; front panel beam finder to facilitate location of off-screen traces; non-glare, parallax-free internal graticule CRT; plug-in circuit boards for easy servicing. Get the double versatility of the hp 132A for the low price of $1275. Call your hp field representative for a demonstration. Or, write Hewlett-Packard, Palo Alto, California 94304, Tel (415) 326-7000; Europe: 54 Route des Acacias, Geneva.

HEWLETT hp PACKARD
An extra measure of quality

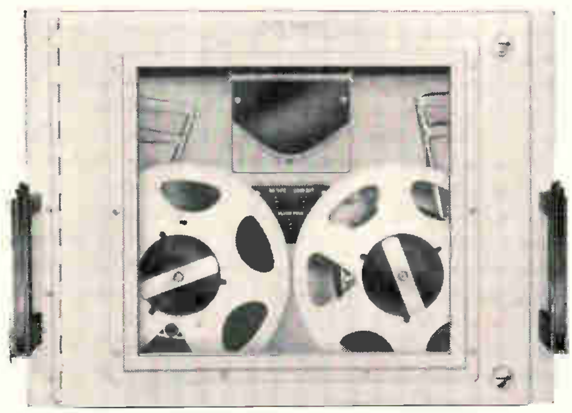
Circle 101 on reader service card

Why Photocircuits' tape readers were selected for...

APOLLO
GEMINI
LEM
MINUTEMAN
TITAN II
SHILLELAGH
GSM 133
CENTAUR
DIMATE
LCSS
TEAMS

... because of the simplicity and reliability of the printed motor single capstan drive, with the electronic control of all tape movement. Troublesome, high-maintenance components such as pinch rollers, brakes and clutches have been completely eliminated.

The fully militarized 500RM was specifically designed as a military unit ... not a "beefed-up" version of a commercial tape reader. It has successfully passed mil specs, MIL-E-16400 Class 3, MIL-T-21200 Class 2 and MIL-T-945; tests for shock, vibration, RFI, altitude, salt, sand, dust and heat and cold.



The 500RM reads bidirectionally at up to 1000 char/sec., has eight inch reels with proportional reel servos, accepts 5, 6, 7 or 8 level tape and has a MTBF of 5000 hours.

For full specifications on the 500RM, or on Photocircuits' complete line of commercial tape readers, contact: Photocircuits Corporation, Tape Reader Division, Glen Cove, N.Y.

Photocircuits
CORPORATION

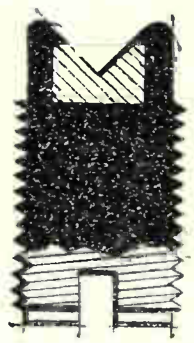
PC

TAPE READER DIVISION
Glen Cove, New York 11542

in meters

SPRING-BACKED

CUSHION-BACKED



FIXED

look for this

watch out for this

SPRING-BACKED JEWELS (left above) dissipate much of the shock energy on a movement's moving part. This prevents damage to the jewel and avoids subsequent "stickiness" or inaccuracy. In contrast are the two constructions shown above right . . . so-called cushion-backed and fixed jewels. The fixed absorbs no shock at all. The cushion-backed protects a little, but still won't do the job under the rugged use to which most of us put meters and test equipment. ■ On the other hand, a spring-backed jewel permits full deflection with less than 20% increase in pivot pressure. Simpson makes a complete selection of spring-backed meter movements as well as fixed. The spring-backed type costs only about 20¢ more than a cushion-back, and 40¢ more than a fixed jewel. Is the spring-backed jewel worth the small extra amount? You bet it is, say most of our customers. ■ Write for Stock Catalog No. 2073 which lists 1400 sizes and types. It may well be the cure for meter headaches and complaints in your equipment.

AGM

Simpson
INSTRUMENTS THAT STAY ACCURATE

SIMPSON ELECTRIC COMPANY
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WORLD'S LARGEST MANUFACTURERS OF ELECTRONIC TEST EQUIPMENT

Circle 103 on reader service card

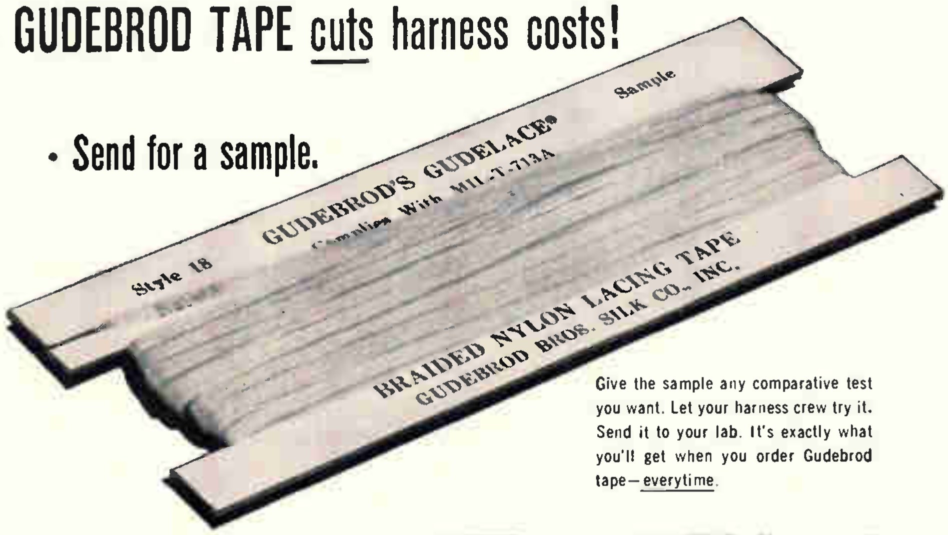
MIL-T SPECS call for 22% to 32% wax coating on LACING TAPE.

• But what really is the right amount for trouble-free, tight-knot lacing?

• GUDEBROD KNOWS. They make yard after yard after yard exactly right!

• GUDEBROD TAPE cuts harness costs!

• Send for a sample.

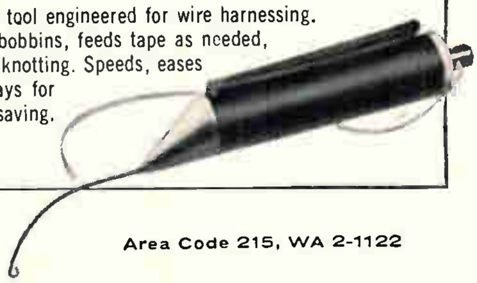


Give the sample any comparative test you want. Let your harness crew try it. Send it to your lab. It's exactly what you'll get when you order Gudebrod tape—everytime.

You are often required to lace with tape that meets MIL-T Specs—with a specified range of wax content. But that's no assurance that you are using a tape that ties tight, holds tight, that probably won't be rejected—unless, of course, you have Gudebrod Gudelace. Like all Gudebrod Lacing Tapes it's manufactured under strict quality control including the wax coating. Every yard of Gudelace is impregnated exactly the same, exactly right. You can count on that—and on speedier, easier, better harnessing. That's where you save real money. Want to know more? Get in touch with Gudebrod.

GUDEBROD CABLE-LACER

The first hand tool engineered for wire harnessing. Handle holds bobbins, feeds tape as needed, grips tape for knotting. Speeds, eases harnessing. Pays for itself in time saving.



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GUDEBROD BROS. SILK CO., INC.

FOUNDED IN 1870

Electronics Division

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Familiar with TEFLON®? Try this quiz.

① TEFLON is transparent!	TRUE	FALSE
② TEFLON can be cemented!	TRUE	FALSE
③ TEFLON can be heat sealed, thermoformed, heat bonded!	TRUE	FALSE
④ A TEFLON film is made by Du Pont!	TRUE	FALSE

All are true with TEFLON® FEP film: a new dimension in TEFLON

Let us tell you more.

Du Pont Company, Room 4612, Wilmington, Delaware 19898

TEFLON FEP fluorocarbon film brings the familiar properties of TEFLON *plus* a new form, versatility and ease of fabrication for applications like: conveyor belting, critical industrial packaging, gaskets, roll covers, reinforced plastics curing, closures, high temperature electrical insulation, flexible flat cable, printed circuitry.

The application I am considering is ____________________

____

To do the job, a material with the following critical properties is required:

	TEFLON FEP FILM	MY REQUIREMENTS
Mechanical	high impact, abrasion, tear strength. Useful at cryogenic temperatures	
Thermal resistance	from −240 to +200°C. continuously	from ______ to ______
Chemical resistance	the most inert of all plastics	to ______
Release, anti-stick	superior	yes ______ no ______
Electrical	No tracking, non-wettable, non-flammable, low power factor and dielectric constant, dielectric strength: 4,000 vpm for 2 mil film.	
Weatherability	high transmittance of ultraviolet and all but far infrared, inert to outdoor exposure	

I am interested in these forms and processing techniques:

Film thickness	½, 1, 2, 5, 10, 20 mil	thickness ______
Heat bonding	directly to metals	substrate ______
Heat sealing	provides a plastic weld at 300°C.	yes ______ no ______
Cementing	available with one or both surfaces treated to accept conventional adhesives, for laminating to metals, rubber, glass cloth, asbestos fabric, etc.	substrate ______ one side ______ both sides ______
Thermoforming	a true thermoplastic, thermoform at 525°F., with conventional equipment	yes ______ no ______ shape ______

Please send full appropriate technical data.

Name ______ Address ______

Company ______ City ______ State ______ Zip ______

Job Responsibility ______ Business Phone ______

TEFLON® FEP fluorocarbon film

BETTER THINGS FOR BETTER LIVING . . . *THROUGH CHEMISTRY*

Circle 105 on reader service card

If every design engineer knew what Slater can do in solving semiconductor problems

we would be 10 times larger!

We're not a large company because we are not widely known . . . as yet. But we're getting there because of our specialized skills in solving unique semiconductor problems.

Slater produces in volume *single junction* diffused 1 and 2 ampere silicon diodes up to 2000 volt PIV. All units provide a 20% safety factor on all specifications and are controlled avalanche.

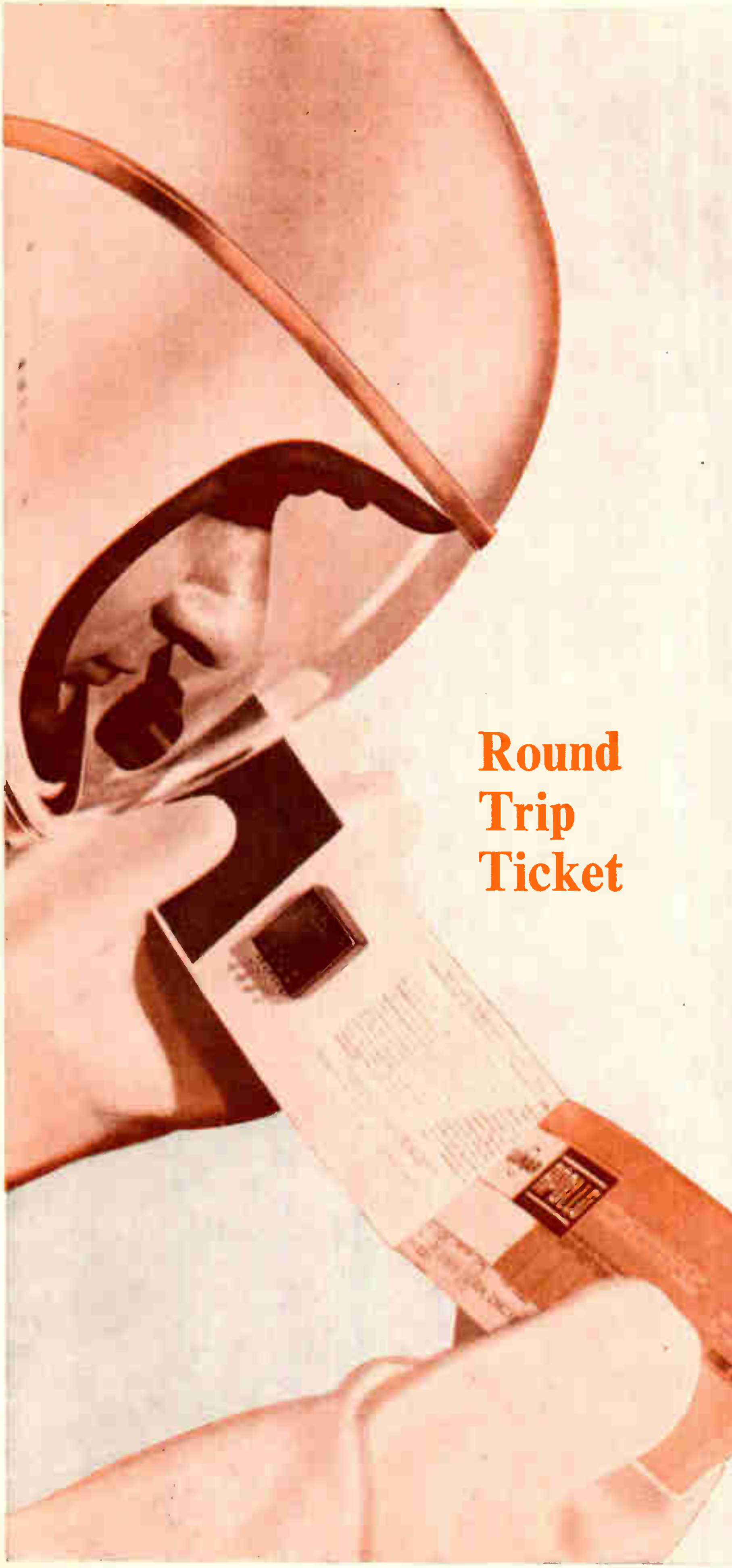
We would be pleased to send you samples of our 1 ampere hermetically sealed diodes up to 1000 volts PIV with guaranteed recovery times of less than 100 nanoseconds. We want you to see how these Slater units expand operation of your circuits into very high frequency applications.

Don't just accept these claims; test us. Find out first hand how Slater can supply 1N3189 series diodes to MIL-S-19500/155 and high voltage rectifiers and assemblies at the lowest price per voltage and ampere rating in the industry.

Let us sample you with our product. Then offer us an opportunity to quote to your requirements. Test us on the quality and reliability of our rectifiers and assemblies and the down to earth prices we offer. You'll like the answers you get. This is the way we'll grow.

Slater

SLATER ELECTRIC INC.
SEMICONDUCTORS DIVISION
45 Sea Cliff Avenue • Glen Cove, N.Y.

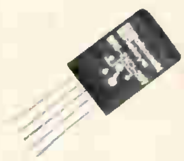


Round Trip Ticket

What more can we say about relay reliability. In the strange environs of space, warranty can be a pretty empty word. We like "integrity" better...a projectable promise backed by the relay industry's most comprehensive quality assurance program.

Babcock's tenure in space began with the earliest satellites under mission-critical conditions, progressed through the life-critical missions of Mercury and Gemini, and continues now with Apollo. This is not only experience and capability...this is responsibility.

To illustrate, let's look at Apollo—from the ground up.



Transistor Can, SATURN 1C stage

10 amp., Crystal Can, Latching & Non-Latching SATURN II & IV B stages

10 amp., 4 PDT Latching & Non-Latching APOLLO service module

½-Size, Latching and Non-Latching, APOLLO command module

Each of these units has its own pedigree, and is produced on our own "TLC" line with Tender Loving Care. Each is the result of close customer liaison and application assistance. Each is the finest, most reliable relay of its type in the world.

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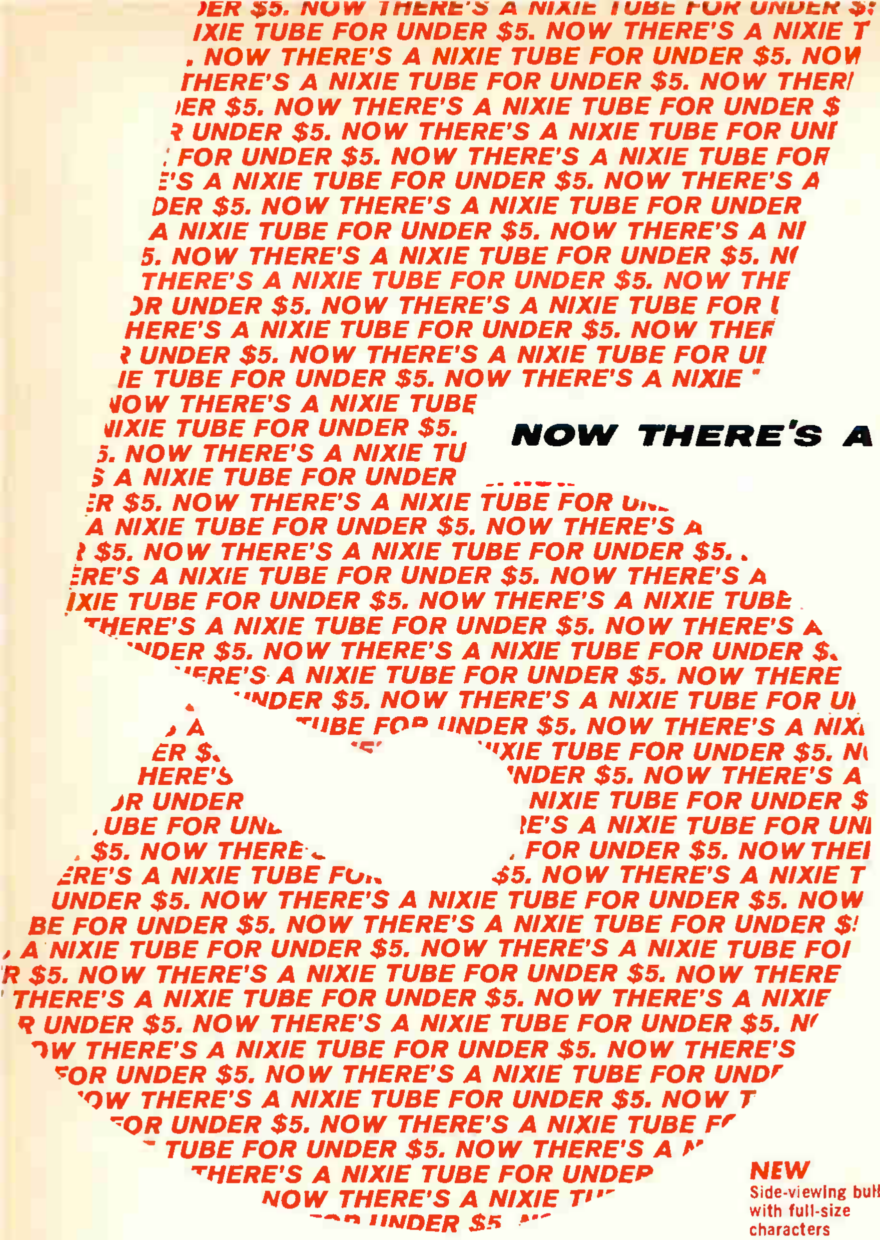

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September 19, 1966 | **Highlights of this issue**

Technical Articles

Computer-aided design: part 1
page 110

The electronics industry is on the threshold of a new era of circuit design. The computer is invading the decision-making province that was once exclusively the engineer's. Computer-aided design is changing the role of the circuit designer and promises to increase engineering efficiency. This article is the first in a series that will appear through most of the rest of 1966. For the cover, a photographer at the Norden Division, United Aircraft Corp. caught a Calcomp plotter as it drew an integrated circuit design created by a computer.

Looking through glasses for new active components:
page 129

Glass can now be made to have the same properties as semiconductors, photoconductors, magnets, transducers, optical switches, memory materials or insulators and dielectrics. Yet device designers have not used this versatile material to its fullest advantage. The author describes some of the unusual properties that make glass useful in active electronic components.

Integrated circuits and pulse coding mean new gains for telephony:
page 139

Pulse-code modulation in communications is an extremely attractive idea because telephone engineers can see a rising demand for digital data transmission coming from everywhere in the world as more government agencies and companies go to computerized operations. In addition, pcm means more channels on a line and can lead to improved voice quality. Integrated circuits now make the conversion from traditional analog circuits to pcm economically feasible.

Air navigation system tests grounded:
page 151

Loran navigation receivers once had to be taken on long flight tests to make sure they worked properly. A new simulator, developed for the Federal Aviation Agency, permits full scale tests in the laboratory. The techniques may be extended to test other navigation systems and coordinate converters.

Coming October 3

- **Voltage-tunable filters**
- **Using glass in integrated circuits**
- **Switching pulse-code modulated signals**
- **Electronics in an orbiting laboratory**
- **Opinion: Rebuttal on obsolescence**

Computer-aided design: part 1
The man-machine merger

The circuit designer and the computer are headed for a new relationship, say the experts, with the computer as the bright, young, junior partner and the designer as the undisputed boss

By Donald Christiansen
Senior associate editor

"When this circuit learns your job, what are you going to do?" asks a poster now appearing widely in subways and buses. Intended to alert the public to the need for job retraining to replace obsolete skills, the rhetorical question can strike momentary terror in the heart of the circuit designer, who suddenly wonders if he is designing himself out of a job.

Unmistakably, the electronics industry is on the threshold of a new era in circuit design. Directly ahead is the period in which circuits—specifically, computer circuits—designed by an engineer may invade the decision-making area that was once the engineer's exclusive province. The circuits he designs may in turn design new circuits.

Faced with this probability, the old-time electronicker, operating solely by intuition and experimentation, has cause for fear, but only if he turns his back on the revolution in progress and ignores the fact that the computer is already working on circuit design. The machine is assisting the engineer by

- Performing repetitive calculations.
- Evaluating the effects of changes in circuit parameters caused by component tolerances, drift, etc.
- Studying the feasibility and cost of circuit optimization.
- Simulating component failure.
- Developing optimum physical device layouts and optimum circuit interconnection paths.

A computer can do a little or a lot; it can be a modest aid or a tremendous help. It can be used at few or many stages of the design process. To decide on the best use of so versatile a tool, computer application consultants at the International Business Machines Corp. suggest that the design process itself be examined first. After that, one can judge which stages of the process should be computerized. The designation of a program depends on this judgment. Unfortunately, confusion is rampant in definitions that relate to computer-aided design. Among terms used frequently and often indiscriminately are these: design synthesis, design automation and computer-aided design.

Design synthesis may be thought of as the creation of a set of specifications describing a circuit. Design automation, on the other hand, would include detailed specifications and machine instructions required to fabricate the circuit. And computer-aided design (CAD) indicates the use of a computer at one or more stages of the design process.

The design process

The designer usually goes through some sequence like this: statement of the problem (or goals), choice of attack, paper design, breadboarding or modeling, optimizing and checking effects of limit devices.

At the optimizing stage he diddles potentiometers and otherwise changes parameter values, then checks circuit performance. The process is cut and try. Since his equipment must operate with components that have some production spread, he then searches for limit devices (transistors with high and low-limit beta, for example) plugs them into the breadboard and notes the output. If it is not within spec he'll go back, change some other component or parameter value, and check the result once again. At some point short of perfection he'll freeze the design, knowing full well that he'd better, or the equipment may become obsolete even before the prototype is built.

Super slide rule

Assigning the repetitive cut-and-try tasks to a computer is the opening wedge to completely automated design engineering. IBM calls this use of a computer the "big slide rule" technique. While helpful, it is limited both in sophistication and payoff.

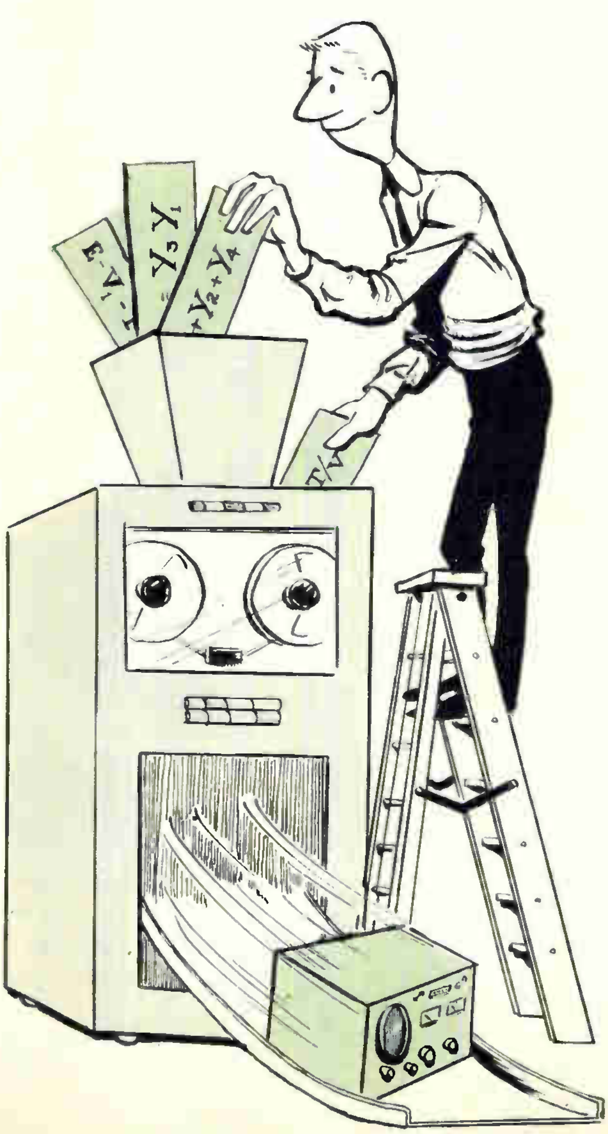
If a computer can simulate a circuit, it can easily perform a given calculation on demand. It is when the computer is called upon to employ its decision-making powers that it plays its most significant role. Then, it can be used to relieve the designer of many intermediate decisions ("Do we have enough gain in this stage, or should we go back and change a resistor?").

Such an approach represents the beginning use of the computer in design synthesis with the computer as a junior partner in the man-computer merger.

Design automation: an example

Since the goal of the design process is to build equipment, the ultimate use of the computer would be its control of the fabrication process for the equipment it has "designed." When design engineering and manufacturing are linked by computer, the process is termed design automation. Carried to its extreme, the technique would mean that equipment could be manufactured directly from the customer's order with little manual engineering. At that point, the computer will be in the main stream of the design function; preparing the engineering paperwork—detailed configurations, machine tool instructions and manufacturing control data—by which the equipment is manufactured.

An example of how close design automation is to reality—at least in one area—is the work done by the Norden division of United Aircraft Corp. under an Air Force contract. Using the same basic circuit definition that was used in analyzing the circuit, Norden developed programs that—through a series of man-machine interactions—convert the circuit to a practical integrated circuit format, occupying a minimum of area, with an optimized interconnection pattern. The intermediate-frequency amplifier on page 118 was designed this way.



I. Among the techniques, dilemmas galore

The computer is a rigid machine, refusing categorically to accept information it cannot comprehend. Communicating with it poses a barrier to the circuit designer because, the experts say, designers know little about programing and programers know less about circuit design.

"What shall we tell the computer a circuit is?" is the basic question. Once a model of the circuit has been developed that the computer can assimilate, it is relatively simple to feed the machine a list of trial inputs, parameter values and constraints. In effect, the computer is told: "Here's what we want in, here's what we want out, and here's a trial design—let's see what happens."

Model behavior

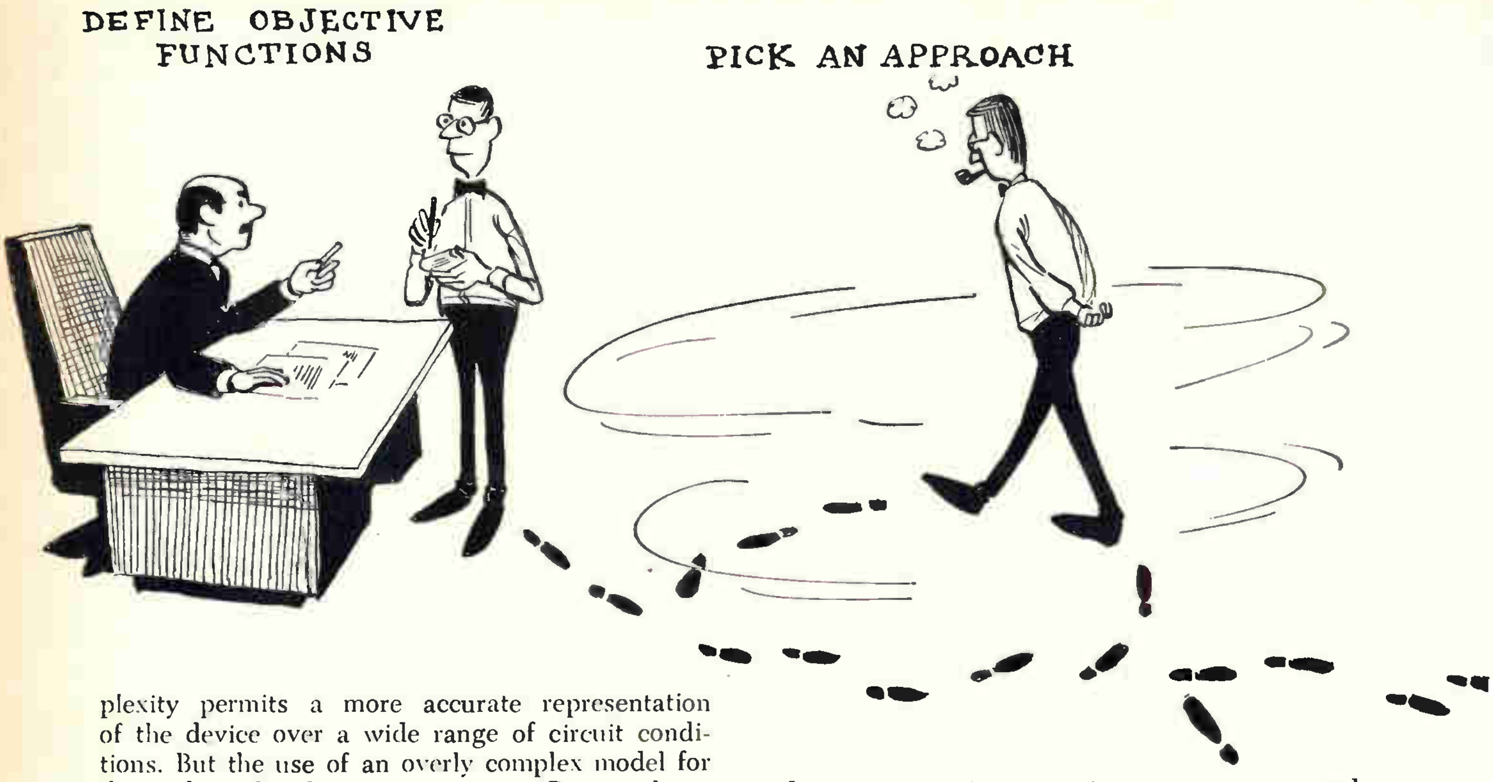
The accuracy of the circuit model fed to the computer determines how valid the computer analysis is. A bad model yields a doubtful result.

Some circuit elements such as resistors are better behaved than others—and can quite readily be represented to the computer. But active devices are tough to model because they're not linear and react to temperature and frequency in a way that is not easily formulated.

Research on what constitutes good models has led Cyrus Harbourt, a professor at the University of Texas, to zero in on the narrower, but extremely salient question: "What shall we tell the computer a transistor is?"

Harbourt says a good device model should successfully predict actual device performance; contain only parameters which can be determined from practical measurements made on real-life devices; and finally, it must be capable of being understood by the computer.

A device model can be simple or complex. Com-



plexity permits a more accurate representation of the device over a wide range of circuit conditions. But the use of an overly complex model for the task at hand is time-wasting. Conversely, a simple model is efficient when assigned an appropriate task, but useless when overtaxed.

Perhaps the most complex transistor model is the one for NET-1, one of the two widely used general-purpose computer programs. A transistor type is defined for NET-1 by 36 parameters, which can be prestored on a library tape, or developed for a new transistor.

In contrast, the other major electronic circuit analysis program, ECAP, uses a do-it-yourself device model. ECAP provides resistors, capacitors, inductors, dependent current sources, and a generalized ideal switch. The chief asset of the switching function is that the value of parameters can be altered when selected currents reach predetermined values.

Most designers say ECAP is superior when flexibility is sought, but they give the nod to NET-1 for accuracy. Harbourt notes that with NET-1 a complex model must be used even when dealing with problems as simple as a saturating logic circuit.

Users of NET-1 express dissatisfaction with the library of device models available to them. Time, effort, and a free interchange among users may resolve the difficulty.

Little work has been done on models for the more exotic solid state devices. Even field effect transistor models are hard to come by. Moreover, some phenomena encountered in devices are difficult to model—minority carrier storage time is an example. One of the few companies developing models for offbeat semiconductor devices is Design Automation, Lexington, Mass.

The designer is still a long way away from the day when he'll push buttons that feed circuit performance requirements into a computer and get a finished circuit—integrated or otherwise. Today he is more likely to make his inputs in the form of cards or tape bearing data that defines portions of the circuit, operating constraints, and input signal conditions. Outputs for the most part are printed out.

Toward the ideal: NET-1 and ECAP

The experts guess that there are anywhere from 200 to 2,000 programs for aiding circuit design. Admittedly, the bulk of them are limited in scope and documentation. Programs proliferate because it's often quicker to develop a new program than to locate, decipher and debug someone else's.

Like the ideal secretary, a computer program must be versatile, efficient, accurate, and above all, available. To gain wide acceptance, a program should handle steady state (a-c and d-c) analysis as well as transient analysis. Franklin Kuo, network analysis expert for Bell Telephone Laboratories, Murray Hill, N.J., thinks the perfect program would have a simple input language, handle a wide range of models of physical devices, and provide a nonlinear analysis capability. Kuo says that if automatic parameter modifications were added—it could replace breadboarding—a design engineer couldn't ask for anything more.

The two programs which come closest to meeting the ideal requirements are NET-1 and ECAP. NET-1 was developed on the Maniac II computer under the auspices of the Atomic Energy Commission at the Los Alamos Scientific Laboratory of the University of California, Los Alamos, N. M. Since its completion in 1962, the program has been translated into versions for the IBM 7040, 7044, 7090 and 7094 computers, and is used at over 60 commercial, government and university installations here and abroad.

One of the chief virtues of NET-1 is that it's easy to use. Specifically, the user need not know how to solve simultaneous nonlinear differential equations, nor manipulate matrix algebra, nor cope with numerical instability. He doesn't even have to know simple programing techniques and, when analyzing a circuit, needn't have the slightest idea how the circuit works.

If instructed properly, the computer will deliver an accurate circuit analysis—one which may provide some insight into hazy circuit operation. NET-1 can simulate fixed value resistors, capacitors, inductors and mutual inductive couplings. Additionally, it can handle both junction transistors and diodes, fixed-value voltage sources and several classes of time-dependent voltage sources —including trapezoidal, sinusoidal, exponential and tabular waveshapes.

The transistor model for NET-1 requires specification of 36 parameters; the diode model, 13.

ECAP, the other major general-purpose program, stemmed from the joint efforts of IBM and the Norden division of United Aircraft. ECAP is written in Fortran for the 1620, 7090 and 7094.

Using ECAP, the designer develops an equivalent circuit based on the circuit he plans to study. In it, he is free to use any representation of a transistor or diode that he chooses, providing it is modeled with conventional circuit elements.

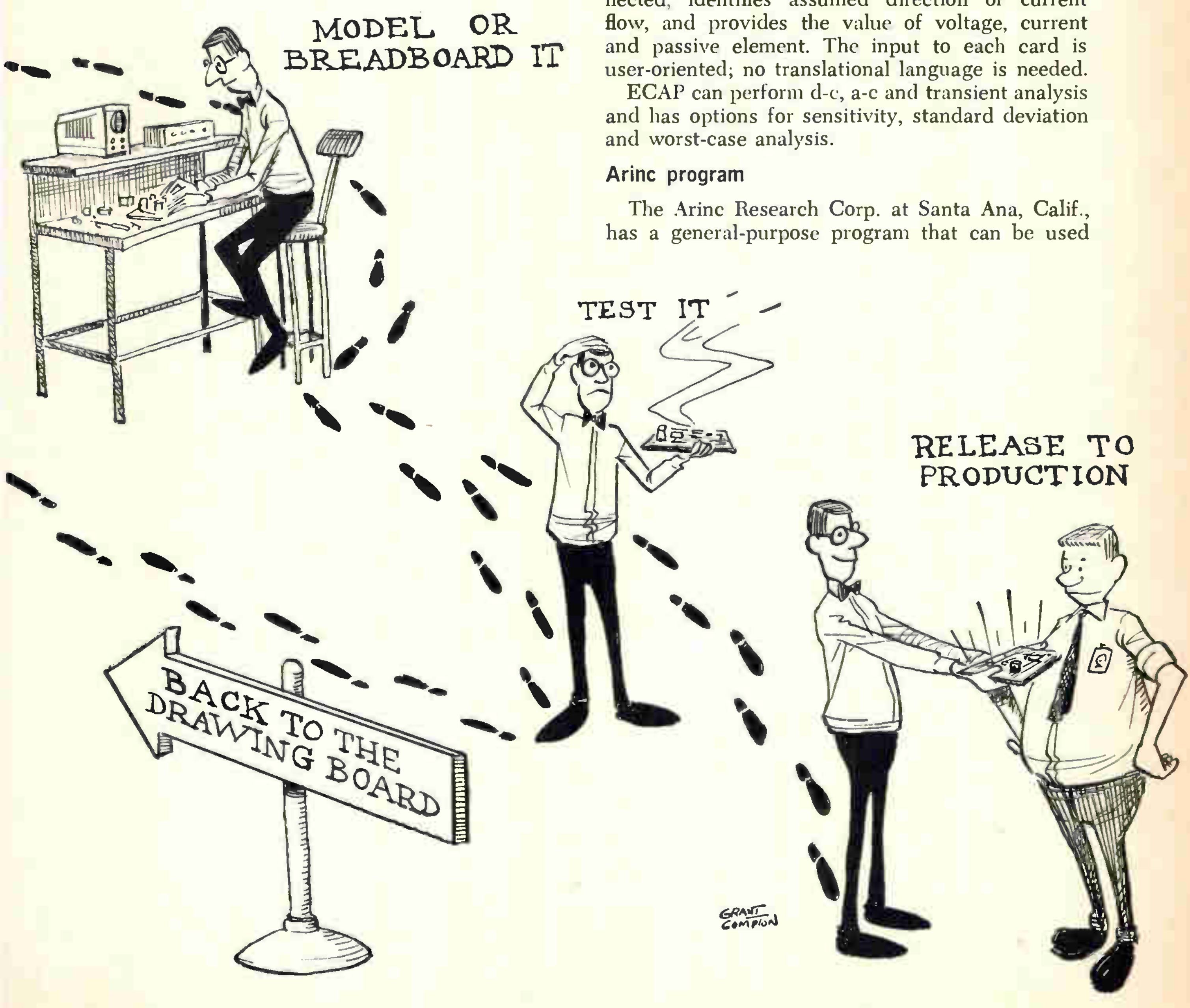
In ECAP, the matrix approach is fundamental and information on basic network branches are key entries to the computer. Each branch comprises three network elements, pictured on the next page—a passive element (resistor, capacitor or inductor) a voltage source and a current source. Branch terminations are called nodes.

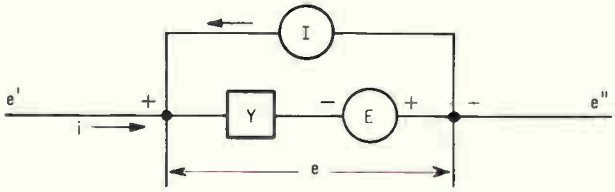
Cards, representing the branches of the equivalent circuit, are punched. Each branch card contains data that tells where the nodes are connected, identifies assumed direction of current flow, and provides the value of voltage, current and passive element. The input to each card is user-oriented; no translational language is needed.

ECAP can perform d-c, a-c and transient analysis and has options for sensitivity, standard deviation and worst-case analysis.

Arinc program

The Arinc Research Corp. at Santa Ana, Calif., has a general-purpose program that can be used





Basic branch for which an ECAP data card is prepared. E and I are voltage and current sources, respectively, e and i are branch voltage and current, Y is the conductance of the passive element, and e' and e'' are node to datum voltages.

without knowledge of either Fortran or machine language. A circuit to be analyzed is described by a linear equivalent circuit for which n simultaneous equations in n unknowns are written. A source deck of punched cards contains the circuit equations in standard matrix notation as well as equations describing the desired output solutions.

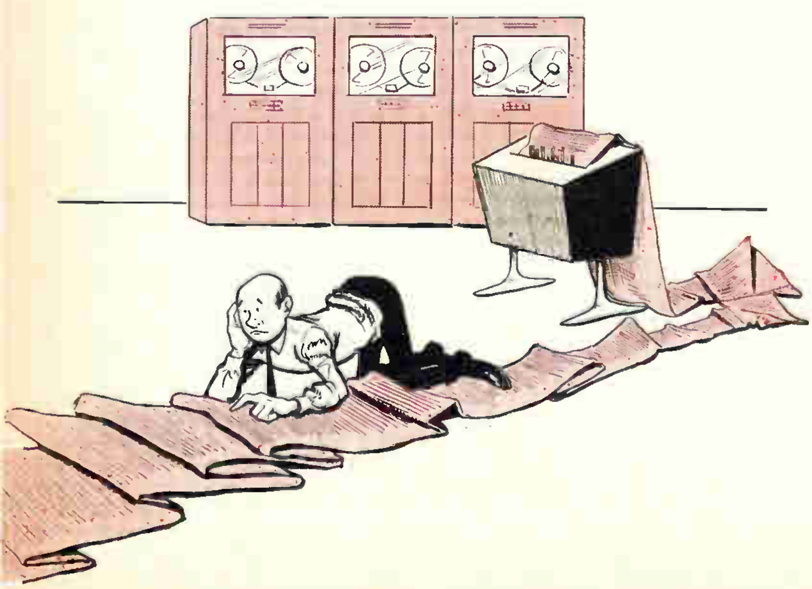
Parameter data for the Arinc program goes on a separate deck of punched cards. Each card represents one circuit element, and contains such data as nominal value, tolerance limits, temperature drift limits, production distribution characteristics and, if appropriate, alternate values.

The engineer feeds the two card decks to the computer, then specifies the analysis options. These include one-at-a-time parameter variation and sensitivity tests, worst-case solutions with all components at drift limits, a Monte Carlo analysis to determine the probable spread of circuit performance in large-volume production, and solutions representing combinations of circuit values.

An example

It may be profitable to follow the steps of the Arinc program on a very simple common emitter amplifier [p. 119]. First, the designer converts the schematic to the equivalent circuit shown. Then he writes a matrix of five simultaneous equations representing the five circuit loops.

Each of the elements of the equivalent circuit gets an input variable number, V_1, V_2, V_3 . . . etc. Each of the coefficients of the equations is punched on a separate card in terms of input variable numbers.



Then cards are punched—one per input variable—that contain the nominal value, tolerance limits, distribution shape, and so forth. For this example, data on the card is listed in the first five columns of the table below the circuit schematics. If an order goes into the computer for a sensitivity test, using the circuit and input variable data that the designer has supplied, the machine will print out the data listed in the last three columns of the table. It's evident that the culprits are R_3, R_4, and the transistor beta; that is, if the values of R_3, R_4 and h_{FE} are permitted to reach their tolerance limits, large shifts occur in amplifier gain.

It should be obvious that the Arinc program cannot be listed among the most sophisticated, since the user must still write the circuit equations. But in the future he'll merely have to supply the equivalent circuit, says Robert Mammano, specialist in circuit analysis for Arinc.

II. Practice: Some successes, some failures

Among firms already applying computers in circuit design are the Autonetics division of North American Aviation, Collins Radio, Hughes Aircraft, Friden Corp., RCA, and Bell Telephone Laboratories.

Having worked on computer-aided design since 1959, Autonetics has produced several home-grown programs. Mostly they are for digital circuitry, such as computer circuits for Minuteman airborne computers. For two years Autonetics has used a program which accepts point-to-point topology and prepares equations automatically [See "Circuit analysis by computer," p. 120]. The division has also applied computer-aided design to advanced radar systems using integrated circuits.

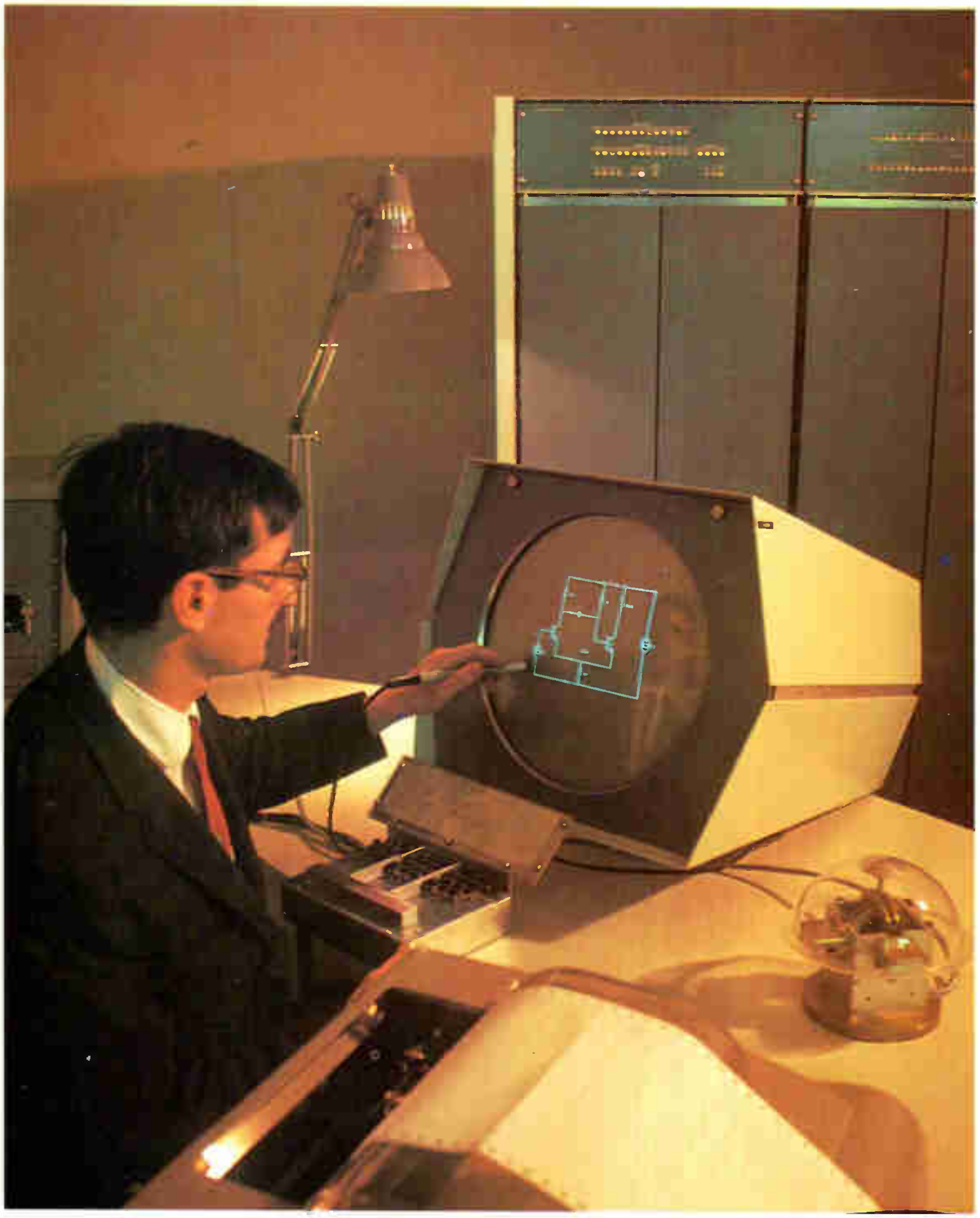
Simulating failures

Autonetics also has a failure mode and failure effects analysis program. In the program, destruction of one circuit element is simulated and overstress of other components noted. At the same time, voltage readings at monitor points within the circuit are recorded. With this data as a guide, the engineer can rapidly judge which component has failed in an actual circuit, without removing individual components for testing. The advantage is obvious, but a specific example is the Minuteman D37 computer; once a component—even a good one—is removed it cannot be replaced.

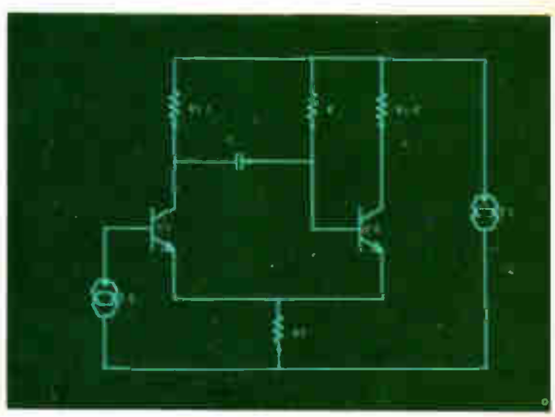
In one of Autonetics' programs, a computer will select the best device among several. In effect, the computer is fed the characteristics of several transistors along with the circuit requirements. The program picks the best transistor and reads out the biasing voltages required.

The Collins Radio Co. uses ECAP for the design of linear circuits and some digital circuits. Its

Talking to computer calls for new techniques



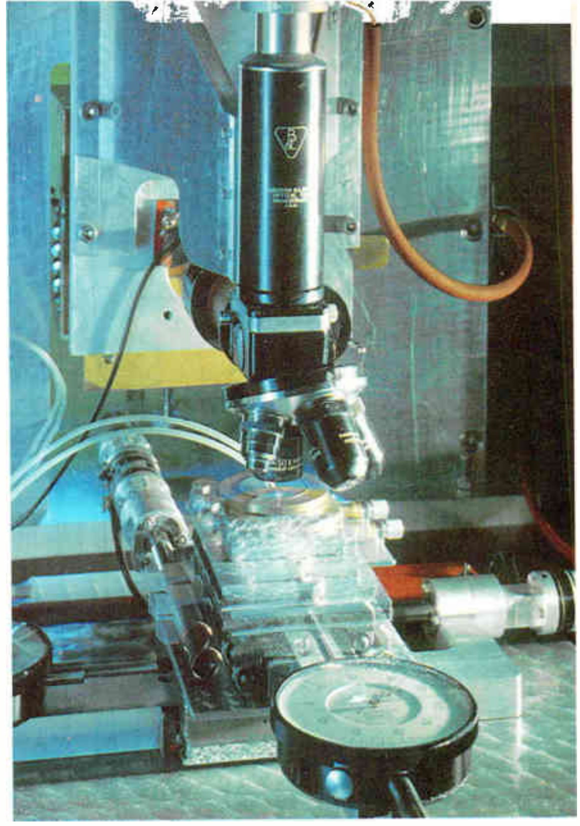
CAD expert Jacob Katzenelson communicates with Project MAC's time-shared computer in an on-line demonstration using the MIT Electronic Systems Laboratory console. Using light pen and typewriter he draws an emitter-coupled multivibrator and assigns component values by typing or sketching characteristics on the display console. Following computer analysis of the circuit, waveforms can be viewed on the console, evaluated, and the circuit returned to the screen for modification. The experiment is carried out by a CAD program called AEDNET, written in MIT's AED-O language.



Operator's eye view of console screen.

A giant step in design automation

Many-circuited wafer is coated with photoresist, exposed in unique pattern by ultraviolet beam (bright spot).

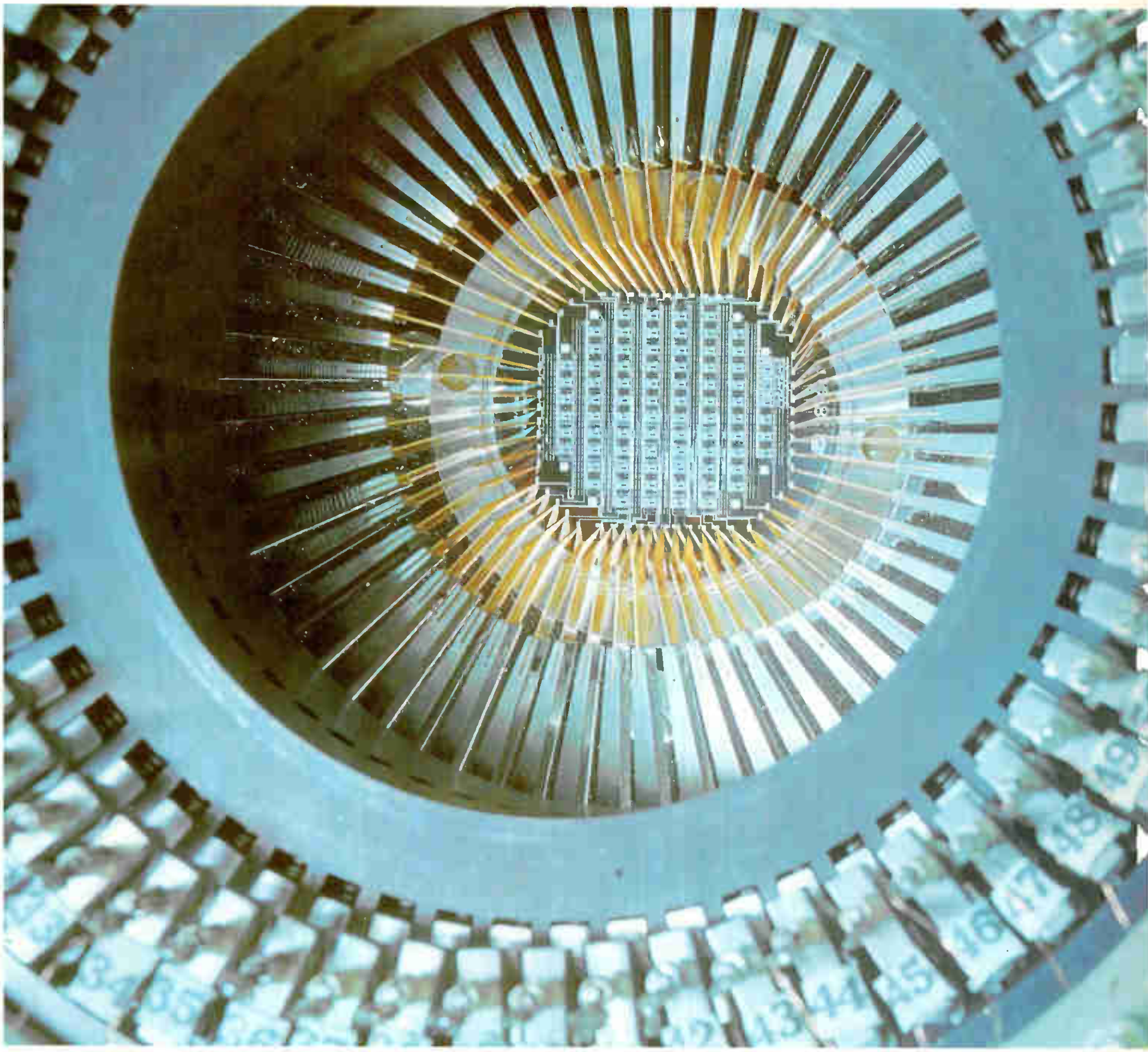


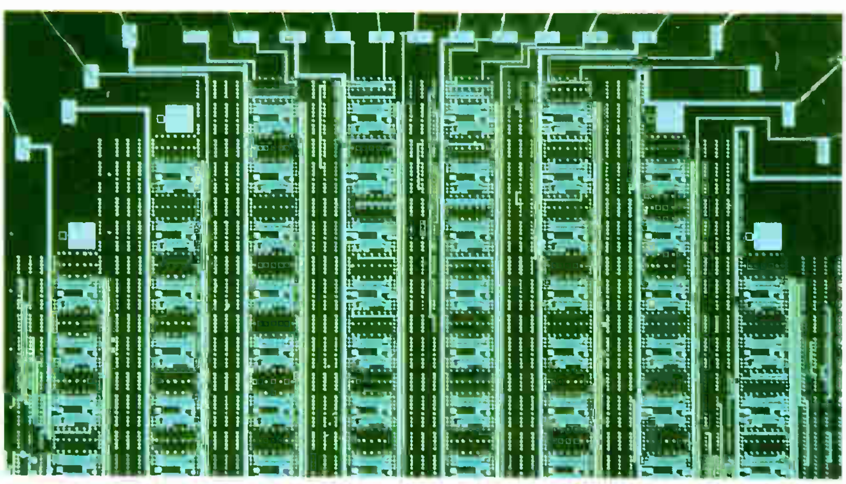
Blurred table is rapidly indexed to generate interconnection path under fixed beam.

Lead wires are affixed to finished array by thermocompression bonding.

At IBM, an experimental program tests each integrated circuit on a completed wafer of many circuits, records the results on punch cards. Cards are fed to a computer along with the interconnection instructions to produce, for example, a small arithmetic and control unit containing about 500 circuits. The IC wafer is then coated with photoresist and mounted on indexing table beneath stationary ultraviolet beam. Under computer control, the table is rapidly indexed in horizontal plane while uv beam exposes a unique pattern that connects only good circuits. Metal interconnection grid is then etched by conventional techniques and lead wires attached.

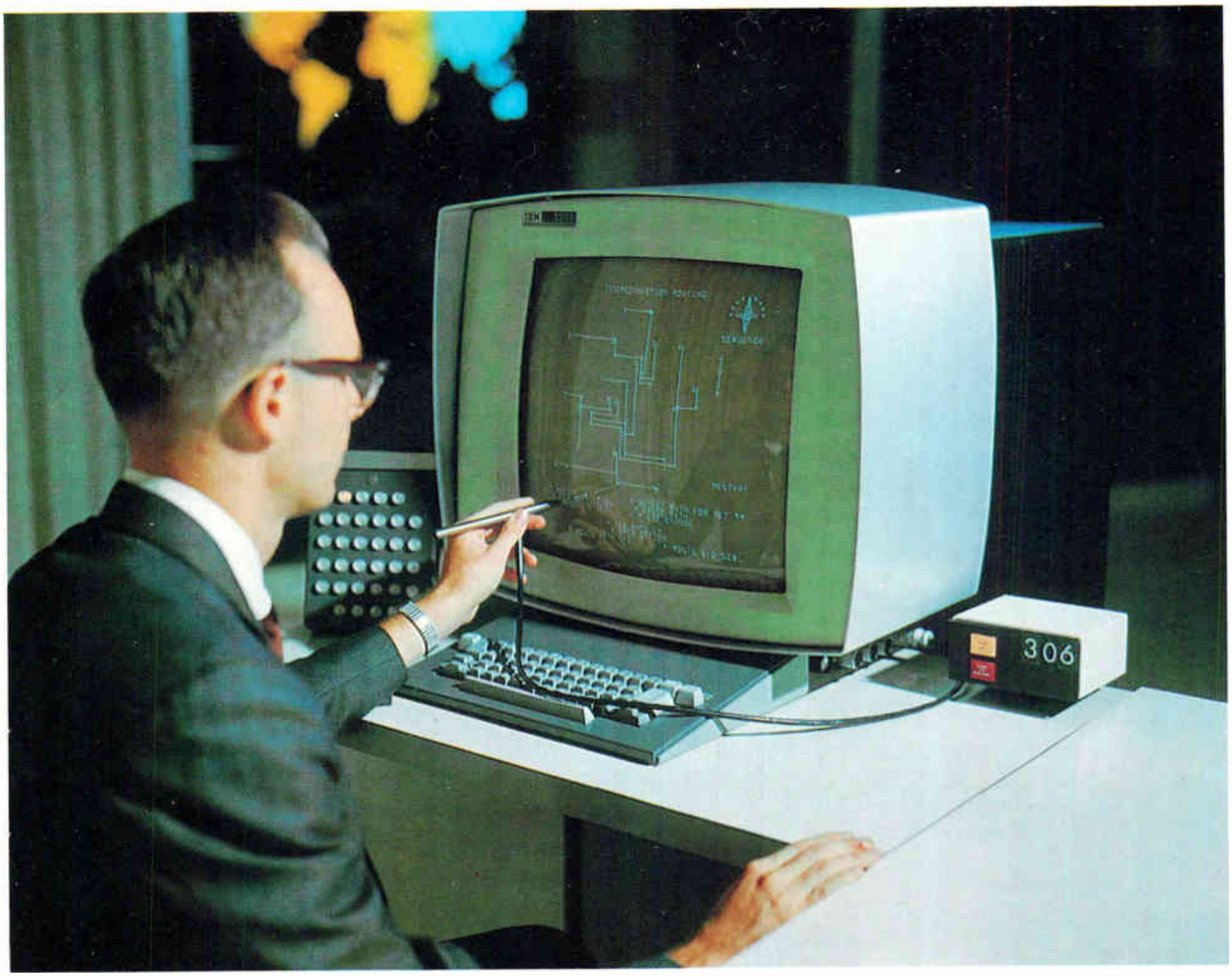
Checking results of computer's aid





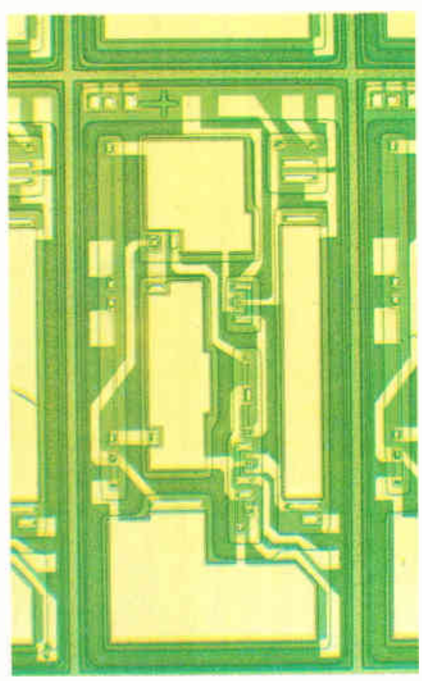
Spider-like multiprobe tester checks one of IBM's completed integrated circuit arrays whose interconnections (close-up at left) were computer-generated.

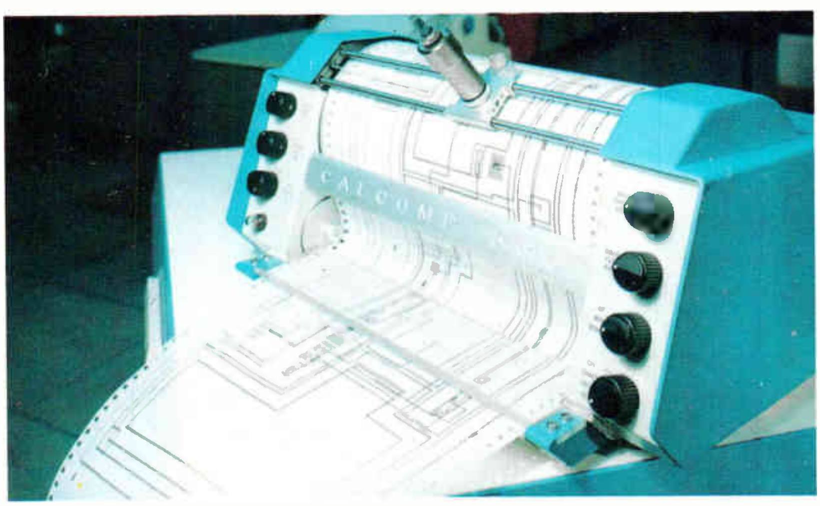
Computers deliver the goods



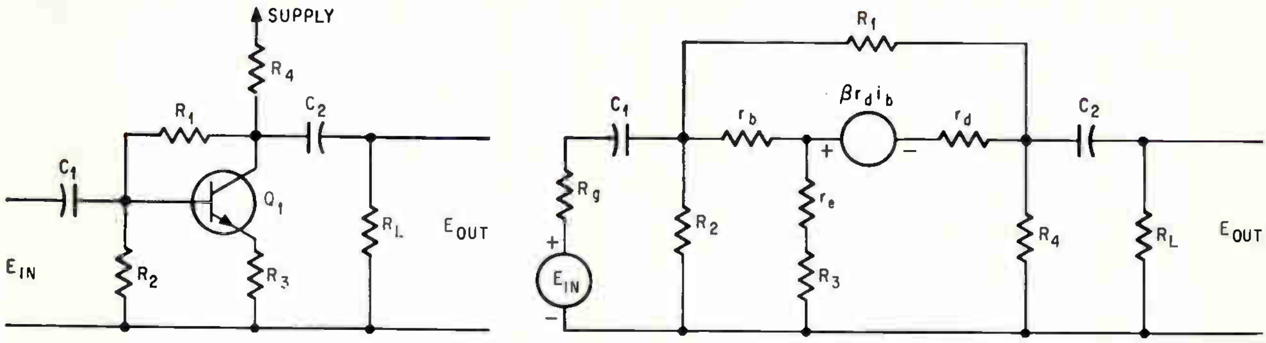
At this console in the IBM World Trade Center in New York, an engineer from the Norden division of United Aircraft instructs an IBM 360 computer in a point-to-point wiring exercise, part of a project Norden has under way to develop on-line methods of man-machine interactions for computer-aided integrated circuit design. The experiment is conducted under an Air Force contract.

Integrated circuit intermediate-frequency amplifier designed using the Norden-developed CAD program. Components are located and interconnection paths developed with an assist from the computer.





Final design of i-f amplifier at the right is drawn automatically by the plotter.



Variable					Amplifier Gain		
Number	Name	Nominal value	Low tolerance	High tolerance	With low tol.	With high tol.	Percent change
1	E_{in}	1.0 v	———	———	11.74	11.74	0.0
2	R_g	1.0 kΩ	900.0 Ω	1.1 kΩ	11.84	11.63	− 1.8
3	C_1	0.2 μf	0.16 μf	0.24 μf	11.67	11.77	+ 0.8
4	R_2	33.0 kΩ	29.7 kΩ	36.3 kΩ	11.69	11.77	+ 0.7
5	R_1	300.0 kΩ	270.0 kΩ	330.0 kΩ	11.64	11.81	+ 1.5
6	r_b	1.2 kΩ	800.0 Ω	1.6 kΩ	11.84	11.64	− 1.7
7	r_e	10.0 Ω	5.0 Ω	20.0 Ω	11.85	11.52	− 2.8
8	R_3	470.0 Ω	423.0 Ω	517.0 Ω	12.88	10.78	−17.8
9	Beta	100.0	50.0	200.0	11.06	12.10	+ 8.9
10	r_d	50.0 kΩ	25.0 kΩ	100.0 kΩ	11.65	11.78	+ 1.1
11	R_4	10.0 kΩ	9.0 kΩ	11.0 kΩ	10.98	12.44	+12.4
12	C_2	0.2 μf	0.16 μf	0.24 μf	11.73	11.74	+ 0.1
13	R_L	20.0 kΩ	19.0 kΩ	21.0 kΩ	11.55	11.91	+ 3.1

To carry out a sensitivity study of the common emitter amplifier shown here, using the Arinc program, an equivalent circuit, top right, is first developed. Then a description of each element of the equivalent circuit (first five columns in table) is fed to a computer, along with the loop equations and a request for a sensitivity analysis. The computer then provides the results tabulated in the final three columns.

designers find the program particularly useful for design of small-signal amplifiers, d-c amplifiers, balanced modulators, phase detectors, active filters, and power supplies. A major use of ECAP by Collins is in checking circuits for tolerance to parameter shifts.

Worst-case studies

The Hughes Aircraft Co., Culver City, Calif., uses ECAP for worst case, transient and frequency analysis. At Hughes' Research and Development division ECAP aids in the design of linear circuits in airborne radar and communications packages such as those for Early Bird and Syncom satellites. ECAP has been very useful in detecting errors and in establishing tolerances, Hughes says.

ECAP helps the Friden Corp.'s military products section, San Leandro, Calif., in digital circuit design, primarily for circuit analysis and reliability studies, and in optimizing topological layout. Its big advantages, Friden engineers say, are in saving time, providing insight, and pointing out redundancy. So far, Friden has not used ECAP in design synthesis.

NET-1 is at work for the Radio Corp. of America's Aerospace Systems division, Burlington, Mass., along with home-built programs, selecting existing circuits to perform a specified function, determining circuit response, optimizing circuit performance, and studying circuit reliability.

The special programs used by this RCA division include a small-signal a-c program based on nodal analysis, a nonlinear large-signal program using mesh techniques, and a piecewise linear program.

Fairchild Semiconductor's active filter facility, Mountain View, Calif., uses computers for filter design. Two Fairchild-developed programs—one for synthesis, the other for analysis—are used. With the first, the customer's specifications go directly into the computer. The computer then spells out the structure and element values needed to realize the specifications (the output is a list of capacitors and resistors). The second program accepts a circuit description and reads out the filter characteristics to be expected.

For two years the Centralab division of Globe Union, Inc., Milwaukee, has used ECAP in designing hybrid circuits. The circuits contain film-type passive components deposited on a ceramic substrate, with active chips added. J.E. Brewer, Centralab's manager of advanced design, notes that an advantage of the hybrid technique is that all the resistive components are accessible and can be precisely trimmed. Among other things, ECAP can spell out the required tolerances, resistor by resistor.

At Norden, some of the most advanced work in CAD is under way. "We pick and choose among

Circuit analysis by computer

By Joseph Mittleman

Senior associate editor

High-speed computers can transform tedious and difficult network-analysis computations to simple routine. The common denominator that ties the computer to network analysis is matrix algebra. It provides a desired generality as well as a convenient mode of expression that can later be translated into machine language. In essence, the computer is indifferent to whether the problem is electrical or mechanical in nature; it reaches a solution only by computation.

Network theory provides a unified method of both formulating and solving a very large and important class of problems. Thus, it is possible to write a network analysis program capable of transforming a large scale digital computer into a kind of super-analog machine of great versatility.

Digital computers are widely used in circuit analysis, time-and frequency-domain analysis, circuit (filter) design and optimization or iterative design (calculating a desired result by repetitive operations that come closer and closer to the desired result). Programs for these tasks are built algorithmically, that is, step by step.

Circuit analysis. Linear circuit-analysis programs, where the aim is to obtain responses to prescribed signal excitations, are based on a variety of methods. Among them are: mesh and nodal analysis (analyzing a network using Kirchhoff's voltage and current laws); topological formulas (analyzing a network graphically from its physical structure), and state variables (analyzing a network using matrix algebra to manipulate a set of simultaneous differential equations). Most of these handle active elements such as transistors, diodes and vacuum tubes by using equivalent circuit models.

State-variable programs based upon Bashkow's[1] A-matrix formulations perform calculations directly in the time domain by means of numerical integration and matrix inversion. The outputs of these programs provide network responses to impulse and step inputs in tabular form.

Most circuit analysis programs perform their calculations in the frequency domain. The program user need specify only the topology of the network, the element values and the transfer functions desired. The computer does the rest. It calculates the specified transfer functions in polynomial form, calculates the poles and zeros of these functions and can also provide transient and steady-state response. With versatile input-output equipment, the output can also provide a schematic of the original network, as well as plots of time- and frequency-response characteristics.

Domain analysis. The time-and frequency-domain analysis programs can be used with circuit-analysis programs or independently. Time-domain programs analyze the network's transient response as a function of time and solve the convolution integral (an intricate interweaving of two mathematical functions) numerically. This eliminates the necessity of finding roots of high-order polynomials and has the additional advantage that the excitation signal need not be specified analytically, but only in numerical form.

Frequency-domain programs analyze the network's steady-state response, given the transfer function in factored or unfactored form. The program user must specify the numerator and denominator polynomials of the transfer functions and the type of steady-state response desired (amplitude, amplitude in decibels, phase, delay, etc.). In addition, he must indicate the frequency and time date points at which the calculations are to be performed—if evenly spaced data is desired, only the minimum point, the number of points required and the increment between them need be specified. If data is only desired at certain points, this must be specified at the input.

Filter design. An example of the profitable use of computers can be seen in programs for filter design. Digital computers are the logical choice when designing insertion loss filters to meet certain amplitude requirements because even the simplest designs require tremendous amounts of numerical calculations. Although considerable time is needed to construct a gen-

available programs," says Martin Goldberg, CAD specialist. "For a-c analysis we're using ECAP; for transient analysis, NET-1, and for nonlinear work we're using our own nonlinear extensions of ECAP."

Shortcomings

Most criticism of existing programs for computer-aided design focuses on their limited flexibility or limited capacity. Frequently voiced complaints concern the programs' limited ability to handle nonlinear circuits and restrictions on the size of the circuit that can be studied. NET-1, for example, can handle 300 each of resistors, capacitors and inductors, 63 fixed-voltage sources, 63 time-dependent sources and 200 nodes (based on 32,000-word memory). ECAP can handle 50 nodes, 200 branches, 200 dependent sources, and 200 switches in its 7094 version, but only 20 nodes and 50 branches for the 1620.

Dennis Walz, head of circuit and component design for Collins Radio's facilities at Newport Beach and Santa Ana, complains that accounting for nonlinearities, in diodes for example, is accomplished by ECAP only in "raw approximations."

The driving-point functions now available for linear circuits don't cover all the points Collins would like to have, Walz says. ECAP, he adds, can't handle discontinuous sine waves adequately. Collins is trying to modify the time-step routine so that the program will handle a larger network, shorter time intervals, and more of them—up to eral filter synthesis program it is worth while in cases where large numbers of filters must be designed to meet different specifications.

One program for filter design has been written by Szentirmai.[2] The program is complete in that it handles the approximation and synthesis problem. It can handle low-high- and band-pass filters with prescribed zeros of transmission. There are provisions for either equal-ripple or maximally flat-type pass-band behavior, for arbitrary ratios of load-to-source impedances and for predistortion and incidental dissipation. The second program synthesizes low- and band-pass filters with maximally flat or equal-ripple-type delay in their pass band and monotonic or equal-ripple-type loss in the stop bands.

The engineer is free to specify both the zeros of the loss peaks and the network configuration desired. If his specifications include neither, the computer is free to pick both configuration and zeros of transmission. The computer chooses a network in which the inductance values are kept at a minimum. The network can be synthesized from both ends.

Finally, the computer prints out the network configuration, its dual, the normalized element values and the denormalized ones. Information such as amplitude and phase response, as well as plots of these responses obtained from a microfilm printer, are also provided by the computer.

Filter designs obtained using the computer are completed in minutes rather than days and at a typical cost of $20 rather than $2,000 (not including initial programing costs).

Network topology. It is sometimes necesary to compute a network function in symbolic rather than numerical form. Although symbolic determinants can be evaluated, the process is slow and complicated. Topological formulas provide a solution.

The generation of trees (a way of representing a network by a set of open branch elements that include all nodes of a given circuit) with the proper sign is the main problem of topological analysis of networks. For this purpose, several procedures have been designed for the computer. However, the use of topological formulas for network analysis does not appear as efficient as other methods. This is primarily due to the fact that the number of trees of a network with say 11 nodes and 21 branches can be about 13,000.

Optimization. Network design is not always accomplished by simple substitution in formulas. Trial-and-error processes are often used. The network designer starts with a set of specifications, selects a network configuration and makes an initial guess about the element values. He then measures or calculates the desired responses and compresses them with specifications. If the measured responses differ widely from the specified responses, the designer changes the values of the elements and compares again. The process is repeated until the measured responses agree with the specified responses within a preset tolerance.

A cut-and-try process can be made to converge quite rapidly using the method of steepest descent.[3] A steepest-descent Fortran program used for designing delay networks has been described by Semmelman.[4]

To use the program, the network designer first selects the initial values for the parameters x_i. He must also provide the specified delays R_j and the frequency data points f_j. The program successively changes the parameters x_i so that the squared error is minimized. The program provides for 128 match points and 64 parameter values. It is capable of meeting requirements simultaneously in the time and frequency domains. The designer is not restricted to equal-ripple approximations or infinite Q requirements. He is free to impose requirements such as nonuniform dissipation and ranges of available element values on the design.

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3. Charles B. Tompkins, "Methods of Steep Descent," Modern Mathematics for the Engineer (Edwin F. Beckenbach, ed.). Chapter 18, McGraw-Hill Book Co., New York, 1956.
4. C.I. Semmelman, "Experience with a Steepest Descent Computer Program for Designing Delay Networks," IRE International—Convention Rec., Part 2, 1962, pages 206-210.

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several thousand steps.

Since chopping a nonlinear problem into chunks to provide a linear approximation is tedious, Hughes Aircraft hopes to get around the problem by developing subroutines for ECAP.

Herbert Scheffler, who is on the technical staff of the director of engineering assurance at Autonetics, says the firm is switching to an IBM 360 from its 7094 to handle larger circuits. A small company, Scheffler noted, would probably have to rent time on a big machine. "Even here at Autonetics, one of our problems is that we can't get immediate service on the computer," Scheffler says. "You submit your problem one day and get it back the next, so a designer can't always follow through on his train of thought."

Debugging a program can also take time, Scheffler says. "No matter how you try to write a program that will take into account every possible occurrence, you never do it the first time," he says. In one case, Autonetics wanted to simulate a shorted resistor, and tried to represent it by setting its value equal to zero; the computer could not handle it.

Expensive data

When using complex device models, such as those for NET-1, the data needed is seldom found in its entirety on the device maker's data sheets, notes Texas U's Harbourt. As a result, either the circuit designer must develop the needed parameter data through expensive tests, or the vendor must be asked to supply it. Asked which transistor model would be best for circuit problems, Harbourt said there is no "best" transistor model; the choice depends on the nature of the problem.

He explained: "Two ideal diodes and a dependent current source may be fine for determining the states of transistors in a saturating logic circuit. Eight small-signal parameters might be ideal for a video amplifier frequency-response calculation. Yet neither of these would suffice in precisely determining the offset voltage in a high performance analog gate circuit."

Tracking the results

Brewer's experience with ECAP at Centralab is that an enormous amount of data begins to accumulate as a design proceeds.

In the iterative loops, which represent design modifications, portions of the data become obsolete. The designer, Brewer notes, must carefully and completely identify all intermediate data as well as the latest version of the design. "In all but the simplest analysis it has been found necessary to use an elaborate identification code to keep track of computed results, he says. "While ECAP generates detailed information it does not help the designer with his data coordination problem."

Since Centralab uses ECAP to analyze hybrid circuits that contain chip transistors and diodes, a big problem is device modeling. Brewer says the problems of generating model data and developing product control procedures that relate well to the models are most difficult. The money spent by Centralab to come up with complete modeling capabilities, he said, was 50 times greater than that spent to install ECAP in the first place.

An obscure error—confusing the letter O with a zero, in keypunching, for example—can throw a monkey wrench into a computer program. It can take days to find such a mistake, Brewer says. To avoid the most-feared error—the one that provides an erroneous result but gives no signal that it's wrong—Centralab checks against a breadboard at an early stage of design.

Sometimes, says Brewer, what the program can do and what the designer wants just don't jibe. It is difficult, for example, to predict the extremes of power dissipation in a transistor because maximum power does not coincide with either maximum voltage or maximum current.

Facts of life

Robert Mammano, assistant program manager at Arinc's Western division, urges the designer to keep uppermost in his mind the basic problem of relating his computer analysis to the facts of life. "Do you really know the distribution of values for the components being shipped by your particular supplier?" Mammano asks.

Component manufacturers may be reluctant to reveal distributions because they relate to yield and to special selection processes which mutilate the basic distribution.

"Here's what we'll tell it this time . . ."

Mammano's solution is a Monte Carlo approach, which, he points out, can only be done with the aid of a computer because of the large number of solutions required. With Monte Carlo, Mammano says, the computer "builds and tests" multiple circuits, selecting individual component parameters from a "bin" of values preprogramed as input data. Errors caused by inadequate knowledge of component tolerances are less significant when Monte Carlo is used. It is particularly appropriate for monolithic IC designs, Mammano says, since the circuit must "take what the manufacturing process gives—and that is often a normal distribution."

Monte Carlo, it must be noted, has its opponents. Arnold Spitalny, chief of the computer branch, advanced engineering section, Norden, says "I'm agin' it." There are ways to get the same information, Spitalny says, with much less use of valuable computer time.

III. Master and slave

Transcending the technical aspects of computer-aided circuit design are philosophical and psychological questions. "Will the computer replace me?" the circuit designer wonders. "Can the design process be so systematized that a computer can handle it from beginning to end? And if so, does this imply that the design engineering function is not truly creative?"

Most experts in CAD have weighed these questions carefully and have strong opinions on them.

The computer-circuit designer relationship may well turn out to be a master-slave relationship, says Kuo, but "the engineer will still be the master; he is the designer of the program that commands the computer." The engineer must still recognize the need for the circuit, determine its specifications, find out if there already are programs to design his circuit and, if so, prepare the input data in language that the computer can handle.

Defensive move

Many engineers become defensive on first encountering CAD. They regard the computer as the enemy, assigning to it many human traits and crediting it with powers it does not possess. An engineer will blame the computer when the answers come up wrong—or when the program won't run.

"The computer is not so smart," he'll gloat, forgetting that the burden of "educating" the computer falls on the program designer in the first place. Moreover, when existing programs fall short, revamping them or constructing better ones is the engineer's job.

A good example of how this is done is a monster program being developed by Autonetics. Richard Miles, who supervises design and analysis methods in the computing technology department, says the program may be working by the time the IBM 360 system is operational—hopefully, toward the end of the year. The program, to be used during preliminary circuit design, will have an optimization technique tied in with analysis. Written in Fortran IV, it will feature an overlay technique. With the overlay, the complete program need not be in the computer at any one time. The program, Miles says, has outgrown the 7094's memory.

Parameter range sweeps on two parameters at a time will be possible through progressive selection of incremental values of one parameter while sweeping the entire range of the other parameter.

A pair of optimization routines, one a direct search type and the other a gradient method will be tied into the d-c program. Miles says; "The idea of having an optimization routine tied into the analysis package is that you can describe the specs of a circuit and tell the computer you want the output voltage to be within a certain range, and temperature sensitivity to be a certain value.

"Using these specs you write an error function. In the case of an amplifier, you'd want a certain gain, plus or minus a certain percentage. You can write an error function which states this is equal to the desired gain minus the calculated gain. You want to minimize this function so that the amplifier will have the gain you require."

Writing the error functions is one of the toughest parts of the job, Miles says.

Garrulous computers

Often, the engineer would like to query the computer by feeding it a scribbled schematic. He'd like the answer in a specific form (a plotted curve, for example), unencumbered by extraneous results.

But, except for a few large general-purpose programs, such simplicity is still more dream than reality, though work is under way to accelerate it.

At the output end, the computer still tends to talk too much. It is an efficient paperwork generator, and the more prolific it is, the more the wanted results become obscured among the chaff.

There's a project at the Massachusetts Institute of Technology to permit on-line design modifications, using the time-shared Project MAC computer [Electronics, Feb. 7, 1966, p.39]. With a light pen and a typewriter, a circuit diagram can be fed into a computer. An operator at a console views an oscilloscope upon which he locates or moves circuit elements with a light pen, and assigns parameter values by using the typewriter. Outputs can also be displayed on the oscilloscope. Thus, plots of branch parameters against time or against one another can be observed.

The experts are sharply divided about who ought to be at the console. Some say the designer should; he can learn a lot and speed the design process. But, referring to Centralab's present use of ECAP, Brewer says "The concept of an engineer sitting at a 1620 console does not seem worthwhile. The only assured result is wasted engineering time and additional machine expense."

Centralab permits only selected technicians and computing-center personnel to prepare and run programs. This policy, Brewer says, fits the engineer's working pattern—requesting an ECAP run is like having a breadboard constructed.

Central clearinghouse

Finding out what has already been done is one of the most difficult jobs facing the potential user of CAD. Frequently the task is impossible; the designer throws up his hands and embarks on his project from scratch. Even if he does find a program that promises to do what he wants, it may be so poorly documented that he'll abandon it.

There are other deterrents. Among them are the proprietary nature of some special-purpose programs, and the cost of others.

The problem, a monumental one, is being scrutinized by observers who are convinced that the same programs will be developed over and over, often at the taxpayer's expense, if something is not done to publicize the availability of programs.

The National Aeronautics and Space Administration's Technology Utilization Branch has issued a grant to the Computer Center at the University of Georgia, Athens, to administer a program called Cosmic that will establish a library of verified programs. The inputs to the library are from NASA program libraries at the Marshall Space Flight Center, Huntsville; the Manned Space Center, Houston; and the Electronics Research Center, Cambridge. NASA intends to make programs available to industry for a nominal fee.

Users of IBM equipment can participate in Share, a closed interchange of information about program applications or obtain, from the Journal of the Association for Computing Machinery, monthly listings of new programs.

Other groups have gone their separate ways, each with the intention of developing a comprehensive library of CAD programs. The best way to resolve the problem is still uncertain.

One thing, however, is certain—CAD is here to stay and it will grow, perhaps faster than the experts think.

This overview of computer-aided design of circuits is the first in a series of articles. Among the contributors, in future issues, will be such CAD experts as Franklin Branin, Harlow Freitag, Martin Goldberg, William Happ, Cyrus Harbourt, Waldo Magnuson, Allan Malmberg, and Arnold Spitalny.

Circuit design

Designer's casebook

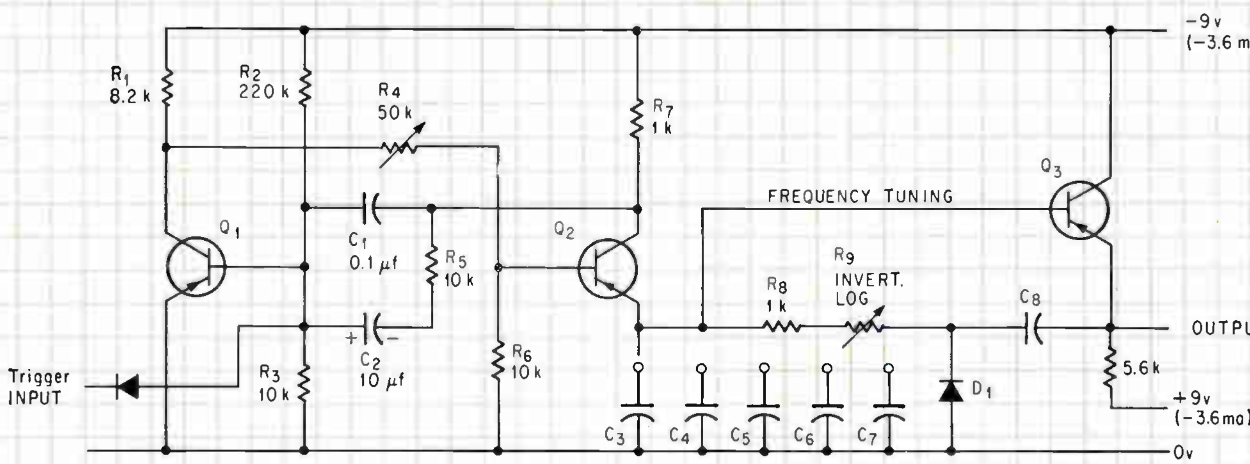
Designer's casebook is a regular feature in Electronics. Readers are invited to submit novel circuit ideas, packaging schemes, or other unusual solutions to design problems. Descriptions should be short. We'll pay $50 for each item published

Sawtooth generator drives cathode-ray tube

By C.C. Hoo

Paratronix Instrumentos Electronicos, Sao Paulo, Brazil

A transistorized sawtooth generator with an oscillating frequency range of 6 hertz to 450 khz (divided into five ranges), good linearity and constant amplitude is shown below. The unit is used to drive a cathode-ray tube when a portable oscilloscope of light weight and low power consumption is desired. Transistors Q_1 and Q_2 form the sawtooth oscillator; Q_3 is in a bootstrap circuit used to increase linearity.



Portable-scope driver is composed of transistors Q_1, Q_2 and Q_3. The first two form a sawtooth oscillator, the latter is in a bootstrap circuit. The design provides constant amplitude over the frequency range of 6 hz to 450 khz.

A trigger voltage of 0.5 to 5 volts root mean square is applied to the base of transistor Q_1 and synchronizes the oscillation to the input waveshape. When the circuit is connected to its power source, the current through resistors R_1 and R_4 causes Q_2 to conduct. Capacitor C_1 and C_2 are charged by the current through R_7. Resistor R_7 should be small so that the charging time is short compared to the sweep duration. The voltage division between R_7 and capacitors C_1 and C_2 drives the base of Q_1 positive. When the base of Q_1 goes positive, the transistor cuts off completely.

Capacitors C_3 through C_7 select the frequency range. When one of the capacitors is connected by the range switch to the emitter of Q_2, the capacitor charges quickly. When C_3 charges, the collector current of Q_2 decreases, the current through R_2 causes Q_1 to conduct and the voltage drop across R_1 makes Q_2 cut off. Capacitor C_3 now is discharged by R_8 and R_9 to the potential of C_8. When C_3 is discharged, C_2 again conducts and the cycle repeats.

During the time that Q_2 is conducting, C_8 is charged through Q_3 and the conducting diode D_1. When the sweep begins, the base and emitter of Q_3 become less negative. Since C_8 is large enough to remain almost fully charged over the complete sweep cycle, the voltage across R_8 and R_9 is practically constant. Hence, the current through these elements is constant and the sweep voltage produced is linear.

Resistor R_4 is a semivariable potentiometer provided to adjust linearity. Too small a value causes poor linearity; too large a value stops the oscillation. Resistor R_4 also influences amplitude and frequency range. The best point is achieved when good linearity is obtained on both the highest and lowest frequencies. This point is not critical. Resistor R_5 is used to eliminate parasitic oscillation at the highest frequency range. Resistors R_3 and R_6 stabilize the transistors.

The following results were obtained: Nonlinearity: less than 1% from 20 hz to 200 khz, less than 15% from 6 hz to 450 khz; output voltage: 3 volts peak to peak; triggering voltage: 0.5 to 5 volts sinusoidal; triggering range: ±10% at 2 volts or above; free running frequency: 6 to 48 hz for C_3 = 8 μf, 47 to 630 hz for C_4 = 0.68 μf, 470 hz to 5.9 khz for C_5 = 0.068 μf, 4.7 to 59 khz for C_6 = 6800 pf and 50 to 450 khz for C_7 = 560 pf.

The transistors used were the germanium-alloy diffused type (AF117) with h_{FE} = 150 and f_1 = 75 Mhz.

Interlock protects display tube

By Karl E. Springer

Hughes Aircraft Co., Culver City, Calif.

Cathode-ray tubes, like most tubes should not have high voltage applied to the anodes without filament excitation. The interlock circuit in the diagram minimizes the possibility. This circuit provides protection against filament power-supply failure or undervoltage, overvoltage and open and shorted filament feed lines.

Under normal conditions the voltage drop across R_1 is greater than the breakdown voltage of D_1 but less than that of D_2. The supply voltage, V_s, is also less than the breakdown voltage of D_3. Current only flows into inverter 1 through D_1, drawing Q_1's collector voltage down and energizing K_1, thus closing the high voltage interlock contacts.

Four possible system faults activate the circuit as follows:

- If the filament supply voltage, V_s, falls below its normal value, the voltage drop across R_1 is not sufficient to break down D_1. With no input current to converter 1, relay K_1 is de-energized, and the interlock contacts open.
- If V_s becomes greater than normal, D_1 remains in the avalanche (breakdown) state. D_3 also breaks down, causing current to flow into inverter 2. The current that was flowing into the base of Q_1 is shunted through Q_2 to ground. Relay K_1 becomes de-energized, causing the interlock contacts to open.
- If the filament feed lines are opened, there is no voltage drop across R_1. Circuit action is then similar to that in the first fault described.
- If the filament feed lines are shorted, the voltage drop across R_1 is greater than the breakdown of D_2. Current flows into the input of inverter 2. Circuit action is then similar to that in the second fault. The interlocking circuit can accommodate a wide range of filament voltages and currents if the following relationships governing the critical parameter selections are used:

$$R_1 = \frac{V_s - V_f}{I_f} \quad (1)$$

$$V_{D1} \leqq V_s - V_f - 1 \quad (2)$$

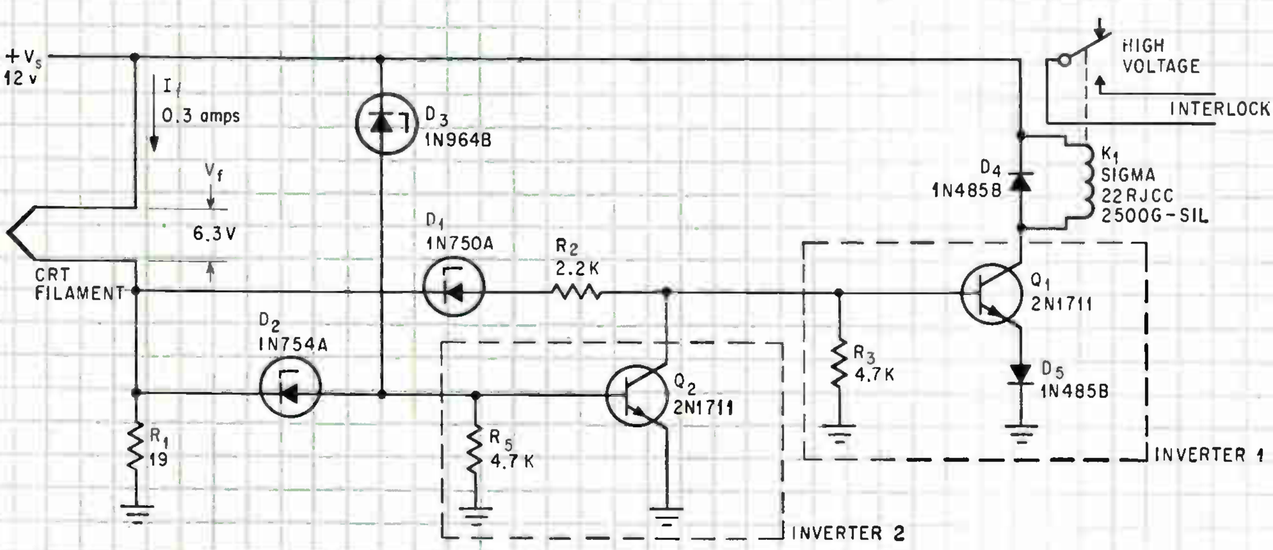
$$V_{D2} \geqq V_s - V_f + 1 \quad (3)$$

$$V_{D2} < V_s \quad (4)$$

$$V_{D3} \geqq V_s + 1 \quad (5)$$

Where V_s is the supply voltage, V_f is the filament voltage, and V_{D_1}, V_{D_2}, and V_{D_3} are zener diode voltages.

Selection of zener voltages to fulfill the conditions of equality of equations 1 through 5, yields



Interlock circuit protects cathode-ray tube against four possible system faults.

the narrowest margin of under-over voltage control, but requires greater precision in other circuit components.

There are other inherent advantages in addition to the circuit's protective features. Line losses may be compensated for by reducing the resistance R_1 from its original calculated value. Further reduction of R_1 brightens the crt display.

Multirange d-c voltmeter

By Richard Traina

Airborne Accessories Corp., Hillside, N.J.

Full-scale meter deflection of 1.0 volt is obtained independently of the input voltage with the circuit shown below. The 1-volt range may be positioned anywhere between 0 and 7 v d-c. For example, the meter may be set to read 1 to 2, 4 to 5, 3.5 to 4.5, and so on.

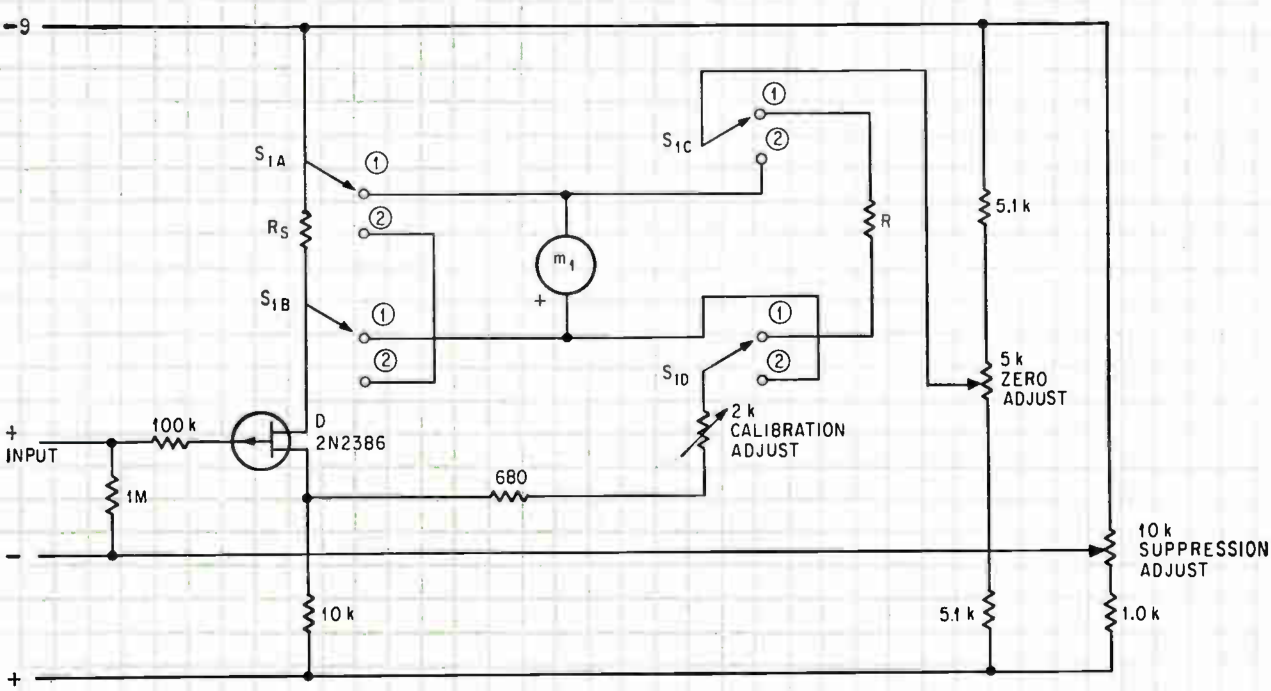
A varying electric field applied across a field effect transistor produces the very high input impedance, essential for optimum operation in a voltmeter. The higher a meter's input impedance the less the meter affects a measured circuit. With this circuit a voltmeter with an input impedance (sensitivity) of 1.0 megohm per volt is obtained for all scales.

With the rotary switch in position 1 the 100-microampere meter is connected in parallel with a shunt resistor, R_s. At the same time resistor R, which is approximately equal to the meter's internal resistance, is connected in the metering circuit. This combination of resistors increases the meter range to 500 microamperes and measures the drain current.

With the input set at the low limit of the voltage to be measured, the drain current of the FET is set at 350 microamperes (approximately the point of zero temperature coefficient of the FET used) with the suppression-adjust potentiometer. This action sets the bias of the FET. The increased bias voltage returns the bridge essentially to a zero input condition regardless of the applied input voltage.

The rotary switch is moved to position 2. The meter now replaces resistor R and R_2 is short circuited. The zero-adjust potentiometer zeros the meter.

The input voltage is now raised 1 v d-c above the low limit and the calibration-adjust potentiometer gives full-scale deflection on the meter. The meter reads 1 volt full scale with an accuracy of ±2% and good stability.



An FET circuit coupled with a 100-microampere meter movement makes a d-c voltmeter with a 1-volt full-scale range. Range can be set between 0 and 7 volts. Accuracy of the voltmeter is ± 2%.

Fail-safe frequency divider

By A. L. Plevy and E. N. Monacchio
Consulting Engineers

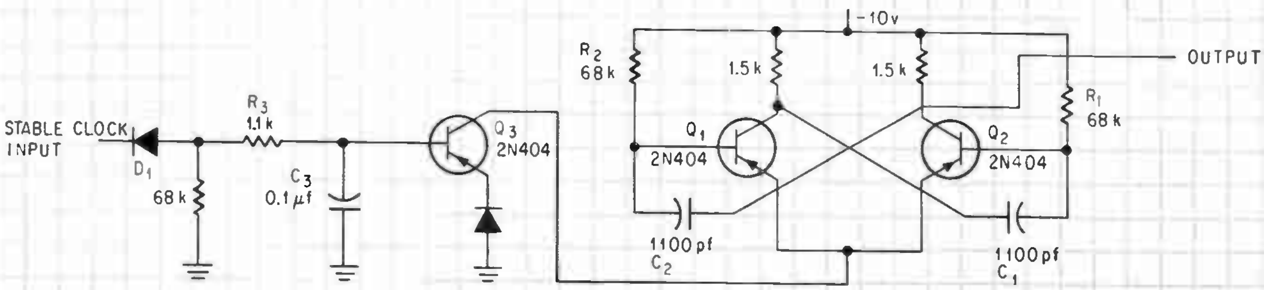
Frequency division by as much as 60 to 1 is possible when the emitters of the astable multivibrator, formed by transistors Q_1 and Q_2, are tied to the collector of Q_3 instead of being returned to ground as in a conventional circuit. The frequency-divider formed stops oscillating if the clock fails and is locked when the clock is running.

Normally, the multivibrator operates at the desired output frequency with a repetition rate, t_r, expressed as:

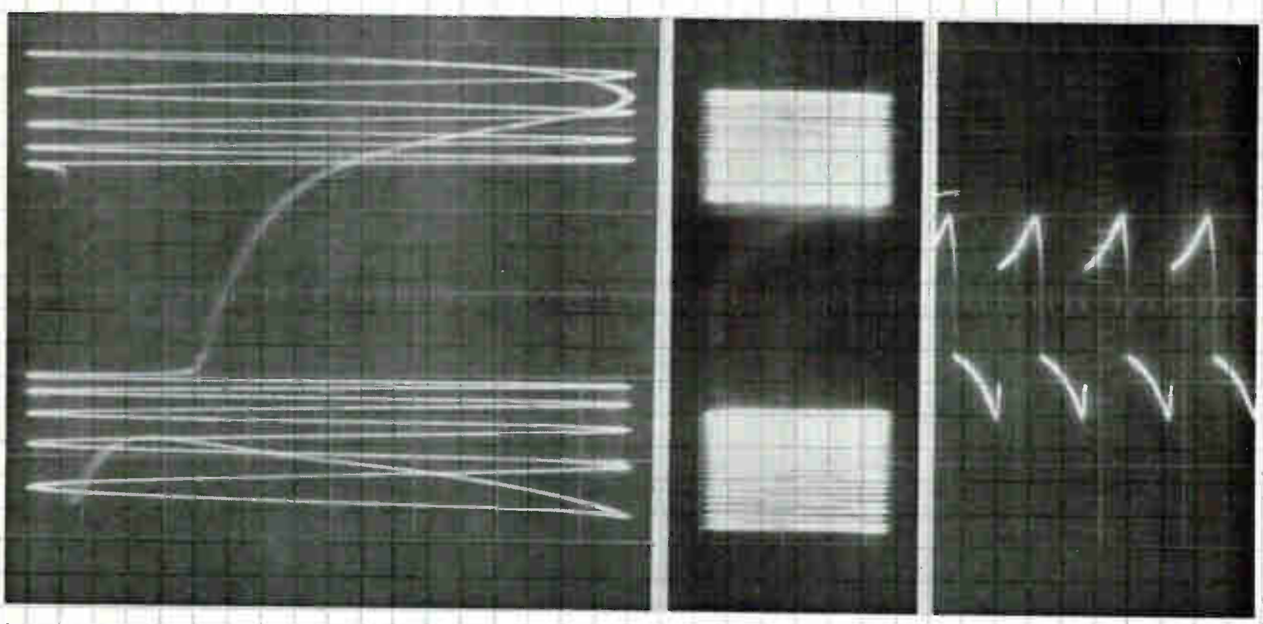
$t_r = 1/2(0.7)R_1C_1 \cong 1/2(0.7)R_2C_2$.

A half-wave rectifier made up of components D_1, R_3 and C_3 is connected to the base of Q_3. Capacitor C_3 is charged by the clock and provides a negative voltage that keeps Q_3 biased on. Resistor R_3 limits the base current supplied to Q_3. Components R_3 and C_3 are selected to offer ripple to the base of Q_3 at the clock frequency. This ripple is amplified and fed to the multivibrator through Q_3 and serves to lock the multivibrator to the clock.

If the clock fails, C_3 discharges and Q_3 is turned off, providing a high impedance path to ground. As a result, the multivibrator stops oscillating. The circuit runs at 10 kilohertz when Q_3 is on, and is easily synchronized to a 92-volt sinusoidal or square-wave clock over a frequency range of 10 to 600 khz. Photographs below show locked Lissajous patterns that indicate a 10-to-1 and 60-to-1 frequency division. To obtain these patterns the output of the multi, which is a good square wave, was purposely distorted by uncompensating the scope probe. The waveshape used for the patterns appears at the right.



Up to 60 frequency divisions are possible from the astable multivibrator connected to the half-wave rectifier. The emitters of Q_1 and Q_2 are not returned directly to ground, as in the conventional astable multivibrator. Instead, they are connected to the collector of Q_3. When Q_3 is biased on, it provides a ground return path for the multivibrator.



Locked Lissajous patterns indicate a 10-to-1 and a 60-to-1 frequency division (left and center). To obtain these Lissajous patterns the square-wave output of the multivibrator was distorted purposely by uncompensating the probe of the oscilloscope. The waveshape for the Lissajous patterns is shown at right; it was measured at 100 kilohertz with a vertical scale of 2 volts per centimeter and a horizontal of 0.1 microsecond per centimeter.

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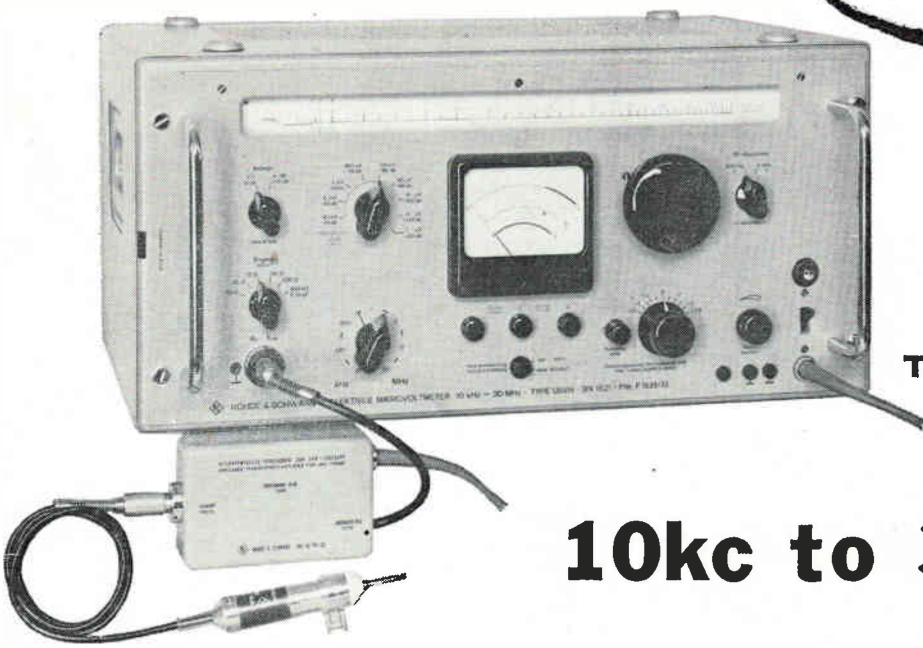

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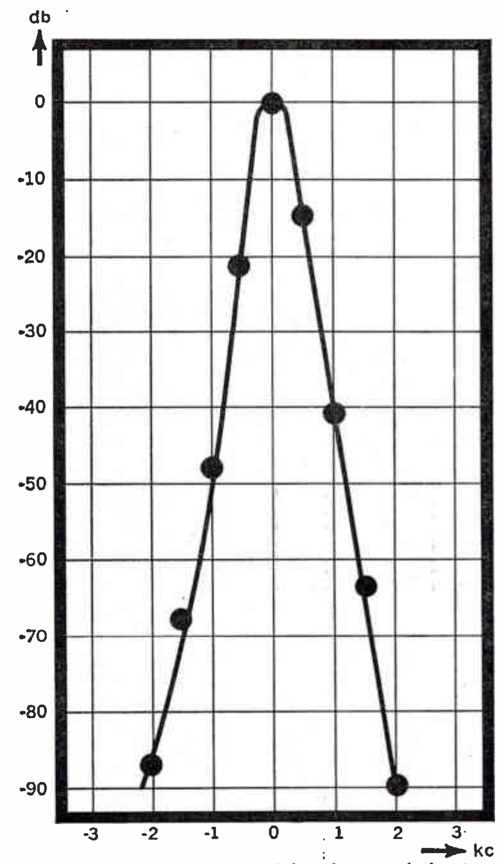

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- **Six input impedances from 50 Ω to 500 kΩ**

Here is a highly sensitive superheterodyne receiver whose output voltage is indicated by a diode voltmeter. A switch permits selection of any of the conventional input impedances. Single frequency changing is used for input frequencies from 10 to 1000 kc, double frequency changing for 1 to 30 mc, the bandwidth being 5 kc in both cases. Additional frequency conversion takes place in 500-cps narrow-band operation.

The local oscillator can be varied in frequency by ±2.5 kc and thus permit shifting of the 500 cps pass band over the 5 kc bandwidth present up to this frequency conversion.

The meter is calibrated in volts and decibels, and features an additional expanded scale with a relative calibration from 0.7 to 1. A head-phone output provides aural monitoring. A built-in calibration oscillator permits checking and adjustment. The power supply is electronically regulated for greater stability with regard to gain and frequency accuracy. A high impedance probe / amplifier is available.

Typical Measurement Applications

- Frequency response on four-terminal networks, especially at low voltage levels.
- Frequency response on amplifiers or filters within their pass bands.
- R-f distortion of long-, medium- and short-wave transmitters.
- Modulation depth.
- Envelope distortion.
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Looking through glasses for new active components

Renaissance in glass technology is providing hundreds of new materials—including amorphous alloys—with potential applications as low-cost semiconductor components, transducers, memories and other devices

By John D. Mackenzie
Rensselaer Polytechnic Institute, Troy, N.Y.

Glass isn't an ordinary electronic material, even though most component designers only use it in ordinary ways. Many kinds of components, from switching and memory diodes to computer memories, might be cheaply produced with glass if recent discoveries by glass scientists were exploited by electronics engineers. Glasses can now be made as semiconductors, photoconductors, magnets, transducers, optical switches, memory materials and superior insulators and dielectrics.

Present applications are mainly based on just a few of the obvious physical characteristics of glass. Most engineers think of it as an easy to form, transparent, nearly impervious solid with high electrical resistivity. So they use glass for optical parts, tube envelopes, protective coatings, insulators and substrates. All are secondary roles, compared with the primary roles assigned to such materials as ferrites and crystalline semiconductors.

This general concept of glass as an auxiliary material is actually very narrow in contrast with the capabilities of hundreds of new glasses. Few people realize, for example, that glasses are not solids, but rigid liquids that can have an almost infinite variety of compositions. Their room temperature resistivity can range from only 100 ohm-centimeters to 10^{20} ohm-cm. They can conduct both ionically and electronically. Their structures can be controlled so that the glassy matrix is host to millions of ferrite crystals, opening up the possibilities of producing microminiature but numerically vast arrays of memory elements.

Device designers can't really be faulted for not having exploited these and other potentially significant features of glass. Materials scientists have still not thoroughly probed all the inherent electronic properties of glass and some of the glasses that enhance such properties are new and untried. But it is apparent that glass is enjoying a technological renaissance certain to make it an increasingly important electronic device material in the coming decade. Some of the recent discoveries have already been converted into practical hardware.

Uniqueness of glass

If device designers are to make maximum use of glass's inherent electronic properties they should recognize that it is unlike any other material. It can be put to work both as a liquid and a solid because it is a "frozen-in" liquid. Like most liquids it can—in the absence of physical disturbances and impurities—be cooled well below its freezing point without crystallizing. The viscosity of a watery liquid is 0.01 poise and that of glycerine is 10 poise. When the liquid becomes so cold that its viscosity has risen to 10^{14} poise it becomes rigid. Such a liquid is defined as glass. Many materials can be rendered into the glassy or vitreous state in addition to the common glasses.[1]

Since glass is a rigid liquid it never melts but only softens when heated. This makes the fabrication of glass objects easy and permits materials to

The author

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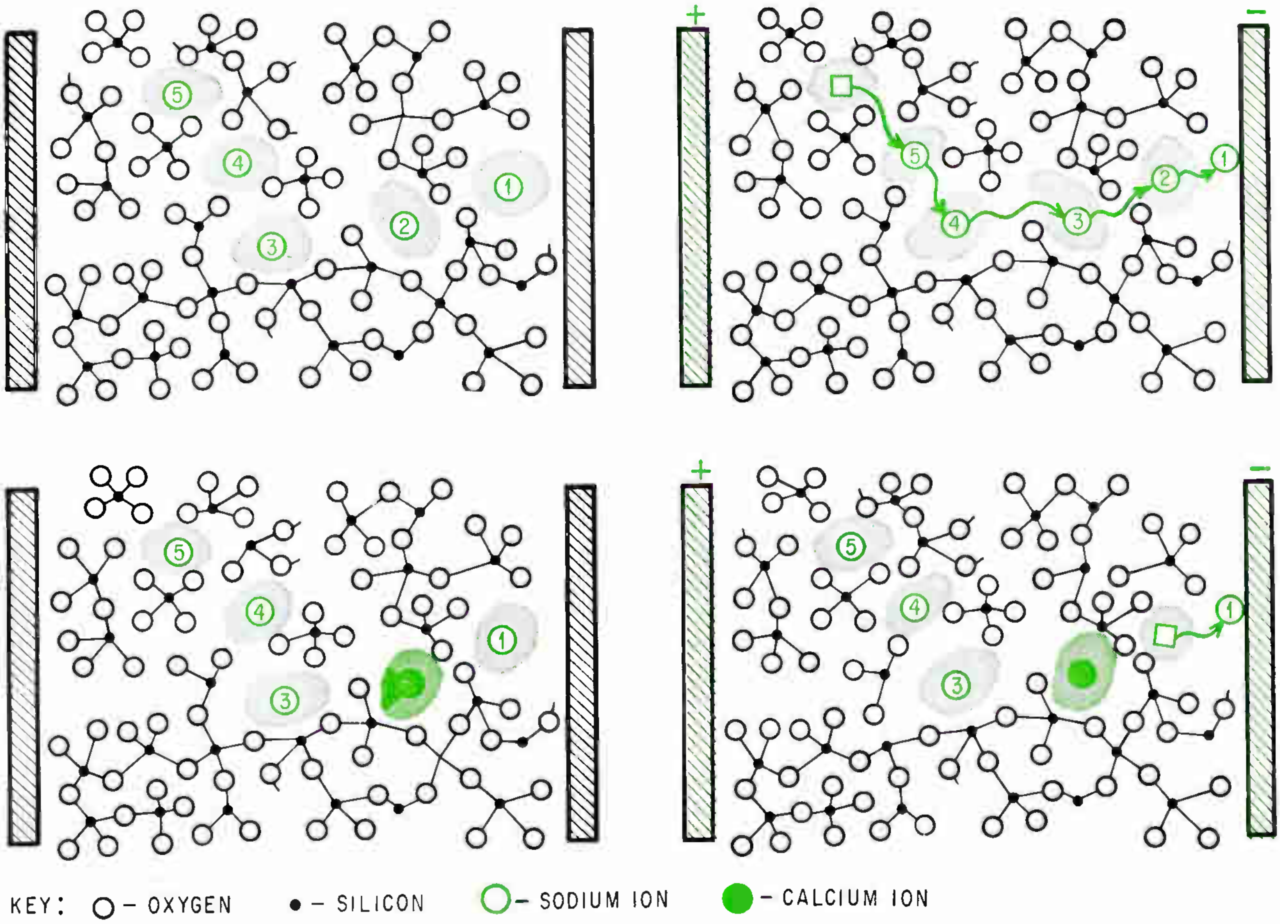
One ion blocks another to make a better glass substrate



Divalent ions such as calcium improve resistivity of glass by preventing ionic condition. Weak electrostatic bonds hold monovalent sodium ions in place (upper left). A direct-current field, indicated by colored electrodes, causes the ions to move between the glassy chains (upper right). The stronger bond of a calcium ion (lower left) allows it to block the ions behind it when there is a d-c field (lower right).

be dissolved in glass at high temperature. The added material can then be precipitated out in a controlled manner when the glass is cooler and rigid. This explains why a second phase—such as ferrite crystals of controllable size—can be uniformly distributed through the glass and why the compositions can be so varied.

The inexhaustible flexibility of composition means, of course, wide flexibility in properties. In contrast, most solids consist of crystals. Since crystals are stoichiometry compounds—having fixed proportions—the control over their properties is restricted. Yet the atomic defects that make crystals so useful in electronic applications can be duplicated in glass. Glass behaves much like crystal in its short-range order (over spacings of a few atomic distances). How advantageous this is, is demonstrated, for example, in the manufacture of high-power lasers. A neodymium-doped glass laser rod 4 feet long and 3 inches in diameter is readily made by conventional glass-making techniques. But there is no practical way of making a sufficiently uniform single-crystal ruby laser of like size.

Glass's fabrication ease should help make practical other new electronic systems, too. For instance, it is difficult to produce fine, superconducting magnet wire with adequate insulation. Many years ago glass workers learned to draw hollow, hair-like fibers of glass by pulling on a softened glass tube. Insulating superconducting wire can now be made inexpensively by putting a slug of the superconducting metal into a tube and softening and pulling both at once.

High-resistivity glasses

Formulating the glass to suppress ionic conduction improves insulating substrates, such as those for thin-film circuits. Common oxide glasses may not be chemically inert to the components they carry because they contain mobile and reactive alkali metal ions, particularly sodium ions. In silicate glasses, for instance, ionic electrical transport is entirely due to sodium ions. Their motion deteriorates circuits placed on the glass.[2]

Using pure silica glass, with a minimum of sodium ions, prevents deterioration. But such glass is difficult to fabricate, is expensive and its coefficient of thermal expansion is negligible—too low for good adherence of metal films. However, the motions of the sodium ions can be suppressed in inexpensive silicate and borate glasses by adding calcium and barium ions.[3] Ionic conduction becomes negligible despite appreciable quantities of alkalis. Some newer glasses containing calcium ions are even much better insulators than silica, as the graph at the right indicates. One such glass, simply fused wollanstonite, is a silicate of the composition $CaO \cdot SiO_2$.

Because ionic conduction occurs on an atomic scale, it has not been seen visually, but the mechanism is probably that diagramed at the left. Apparently the sodium ions must travel in preferential paths, which highly immobile ions such as calcium can block to pin down the sodium ions.

Normally, the sodium ions are held in place between the silica tetrahedra (silicon atoms bonded to four oxygen atoms) by electrostatic binding, as in the upper left drawing. The sodium ions are cations (positively charged) while the oxygen has a negative charge. However, when there is a d-c potential across the glass, as in the upper right drawing, the greater attraction of the negative electrode causes the sodium ion numbered 1 to vacate its original site. Ion 2 can then move through the opening in the polymer-like chains of tetrahedra and replace ion 1. Ion 3 can then replace ion 2 and so on until ion 5 has moved along the path.

Sodium ions move easily because their valence is low, only 1, and electrostatic binding is proportional to the valence, or charge, squared. Calcium and barium are divalent so their electrostatic binding is four times as strong. The lower set of diagrams show how a calcium ion—the solid colored circle—stays put in a d-c field. Sodium ion 1 can still move to the negative electrode but sodium ions 3, 4 and 5 are blocked. This blocking can occur millions of times in a piece of glass, effectively suppressing ionic conduction and making the glass more inert and more resistive.

Semiconducting oxide glasses

Most polyvalent cations are not only immobile in glass—even at temperatures of 200° to 300° C—but because they have different valence states they make possible electronic conduction in glass. Hence, glasses can be semiconductors, often surprisingly good ones. Some of the possible applications for such glasses are tabulated at the right.

In a crystalline transition metal oxide like iron oxide, electronic conduction occurs by means of a highly complex charge-transfer mechanism. The mechanism involves carriers of low mobility, say less than 1 cm² per volt-second. Electron motion in an n-type conductor may be represented by:

$$Fe^{2+}—O—Fe^{3+} \rightarrow Fe^{3+}—O—Fe^{2+}$$

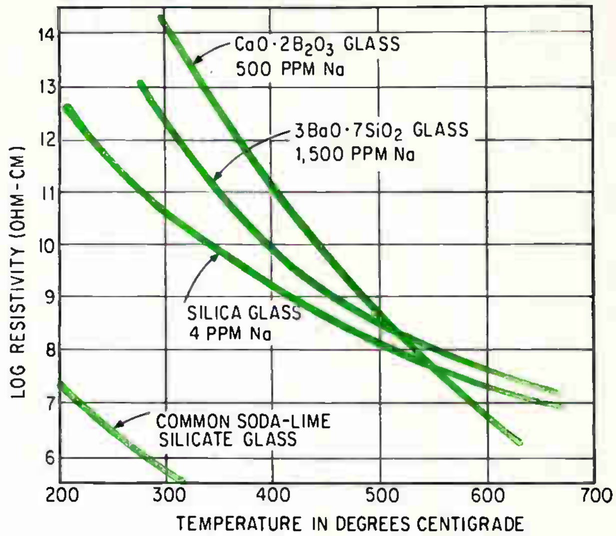
Electronic conduction can also occur in glass when enough variable valence ions are present, since the glass's short-range order is considered similar to a crystal's. Silicate glass containing 10% iron oxide has high resistivity but is also electronically conducting, so it is a semiconductor.

In glasses the charge transfer is generally called "hopping" and is thought to be similar to impurity-band conduction in doped germanium. This hopping, together with polarization induced by the charge, is called a polaron, which is now thought to be the most likely conduction mechanism. In glasses containing vanadium oxides, which the author has studied extensively, the hopping process is represented by:

$$V^{4+}—O—V^{5+} \rightarrow V^{5+}—O—V^{4+}$$

Many hundreds of such semiconducting glasses have been made recently.[4] Conduction is a bulk effect so the semiconductors are not polarized. Resistivity can vary with the concentration of variable valence ions and other factors.

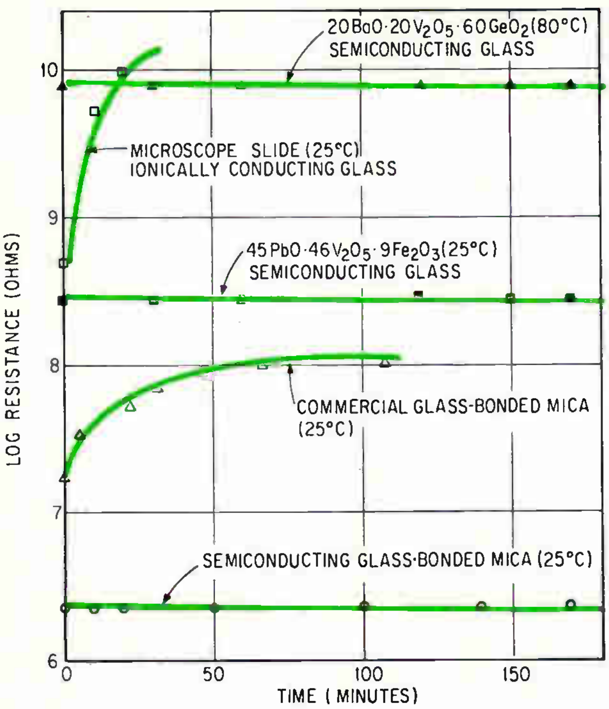
Semiconductor glasses are superior to conventional silicate glasses for all direct-current applications. An immediate and important application is improving the long-term performance of image-orthicon tubes. The targets of these tubes are glass disks 2 to 5 microns thick and about 2 inches in diameter. Their thickness must be uniform and the



Ionic blocking of calcium or barium ions gives glasses containing sodium much higher resistivity than silica glass, which is nearly free of sodium but expensive.

Possible uses of semiconducting glass

Glass system	Use	Source
Iron-vanadium-borate	television camera tubes	General Electric Co.
Aluminosilicates	infrared detection devices	English Electric Co.
Vanadates	surface junction detectors	Bausch & Lomb, Inc.
Complex	electronic ceramics	Phillips Gloeilampen-fabrieken N.V.
Barium-iron-borate	magnetic ceramics	Osaka Government Industrial Research Institute
General	transducers	J.D. Mackenzie



Superiority of semiconducting glass and glass-bonded mica over ionically conducting materials is indicated by effect of 200 volts of direct current. Increase in resistance with time indicates deterioration.

glass resistivity should remain at about 10^{12} ohm-cm at room temperature. Targets made of common glass deteriorate in time—ionic charge transfer under the d-c potential of tube operation causes electrolysis. Targets made of the new semiconducting glass give the tubes long life because the charge transfer is largely by electrons, not ions, and electrolysis does not occur.[5]

Crack-proof dielectrics

Semiconducting glasses can also improve glass-bonded mica, widely used in electronics because of highly desirable dielectric and mechanical properties provided by the mica it contains. Unlike ordinary glass, cracks apparently do not propagate through this composite material, so it can be made into complex shapes by machining or molding.

However, charge buildup during prolonged exposure to electrons leads to dielectric breakdown.

Semiconducting glass-bonded mica

	Sample 1	Sample 2
Glass (300-mesh muscovite mica; 100-mesh glass)	$7V_2O_5 \bullet 3P_2O_5$	$8V_2O_5 \bullet 2P_2O_5$
Hot-pressed at	340°C, 2,700 psi, 5 minutes	450°C, 1,500 psi, 5 minutes
Electrical resistivity	2.4×10^9 ohm-cm at 25°C	3.4×10^6 ohm-cm at 25°C
Density		2.336 gm per cc
Flexural strength		15,000 psi
Elasticmodulus		6×10^6 psi

This is due to the ionic nature of the glassy phase. If semiconducting glass is substituted for common silicate glass, electron conduction overcomes this difficulty,[6] as shown at the left. Furthermore, the composite's resistivity range, controlled mainly by the glass phase, is greatly extended.

The layered structure of the mica, as in the photomicrograph at the right, is probably what prevents crack propagation.[6] Many other inorganic materials also have a layered structure. Among them are boron nitride, a good dielectric, and graphite, a good conductor. The author formed composite glasses with both these materials. They are machinable and possess interesting electrical properties. Varying the amount of graphite changes the resistivity and its temperature coefficient. The glass containing boron nitride has very low-loss factors, indicating it would be a superior capacitor material.

Glass transducers

Exploitation of glass semiconductors as active semiconductors is still in its infancy. But it appears that oxide-glass semiconductors could make good temperature and pressure transducers and that other glasses can be made into switching and active but nonvolatile memory components.

Many oxide-glass semiconductors have large Seebeck coefficients (a measure of thermoelectric conversion efficiency), as indicated by the typical values given in the graph and table at the right.

The graph indicates also that the Seebeck coefficient is relatively stable over wide ranges of temperature and that the glasses can be made as p-type semiconductors (upper curves) or as n-type (lower curves). Thus, these glasses might make good, low-cost temperature sensors.

Another distinction between semiconducting glasses and ionically conducting glasses is that the electronic conductivity of semiconductors increases with physical pressure. The resistivity change can be remarkably linear, as plotted by the author in the graph on page 134. The pressure was applied hydrostatically at room temperature; at 100° C, the resistance drops about an order of magnitude but is still very linear. Analysis indicated that the conductivity increase was due to compression of the glassy matrix, which increased the concentration of vanadium atoms per unit volume and increased conduction by the hopping process.

An obvious potential use of this glass is as a pressure transducer. Such a transducer could have advantages over conventional pressure sensors, since the pressure sensed by a calibrated device could be read directly as a resistance value or used to initiate a control signal without converting from a nonelectronic value.

Glass ceramics

Uncontrolled crystallization in glass is undesirable because it makes the physical properties uncontrollable. However, in recent years the controlled crystallization of glass has become a highly successful technology with electronic implications far wider than the present use of the technique to produce supporting materials.

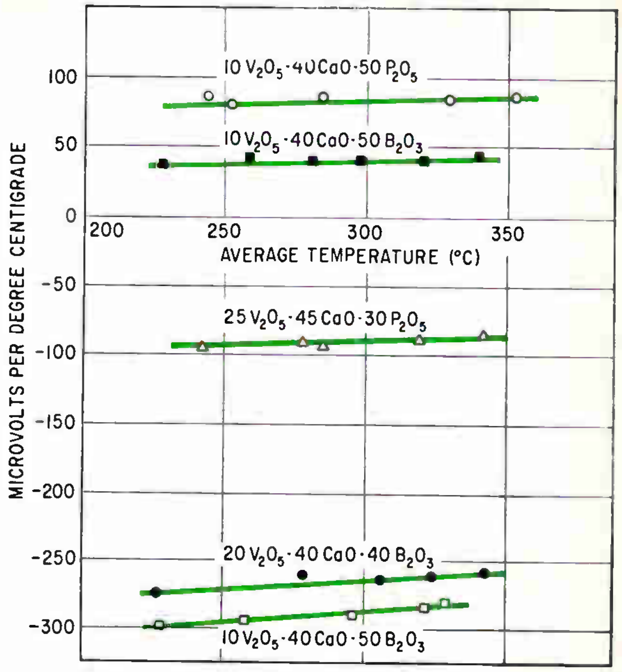
Glass can crystallize because it is a metastable solid—one whose structure may be radically changed by an impurity or physical disturbance. It tends to crystallize at temperatures that make the ions sufficiently mobile because the crystalline phase is invariably more stable thermodynamically.

The glass ceramics widely used in electronics for missile radomes, high-temperature circuit boards and other components are an example of controlled crystallization. The insulating types are detailed in a recent book.[7] The crystals, whose formation is triggered by electromagnetic radiation and heat, are less than a micron in diameter and closely knit together, so mechanical properties are excellent. They can also have high electrical resistivity and low loss factors.

Glass ceramics with active electronic properties—such as the semiconductor glasses—can also be produced today. So it should be possible to further tailor and enhance their electronic properties.

The composition and hence the electronic properties of such glass can be remarkably uniform, as evidenced by the electron micrograph on page 135. The picture shows semiconducting glass in an early stage of crystal formation, enlarged 40,000 times. The droplets that will later become crystals are only about 100 angstroms in diameter and the distances between them vary by only a small fraction of a micron.

No such precision can be achieved in formation of single-crystal semiconductors. If three constituents—call them A, B and C—are combined to form a crystalline material, A and B will probably concentrate on the surface and C will have a concentration gradient. The electrical properties will also be nonuniform through the body of the material, and such factors as variations in temperature coefficient of expansion may cause strains and other defects.



Seebeck coefficients of semiconducting oxide glasses change almost linearly as temperature changes, indicating they would make good temperature sensors and thermoelectric devices.

Layered structure of semiconducting glass-bonded mica, magnified 300X. Such high-strength composites can also be made with boron-nitride dielectric and graphite.

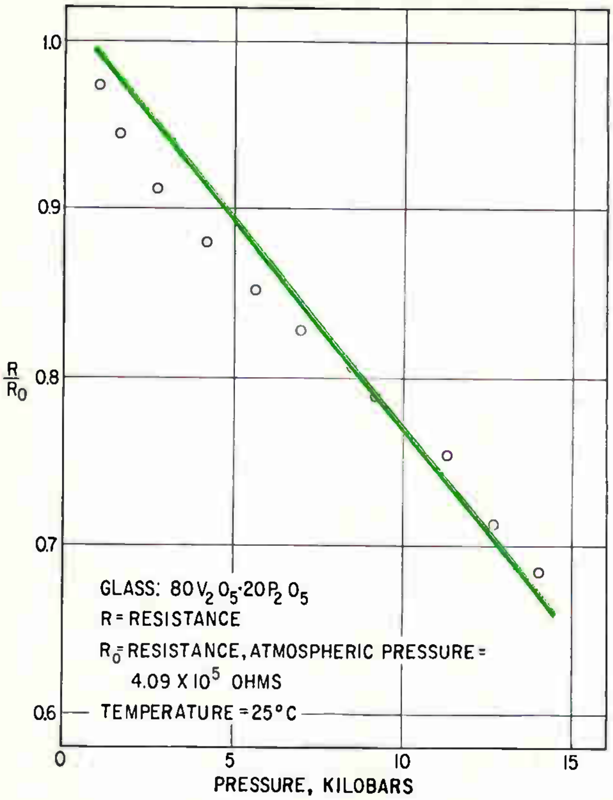
Glassy semiconductors on the other hand—including the amorphous metals discussed on page 136—are almost like perfect single crystals in that there are no grain boundaries, with attendant faults and concentrations of impurities. This uniformity might someday be exploited to solve semiconductor production problems. For example, integrated-circuit manufacturers are beginning to make monolithic circuit arrays containing thousands of devices on a single-crystal substrate. When crystal semiconductors are used, the number of devices ruined by random flaws in the crystals pose serious problems. One such problem is the need to develop custom wiring patterns that avoid the faulty devices.

New magnetic materials

Well on the way to laboratory success is the production of glass ceramics containing ferrite crystals

Seebeck coefficients of oxide glasses

Glass system	Average temp. °C	Type	Coefficient $\mu V/°C$
$CaO \times B_2O_3 \times V_2O_5$	50-250	n	600-400
$CaO \times B_2O_3 \times V_2O_5(H_2)$	50-250	n	110-90
$CaO \times B_2O_3 \times FeO$	330	p	600
$CaO \times B_2O_3 \times TiO_2$	40-150	n	380-360
$Bi_2O_3 \times B_2O_3$ (slightly crystalline)	290	p	1,000
$V_2O_5 \times TeO_2$	40-150	n	500-300
$V_2O_5 \times PbO$	70-200	n	270-220
P_2O_5 35 V^{4+}/V^{5+}:0.3	120	n	140
P_2O_5 35 V^{4+}/V^{5+}:1.0	120	p	100



Increasing pressure linearly reduces resistivity of semiconductor glass, probably because distances between vanadium ions decrease, allowing conduction to increase. This glass could be used as a pressure transducer.

of controlled composition and distribution. This creates exciting possibilities in development of microelectronic magnetic devices.

For example, if oxides are melted to form glass with a molecular composition of 20% B_2O_3, 30% BaO and 50% Fe_2O_3, controlled heat treatment will crystallize barium ferrite out of the glass.[8] Barium ferrite is a hard, ferromagnetic material, suitable for magnets. Virtually any ferrite can be produced in glass hosts in this way. Thin films of barium-titanate ferroelectric have already been made,[9] an achievement that makes possible the manufacture of thin-film capacitors with high dielectric constant.

From a manufacturing viewpoint, the significance of glass ferrites is the ease of shaping and "assembling" ferrite elements, compared to the complex sequence of processes and assembly steps needed, for instance, to produce a ferrite-core memory. The glass can be pressed, molded, blown or drawn to produce rods, plates, films, fibers or complex forms. The crystals can be oriented in the glass by controlling the direction in which they grow. Phosphate glass, for one, contains long, glassy chains; ferrite crystals will grow along these chains and their easy direction of magnetization will be along the chains.

Selective crystallization techniques, such as selective heating or irradiation, can control the location of the crystals. As a simple proof, the author wrapped a resistance-heated wire around a glass cylinder. When the glass was cooled, the ferrite appeared as a helix around the cylinder. Perhaps sense and drive wires could be counterwound on such a helix by an ordinary coil-winding machine to produce a small memory. Or perhaps thin-film memories could be made with orthogonal wiring; if in a forming stage wiring crosspoints were heated by an overcurrent so the ferrite crystallized in the underlying glass film, many of the deposition processes now required to make planar or laminar memories could be avoided. These possibilities remain to be proved by electronic device designers.

Optoelectronic switches and memories

Controlled crystallization has also led to the invention of phototropic or photochromic glasses—materials that change color when irradiated by light of one wavelength and then revert to their original color under light of another wavelength.

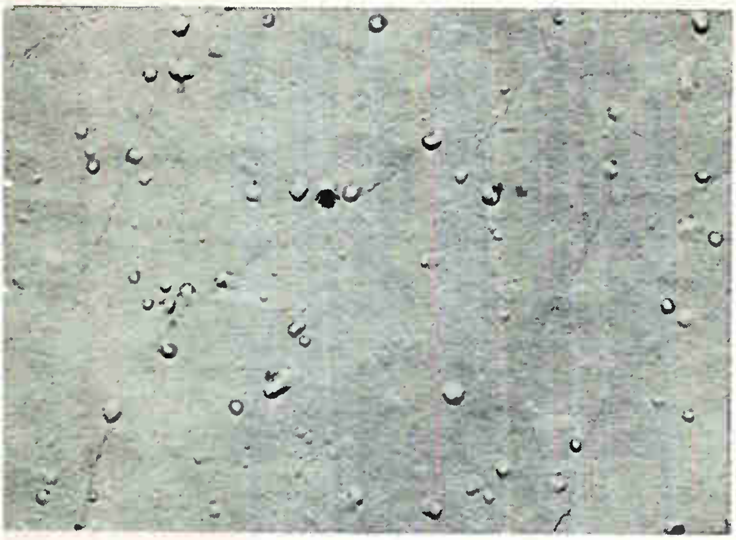
Optoelectronic system designers have worked for some time with organic phototropic materials, but these suffer from "fatigue"—usually, after a few hundred color changes they lose their phototropy.

Scientists at the Corning Glass Works discovered that silicate glasses containing about ½% of silver-halide crystals retain their phototropy for more than 300,000 cycles.[10] Corning is studying the feasibility of using such glasses in optical displays, temporary data storage and data-processing systems, as well as ophthalmic, automotive and architectural applications.[11] It might also be used as a Q switch, a device that boosts the peak power of laser pulses.

The phototropy is a result of glass being a rigid liquid. Silver halide is dissolved in it at high temperature. After the glass is shaped it is heat-treated at a lower temperature until the halide crystals are about 50 to 100 angstroms in size. The glass is transparent to visible light, darkens under ultraviolet light and bleaches under light of a higher wavelength or when heated. Apparently, darkening results when the first wavelength releases halogens, but they cannot disperse in the glass and so they recombine under the bleaching stimulus.

The reactions take from less than two minutes to hours depending on composition and stimuli, and darkened glass eventually bleaches. Corning scientists concede slow reactions may bar high-speed electronic applications, but point out that optical resolution is 10 to 20 times that of photographic film. So they envision other data and display uses.[11]

Another phototropic glass, discovered several years ago at the Pittsburgh Plate Glass Co., is based on glass having a short-range order like a crystal.[12] It has long been known that crystals can be made phototropic by generating color centers in them. Centers can be formed in glass by melting it under highly reducing conditions. Doping with cerium or europium ions improves the phototropy. A company spokesman reported in August that it has not been pursuing electronic applications of



Semiconducting glass magnified 40,000 times by electron microscope. "Droplets" are tiny crystals about 100 angstroms in diameter. The size and distribution of crystals such as ferrites can be closely controlled in glass.

the glass because of the low volume that would be used.

Nonoxide glasses

A group of glasses known as the chalcogenides now used for infrared transmissions started with arsenic trisulfide in the early 1950's.[13] The constant hunt for better infrared transmitters that are more stable at high temperatures led to the discovery of many such nonoxide or elemental glassy systems. Again, many possess intriguing electronic properties.

These glasses are made by melting together various proportions of the following elements: sulphur, selenium, tellurium, arsenic, antimony, thallium, chlorine, bromine, iodine, phosphorus, silicon and germanium. The melt is quenched to produce the glass. Some typical glass systems and applications are: As-S-Se, an insulator that melts at low temperature; As-Te-I, electronic switches and memory devices; As-Se-Te, photoconductor; and As-Ge-Si-Te, an infrared transmitter that withstands high temperature. Some elemental glasses transmit infrared light with wavelengths as long as 20 microns.

Recently, the American Optical Co. began making arsenic trisulfide in long fibers by pulling the melt. This allows infrared light to be piped, as in visible-light fiber optics, and might pave the way for better methods of transmitting and steering laser signals.

Some chalcogenides soften at temperatures below 0° C, others are viscous at 100° C, making it feasible to dip-coat temperature-sensitive devices in glass rather than organic materials. The softening temperatures can be controlled over a wide range.

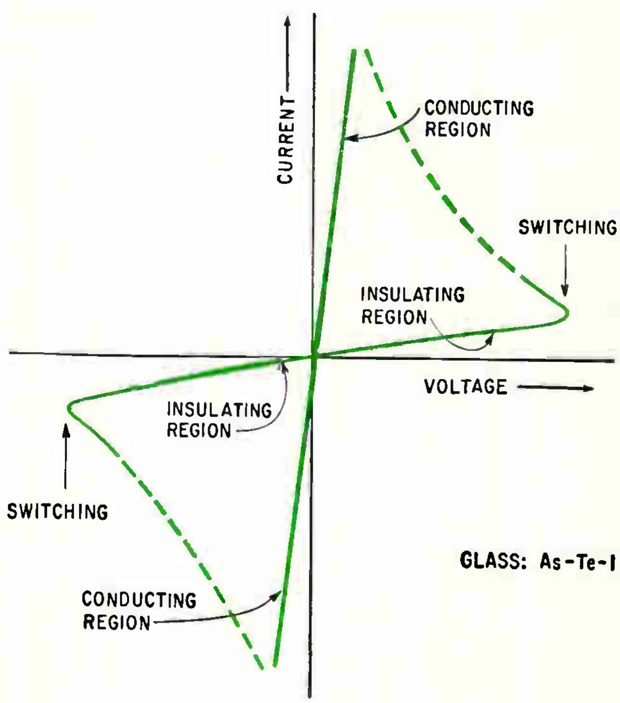
Several years ago, Bell Telephone Laboratories reported experimental success in dip-coating diodes with arsenic and sulfur glasses. They were good insulators and their chemical stability was superior to organic polymeric materials.[13] But according to A.D. Pearson of the research team, that work was set aside primarily because the planar-passivation process for silicon devices proved better. Nonetheless, glass should be an attractive coating for other types of devices.

Elemental glass switches

Current-voltage characteristics of some elemental glasses indicate they can be used as switching and memory devices. Pearson and his co-workers at Bell Telephone Laboratories reported on such devices verbally in May, 1962, at an Electrochemical Society meeting. When point contacts are made to a glass such as As-Te-I, a variation in applied voltage switches the device from an insulating to a highly conducting state.[14] The switching can occur in less than a microsecond and is reversible. The diode would remain in a given state, even under zero bias, and could remember which state it was in for many days. A generalized current-voltage plot is shown below.

Pearson says this work, too, is inactive at present. One reason is that crystal semiconductors have better long-term stability and thus are considered more suitable for telephone system applications. However, several companies in the U.S. and Europe are actively attempting to develop practical uses for elemental glasses. Little of this work is reported in the open literature since it is considered proprietary.

[The Energy Conversion Devices Co. disclosed this month that the semiconductor devices it has



Current-voltage characteristics of diodes made of elemental arsenic-tellurium-iodine glass. Besides pronounced switching behavior, diodes made of this semiconducting glass will remember their states for long periods at zero bias voltage.

begun offering commercially are principally elemental glasses and amorphous alloys. The active materials are homogenous, without p-n junctions. Devices being made or under development include a-c and d-c switches, temperature and pressure transducers, adaptive devices and nonvolatile memory elements.—Editor]

Photoconducting glasses

The Russians have extensively studied the electronic properties of nonoxide glasses. One of the better known properties is photoconductivity—the photoconductivity of glassy selenium, for example, makes it a basic material for xerography.

Glasses based on selenium, tellurium and arsenic are also photoconductors.[15] In contrast to crystalline materials, the conductivity of the glasses is insensitive to impurity contents. This means electronic properties are easier to control during manufacture. Silicon and germanium are rendered into the amorphous—or glassy—state by vacuum evaporation and show higher conductivity and other interesting variations in semiconducting property.[16] It is not known for certain whether such vapor-deposited noncrystalline films are glasses. Glasses are usually considered materials made by cooling molten materials.

Still another new form of glass of interest to electronics is electronically conducting glass based upon mixtures of oxides and nonoxides.[17]

Quenched and pseudo glasses

Quenching and other exotic techniques of producing glasses from metals and other unusual materials are also being tried. In one quenching technique, called splat-cooling, droplets of molten metal are sprayed at high speed onto a revolving substrate cooled by liquid nitrogen. Alloys such as silicon and gold or silver can be made as glass by this method,[18] and some metals that normally will not mix can be rendered into glassy or amorphous alloys.

The technique is based on the fact that undercooled liquids can be prevented from crystallizing if the cooling—called quenching—is rapid enough. Since quenching rate depends upon heat conduction, the smaller the amount of material, the easier it is to make it into glass. Tiny glass bodies may not interest window and bottle manufacturers, but small amounts of materials can be highly important in processes such as those used to produce semiconductor integrated circuits.

Although little information is available on metal glasses, related materials give strong indications that interesting electronic properties can be expected. These indications come from noncrystalline films formed by vapor deposition. The films are not necessarily similar to quenched glass films of the material, but often they are alike.[19] Silicon-dioxide films formed by diverse techniques—such as melting, vapor-phase hydrolysis, sputtering, thermal decomposition and shock-wave transformation and neutron bombardment of crystals—have similar refractive indexes and infrared absorption bands.[20] One can conclude that each SiO_2 sample is glass.

If one also assumes that all vapor-formed, noncrystalline films are glass, many new electronic glasses or pseudo glasses have been discovered in recent years. Among these are: bismuth, a superconductor; MgO and MgF_2, infrared transmitters; and cobalt-gold alloys, ferromagnetics. The latter should settle the question whether a noncrystalline material can be ferromagnetic.[21]

The cobalt-gold alloys were made by researchers at the International Business Machine Co. They vacuum-deposited the two metals onto a liquid-nitrogen cooled substrate. The material remains amorphous until heated. As it becomes crystalline, its coercive force jumps, typically from 20 to 40 oersteds. The alloy appears to have a magnetic structure like fine-grained Permalloy.

It seems, therefore, that microelectronic systems designers searching for new magnetic materials now have a possible alternative to conventional materials and oxide glasses containing ferrite.

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Integrated circuits and pulse coding mean new gains for telephony

Replacing analog circuits with digital integrated circuits in pcm telephone systems is resulting in lower costs, more channels on a line and improved voice quality

By A.E. Chatelon
Laboratoire Central de Telecommunications, Paris

Low-cost integrated circuits are now making it economically attractive to convert existing telephone networks to pulse-code modulation systems. A pcm system has always been technically desirable because it transmits speech as digital signals that are highly immune to noise and transmission line attenuation. But the cost of such a system was always too high. Now, integrated circuits have made it possible to attain not only the technical benefits plus higher reliability, but also lower manufacturing and operating costs.

Since pcm signals are merely a string of digital pulses, they can be regenerated at points along the transmission line so that the received pcm signal is exactly as transmitted. Also, pcm allows 24 or more voice signals to be time-division multiplexed onto an existing telephone line previously limited to one voice channel. This means that the quality and amount of traffic on existing telephone lines can be increased without having to replace the line itself—an extremely expensive proposition in metropolitan areas.

Basically a pcm system takes voice signals from a telephone, samples them many times a second and encodes each sample as a digital number. During this process, weak signals are given preferential amplification to make the signal level independent of the voice level of the speaker. This is called compression. The encoded digital number is the pcm signal that is transmitted along the line. To make the digital signal independent of line characteristics, the pulses are reshaped at regular intervals along the line. This signal is then reconverted to a voice—analog—signal by reversing the process (expanding) before the signal reaches the other end of the line.

There have been telephone exchanges with pcm in the United States since 1962 [see "Pcm: advantages and basic principles" p. 142], but existing pcm systems employ electromechanical exchanges that require that the pcm signal be converted to analog before switching.[1] New exchanges are being designed that can switch the pcm information directly. Combining a pcm exchange and pcm transmission results in a system called an integrated network.

Meantime, the Laboratoire Central de Télécommunications of Paris, a French laboratory of the International Telephone and Telegraph Corp., has found a way to reduce the number of analog components in the transmission portion of a pcm system. This means reduced costs and improved reliability—and the equipment also can be used in an integrated network. [A pcm exchange in an integrated network will be discussed in an article in the next issue of Electronics.]

Modernizing a telephone system

An electromechanical exchange as represented in the top diagram on page 141 might serve subscribers by connecting individual two-wire lines

The author

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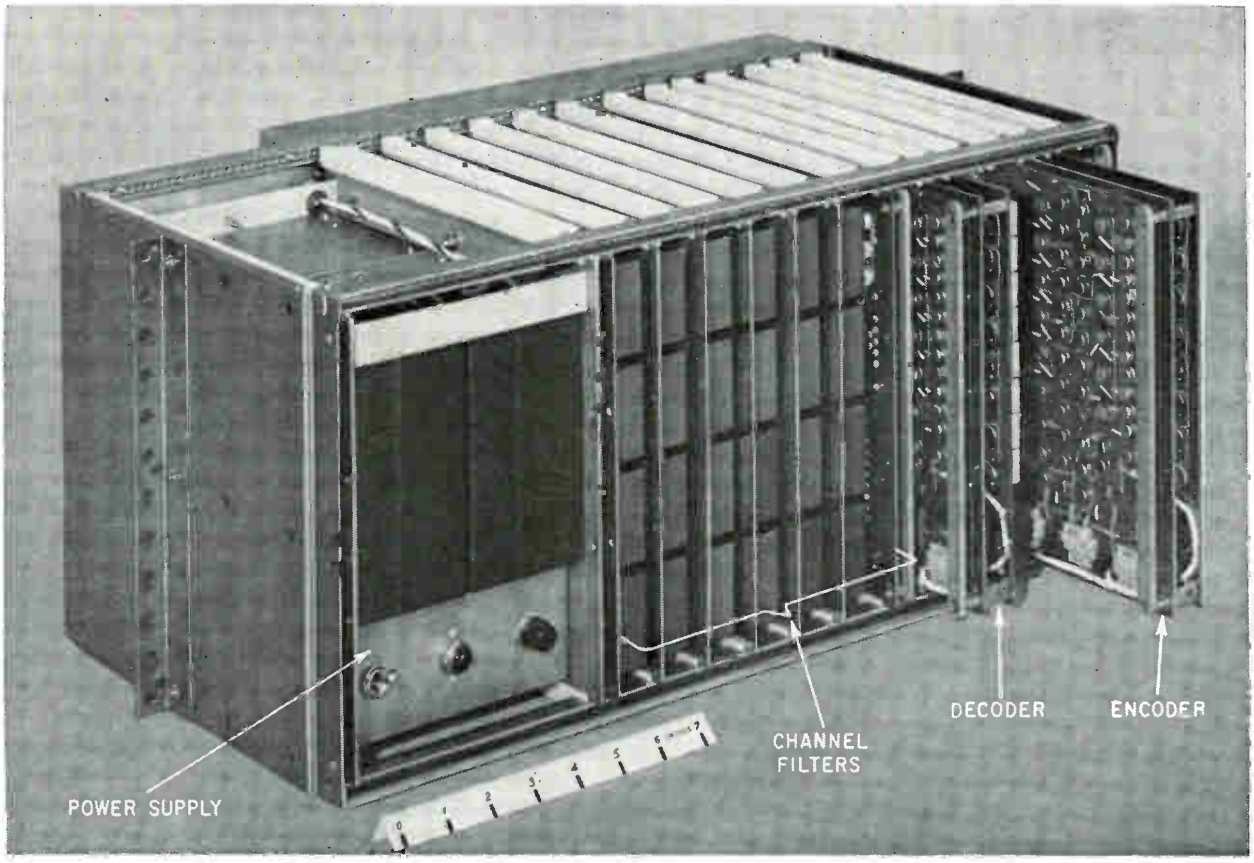


Terminal for 24 pcm channels includes a power supply, channel filters, decoder circuits and encoder circuits. The inexpensive channel filters are used to convert the pcm signal back to analog.

in a cable from the subscriber through many exchanges. If traffic increases, it is necessary either to use frequency-division multiplexing or to increase the number of lines. Both alternatives are expensive.

Instead, if speech signals are converted to pcm signals as in terminals A_1 to A_4 in the middle diagram, additional channels may be added to the pair of cables that once carried a single speech signal. Most pcm terminals such as in the photograph above multiplex 24 speech signals by time division onto a twisted-wire pair. The exchange unit includes both coding and decoding equipment.

Encoding equipment to convert analog speech signals to pcm is relatively complex, but because the signals are multiplexed, the encoder's cost is shared by 24 channels. Pcm transmission reduces terminal costs because there is no need for the expensive filters required in a frequency-division multiplex system. Pcm thus increases traffic even with electromechanical exchanges, but these exchanges must be capable of handling the traffic. The drawback to this system is that the pcm signals must be converted to analog in a terminal like A_2 to get through the exchange; then the analog must be converted back to pcm in A_3 so that it can be transmitted further down the line. These modulations and demodulations increase system noise and require the additional equipment terminals A_2 and A_3.

The bottom diagram on page 141 shows that the number of modulations and demodulations and the number of pcm terminals may be reduced by using pcm exchange T. Terminals A_2 and A_3 in the middle diagram are no longer needed and the number of modulations-demodulations is reduced, improving the quality of communications. With a pcm exchange, modulations-demodulations occur only in terminal A_5 or in local line concentrator C_1 or remote line concentrator C_2. A concentrator is a small terminal that connects phones in a small area to a local exchange. The concentrator's traffic capacity to the exchange can be less than the number of subscriber's lines because phones normally are not all used at the same time.

Compression and encoding

As discussed earlier three basic operations are performed on the pcm transmission line—sampling (and time-division multiplexing), compression and encoding. However, most pcm systems require a great number of expensive analog circuits that increase costs and present difficult manufacturing problems.

The method for sampling, compression and encoding in the T-1 pcm system of the American Telephone & Telegraph Co., for example, is illustrated in the figure on page 144. A compressor is placed between the sampling gates, SG, and a linear encoder—an analog-to-digital converter. The linear encoder's output is a digital representation of the instantaneous input voltage amplitude.

The sampling gates to the various telephone lines are connected sequentially and convert the continuous signals into a time-division multiplexed train of pulses. The amplitude of each pulse is determined by the amplitude of the voice signal at the time of sampling; therefore the sampled waveform is referred to as a pulse-amplitude modulated (pam) signal. After compression the pam signals are encoded for transmission as pcm signals. The compressor and the associated analog amplifiers as well as the equipment to reverse the process—the expandor—must be extremely accurate and reliable. If the expandor does not have the exact inverse characteristic of the compressor, the signal is distorted. The problem is further complicated because one compressor may handle signals that are distributed to many lines—each with a different expandor. This means, for example, that the carefully matched diodes that develop the compression characteristics must be maintained in a temperature-controlled environment that is held to within ± 0.1°C.

The pam amplifiers must be linear over a 60-decibel range of audio levels produced by loud and soft talkers. Cross talk between adjacent pam pulses must be less than 75 db or the signals will be noisy.

Pam amplifiers must have bandwidths greater than 100 megahertz because at a sampling rate of 8,000 times per second and with 24 channels multiplexed on one line there are 192,000 pam samples a second, each sample separated by only a half microsecond. To minimize the interaction between channels, it is necessary to reduce the pam circuitry and the length of wiring.

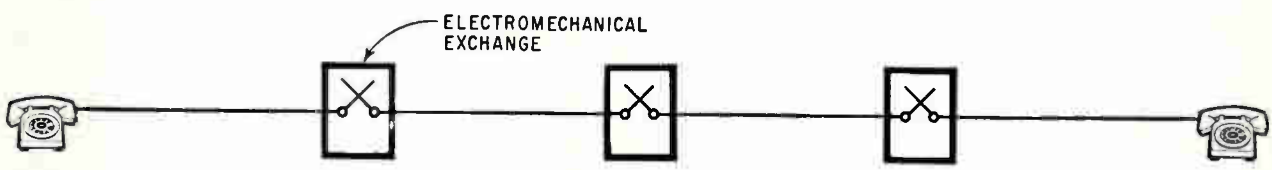
Some of these problems have been simplified in the T-1 system by splitting the pam path into two sections—one for the odd-numbered channels and one for the even-numbered channels. This reduces the pam repetition frequency and increases the spacing between pam samples for each path. However in operating with two paths a great deal of equipment is duplicated, resulting in increased cost.

A matched pair

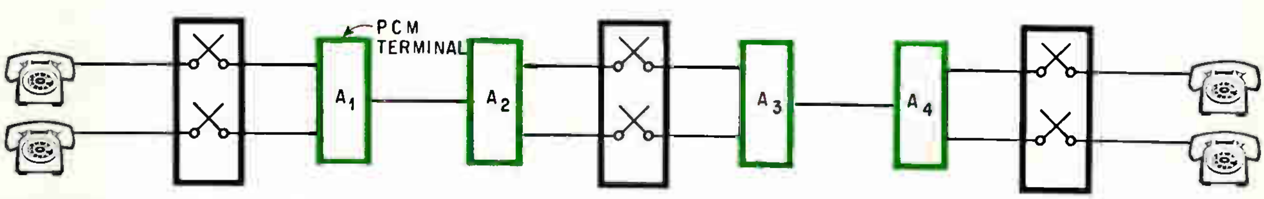
The problem of matching compressors and expandors and reducing size of the pam circuitry has been solved in LTC's equipment by eliminating the analog compressor and expandor and replacing them by digital equivalents. The compressor and encoder are combined into a single unit called a nonlinear encoder because compression is a nonlinear operation.

The block diagram on page 145 indicates that a nonlinear encoder consists of three main parts—a digital comparison amplifier (comparator), a matrical decoder and a digital centering device. The nonlinear encoder is basically an analog-to-digital converter that employs a digital-to-analog feedback path.

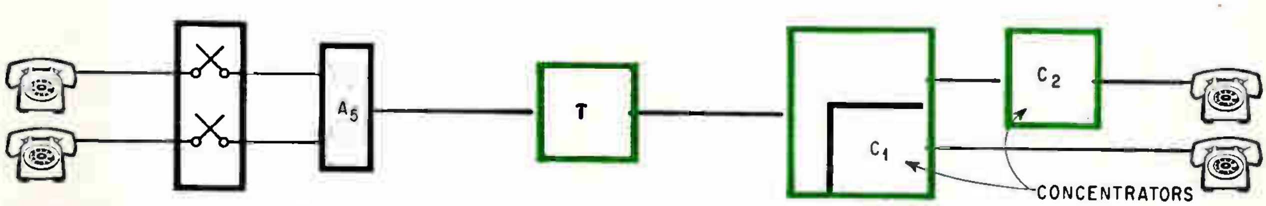
By comparing the input pam signal with the



Conventional local telephone transmission requires that each telephone have its own line as signal moves through electromechanical exchanges. Adding frequency multiplexing to the line requires expensive filter networks.



Pulse-code modulation terminals A_1 to A_4 multiplex signals onto a single cable. Although 24 multiplexed pcm signals require 1.4-megahertz bandwidth, the digital signals may be transmitted over conventional cables designed to carry audio signals. Before entering electromechanical exchange, pcm signals must be converted to analog by terminal A_2.



Tandem pcm terminal T switches signal directly, reducing the number of pcm and electromechanical terminals needed on the line. C_1 and C_2 are line concentrators serving subscribers in a local area. The concentrator's capacity is less than the number of subscriber lines because phones normally are used infrequently.

Pcm: advantages and basic principles

A pulse-code modulation telephone system offers the following technical advantages over conventional telephony:

- The quality of transmission is practically independent of the line's length because the repeaters in the line can periodically regenerate the digital signals to their original form. Noise with a peak value below a design threshold is rejected by the pulse regeneration circuits.
- The amplitude of the decoded signal is independent of the line's attenuation characteristics. Since the amplitude is coded, line attenuation has no effect as long as the code is received without error.
- As many as 24 signals can be multiplexed onto a line that previously carried one or two voice signals. This is accomplished by removing the loading coils needed for conventional analog transmission. These loading coils flatten the 4-kilohertz passband needed for audio and sharply attenuate signals beyond the passband. Removing the coils provides the increased bandwidth needed for pcm transmission. Of course more than 24 pcm signals can be multiplexed on special transmission lines, such as coaxial cable.

There is no longer any doubt that pcm is the most economic way to multiplex telephone signals over short distances. A pcm system uses digital circuits instead of the expensive filters required by a frequency-division multiplexed system. Although less obvious, an equally important reason for pcm's economy is that high-speed data and telephone signaling information is simply incorporated into the pcm multiplex format. The cost of a telephone channel's signaling unit, an important part of a terminal, can be reduced to a minimum.

History

In 1938 A.H. Reeves, then a staff member of the International Telephone and Telegraph Corp.'s French laboratories, described the principles of pulse code modulation in a French patent.[5] Reeves' work was extended in the 1940's by the information theory studies of Claude Shannon of Bell Telephone Laboratories. However, since many more active components are required for pcm multiplexing than for frequency-division carrier systems, pcm was not a practical possibility until the advent of transistors in the 1950's. Inexpensive vacuum tubes were not reliable and each needed a few watts of power.

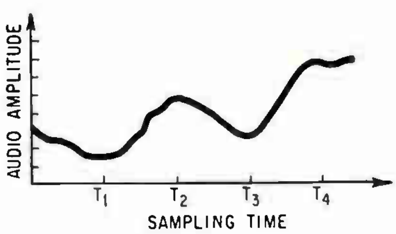
The first pcm system—Bell Lab's T-1 system—was introduced into a public telephone network in 1962. Now more than 100,000 pcm telephone channels are in service on trunks interconnecting exchanges in local telephone networks. Many countries, such as England, Japan and France, are developing pcm carrier systems for their telephone systems.

In pcm systems three basic operations—sampling, compression and encoding—transform the narrowband (less than 4 khz) speech signals into wideband but relatively noiseproof pulse-coded signals. Generally the signals are time-division multiplexed at the same time that they are sampled.

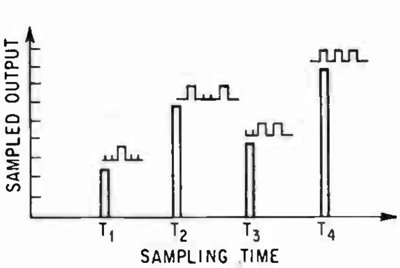
Sampling

In almost every pcm telephone system voice signals [top diagram, below] are sampled 8,000 times a second. This produces a string of pulses [lower diagram below] whose amplitude is the amplitude of the waveform at the instant of sampling. The samples are referred to as a pulse-amplitude modulated (pam) signal.

To recover the original voice waveform, the samples are passed through a low pass filter that has a bandwidth equal to 4 khz. There is hardly any degradation in the recovered signal if the original sampling frequency is greater than twice the highest frequency component in the voice signal. This explains the choice of a sampling rate of 8 khz.



Audio waveform is sampled at time intervals such as T_1, T_2, T_3 and T_4.



Sampled waveform has amplitude of audio wave at instant of sampling. Binary pulses above samples are digital representations of amplitude assuming that a 3-bit code is used.

Usually 24 audio signals are multiplexed at a time by sequentially taking a sample from each of the 24 waveforms. Since each signal is sampled at 8,000 times per second, there are 192,000 samples per second on a 24-voice multiplexed line.

The same gate that samples can also operate as a multiplexer and serve as a switching point since in the multiplexing process it can transfer information from a subscriber's line to a trunk line.

Encoding

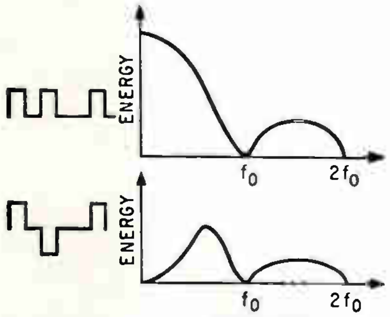
Encoding or quantizing can only approximate the signal levels in a voice waveform. A 7-bit code—used in most systems—can only represent 2^7 (128) distinct amplitude levels, but the number of amplitude levels in any voice signals is infinite. If the maximum speech signal is 1 volt and a 7 bit/128 level code is employed, the linear encoder divides the 1 volt into 128 amplitudes, each 1/128 (0.00781) volt high. Any voltage within one of these steps would be encoded as the same binary number. For example, all amplitudes at 0.500 $\pm$ 0.0039 volts would be encoded as the same binary equivalent of 0.500 volts.

Because quantizing only approximates the voice signal when the pcm signal is decoded (converted to pam) and filtered, the output's waveform is not an exact replica of the input's waveform. The difference in the two signals is called quantizing noise. Quantizing is the major source of noise in pcm.

Every conversion from voice to pcm increases the quantization noise in the system. One reason for the international acceptance of a 7 bit/128 level code is to hold the quantization noise to an acceptable level even after many modulations in the pcm network. A 6 bit/64 level or smaller code could be used if fewer modulations-demodulations occurred.

Increasing the number of bits in the code reduces the quantizing noise because the quantizing steps are narrower. However, more bits require digital components with higher switching speeds and more storage capacity in memory equipment. In addition, speeding up the bit rate increases the digital signal's bandwidth. The wider band signal would probably have to be regenerated more frequently.

It is possible to modify the frequency spectrum of the encoded pulses by choosing special digital codes. This is done to eliminate d-c levels, which are difficult to transmit, and to reduce high frequency signals, which cause cross talk. A simple binary or unipolar —off-on—code has a (sin X)/X amplitude variation versus frequency as in the top curve below. Frequency components have their largest amplitude near zero frequency. This unipolar code also produces a d-c component.



Binary waveform at top produces energy at zero frequency. Bipolar waveform below has a lower amplitude and no d-c component.

If alternate pulses are inverted, as in the bipolar code in the lower diagram above, the d-c component is removed and the bulk of the energy will be concentrated between zero frequency and the pulse-repetition frequency. Bipolar encoding is used in Bell's T-1 system and is being considered for most of the other pcm systems that are under development.

Since a multiplexed line normally encodes 192,000 voice samples per second, the minimum bit rate with a 7-bit code is 1.344 megabits per second. However, pcm systems add an extra bit for supervisory and signalling information so that 8-bit words are transmitted. This increases the bit rate to 1.536 megabits per second.

Every time the entire group of 24 signal code words is encoded, a bit (or framing pulse) is usually added. These framing pulses raise the total bit rate to 1.544 megabits per second. Various pcm systems will have slightly different bit rates depending on the exact number of bits used for coding, signalling and framing.

Compression

A system handling speech signals must be able to accommodate signals with a 1,000 to 1 range in voltage amplitude. This large amplitude variation represents the ratio of the highest voice level of a loud talker to the lowest voice level of a soft talker and corresponds to a 60 decibel range.

If the encoder in a pcm system were adjusted to encode the highest voice signal, then these high-level signals would fall into all 128 voltage steps associated with the 7-bit encoder as desired. However, low-level signals would only pass through the lower voltage steps. Therefore the encoding would be much coarser for low-level signals and signal quality would be seriously impaired.

To take full advantage of the code, the range of signals is compressed; low-level signals are amplified more than stronger signals resulting in a signal level relatively independent of talker level. As a result the signal-to-quantizing noise ratio is kept fairly constant even though the input levels vary over a large range.

Compression is effective, however, only if the signals are expanded to their original values at the other end of the line. Expanding characteristics must be the exact inverse of the compressor if the signal is not to be distorted. This is a critical requirement and is solved in a number of ways as described in the article.

Compression curve

The compressor's characteristics are determined by a compression curve that relates the output level of the compressor to input level. Because the ear's response to sound is proportional to the logarithm of the sound amplitude, the compression curve often selected also has a logarithm characteristic. In the T-1 pcm system the compressor curve is based on the law given by

$$E_{out} = \frac{\ln(1 + \mu E_{in})}{\ln(1 + \mu)}$$

where

E_{in} = input level normalized to the allowable peak input level.

E_{out} = Output level normalized to the allowable peak input level

μ = a constant with an approximate value of 100 to give the desired compression characteristic

ln = natural logarithm

The curve in Bell's equipment differs from the equation in that it passes through the origin ($E_{in} = 0$); the logarithmic relationship does not pass through zero. Bell uses a smooth compression curve because the T-1 system compresses the pam signals. Laboratorie Central de Télécommunications, Paris, employs curves that are approximated by straight line segments as in the graph on the bottom of page 147; these curves are easier to implement in LCT's digital encoder-compressor.

Regeneration

During transmission, line attenuation and variations in phase with frequency will tend to smear the pulses in the digital signal. Most of the high frequencies in the spectrum will be lost because of line attenuation.

One major advantage of pcm is that this deteriorated pulse train can be regenerated into its original pulse waveform and then sent further down the line. This regeneration is performed by pcm repeaters spaced about a mile apart on the transmission line.

A repeater actually does three things: it equalizes the line, retimes the pulses and regenerates the pulse train.

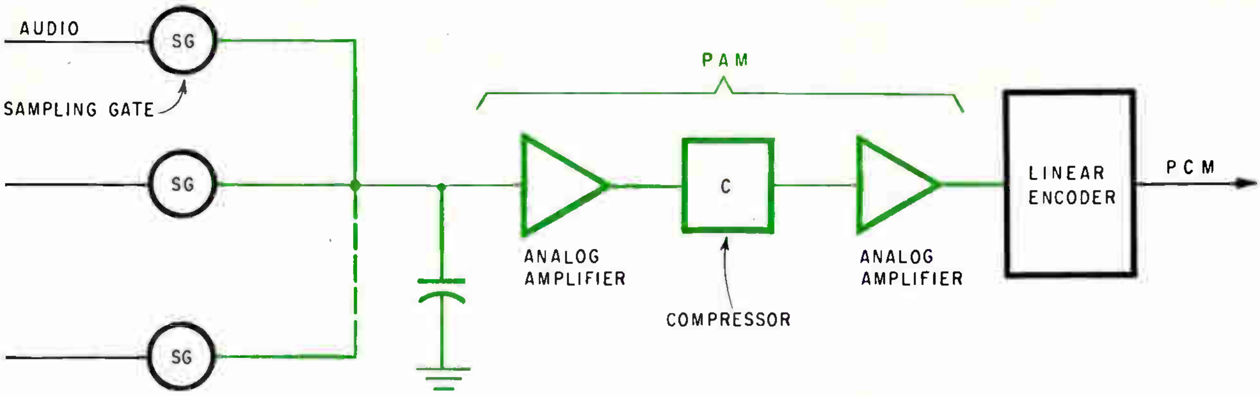
The equalization circuits restore some semblance of a pulse train by compensating attenuation characteristics.

In retiming, the repeater locks itself to the timing information in the signal. This allows the retiming circuits to signal the regenerator when it is time to make a decision on the amplitude of the pulse.

The regenerator establishes a reference level proportional to the received pulse height after equalization. The repeater compares the reference level with the height of the digital signal and decides if a pulse is present. The regenerator is usually designed to eliminate all noise spikes that are less than one-quarter of the received pulse height (eliminating pulses less than a half the received pulse height is the ideal criterion). If the noise is too great the signal will be regenerated with an error.

One principal source of noise that causes regeneration errors is voltages induced in pairs of cable by nearby conductors. The most serious problem is cross talk near a repeating section. Cross talk occurs when amplified signals couple into the inputs of other lines and mask the desired signal. Careful selection of repeater locations can reduce cross talk problems.

Leonard Weller



Linear encoding requires compressor in line containing sampled audio pulses (pam). Analog compression circuits and amplifiers are expensive and require careful adjustment.

feedback signal, the comparator generates the code word that is the digital equivalent of the pam amplitude. The matrical decoder converts the pcm code word back to an analog signal that is the feedback voltage for the comparator. Compression takes place in the matrical decoder.

The feedback voltage is increased until it equals the voltage developed by the pam sample. This equalization is carried out in seven steps, each step generating another bit of the code.

The digital centering device prevents an increase in the signal-to-quantizing noise ratio by eliminating d-c drift at the nonlinear encoder's input. The photograph on page 146 shows the integrated circuits for a 24-channel nonlinear encoder.

The nonlinear encoding scheme simplifies the problems associated with a separate compressor and expandor in three ways:

- The analog compressor is replaced by digital components that require no thermal stabilization.
- Digital components do not have to be specially selected nor do their characteristics have to be matched.
- Instead of one type of circuit for compression and another for expansion, the same type of decoder is in the encoding-compression and encoding-expansion equipment.

Problems in the analog circuitry have also been eliminated. The pam path is shortened since the compressor has been removed, and d-c shift is eliminated by incorporating a digital centering device in the encoder.

The nonlinear encoder is more economical than the linear version because inexpensive digital components replace precision analog components. The proportion of digital to analog circuits has increased from 50% to 90%. Also contributing to cost reduction is the ability to use identical current generators and resistive ladder networks.

Digital compression

Compression takes place because the feedback voltage in the matrical decoder is nonlinearly related to the coded output. As a hypothetical example, the pcm word 1010000 (decimal number 80) may correspond to an input analog-voltage of 20 millivolts, while the binary word 1110000 (decimal number 112) may correspond to a voltage of 420 mv. The ratio of the input voltages is 21:1. Since the coded outputs are referenced to the digital word 1000000 (decimal number 64) which corresponds to zero input, the ratio of the differences between the output numbers and 64 is only 3:1.

The compression characteristics are determined by the compression curve of the encoder which is a combination of the linear relationship

$$y_1 = \frac{A}{1 + \ln A} E_{in} \quad \left(0 < E_{in} < \frac{1}{A}\right) \tag{1}$$

and the logarithmic relationship

$$y_2 = 1 + \frac{\ln E_{in}}{1 + \ln A} \quad \left(\frac{1}{A} < E_{in} < 1\right) \tag{2}$$

where

y_1 = the compressor's output for a low level signal

y_2 = the output for higher level signals

E_{in} = the input analog voltage

A = a constant

Equation 1 describes a portion of the compression curve for low-level signals while equation 2 represents a portion of the curve for the higher levels. Combining these two portions to form one compression curve provides a more constant signal-to-quantizing noise ratio than the compression characteristics of the T-1 network [see "Pcm: advantages and basic principles" p. 143].

In the encoder the curves are approximated by straight lines that result in encoding-compression curves in the graph on the bottom of page 147. The two curves differ in the number of straight line segments that make up the approximation.

Signal-to-quantizing noise ratios measured at the output of a transmission link that has a nonlinear encoder are plotted in the graph at the top of page 147. Sine waves at a frequency of 850 hertz were encoded, transmitted and decoded.

The "teeth" in the curves are the result of sharp changes in the slope of the companding characteristics. It is generally accepted that even the coarser characteristic of the four-slope curve provides adequate signal-to-quantization noise ratio for telephone conversations.

The transcoding matrix in the feedback circuit is the most expensive part of the compression system; the smoother the compression curve the greater the cost. The curve's smoothness in turn is a function of both the required signal-to-quantizing noise ratio and the type of signals to be transmitted.

The transcoding matrix for the four-slope compression curves has been built with 21 resistor-transistor logic elements. However, with transistor-transistor logic only 15 elements are needed. A seven-slope compression curve requires 24 transistor-transistor logic elements.

Digital centering

The purpose of the digital centering device,[2] which is connected between the pcm line and the comparator's input, is to reduce quantizing noise introduced by drift in the pam amplifiers. When a separate compressor is inserted in the pam path and linear encoding is employed, there is no way of automatically compensating for this drift.

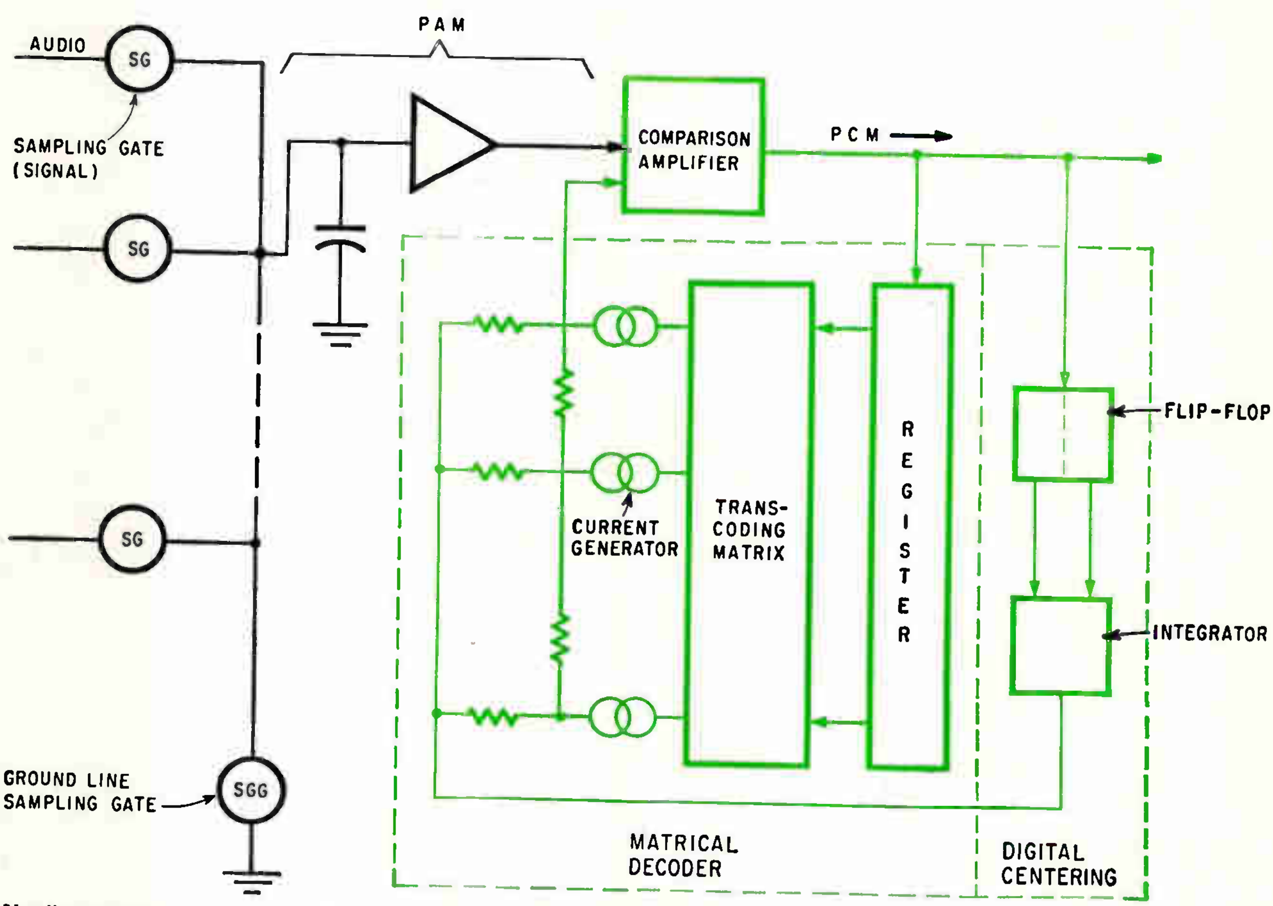
However, with a nonlinear encoder, compensation can be accomplished easily. To do this, ground signals are sampled by the ground sampling gate (SGG). These samples are sent to the encoder through the common pam path, and the encoder senses the polarity of this SGG signal at the output of the pam chain. Depending on whether the polarity is plus or minus, a flip-flop charges or discharges an integrator. Current supplied by this integrator is fed back to the encoder in such a direction as to counteract drift. Because the drift correction will vary, the reference current has a slight amplitude oscillation around the desired level.

The digital centering operation takes place during the synchronizing time slot—the time when synchronizing pulses are transmitted—rather than when the encoder is operating on speech signals. Only a portion of the synchronizing time slot is necessary for this purpose since only the polarity of the drift must be recognized.

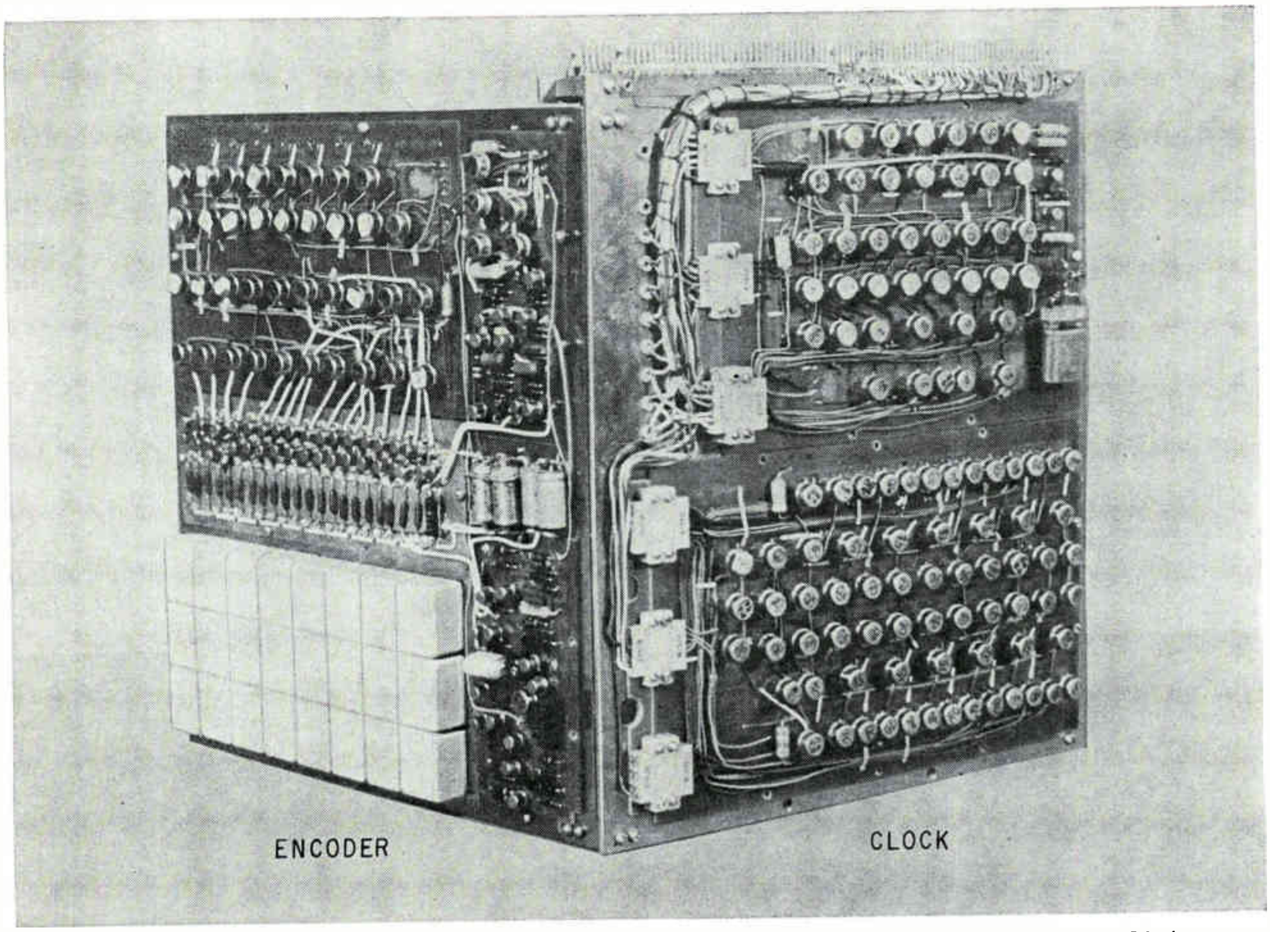
Digital memory encoder

Although the nonlinear encoder reduces some of the pam problems, a further reduction is possible by using a multiplexing and encoding scheme that utilizes a digital memory with a variable speed counter and ramp encoder.

Ramp encoders are frequently used in digital voltmeters because they provide analog-to-digital conversion with excellent linearity. By using a variable-speed counter synchronized with the ramp encoder it is possible to eliminate the external



Nonlinear encoder (in color) performs compression in the feedback loop. Output of transcoding matrix is converted to analog signal in resistive ladder network which feeds one input of comparison amplifier. Digital centering circuit reduces effect of drift in analog amplifiers.



Encoder for 24 pcm channels uses matrical decoding and includes circuits for digital centering. Almost 90% of the circuits on these boards are digital; in previous transistorized versions only 50% of circuits were digital.

compandor and obtain companding laws like those in the graph at the bottom of the next page.

There are two main drawbacks to this encoding scheme. First, it does not completely eliminate the pam circuitry. Second, the counting speeds become excessively high. A 7-bit, 128-level code corresponds to a counter speed of 1 Mhz for a single channel or 24 Mhz for a 24-channel multiplex system. The counter speeds are higher than the bit rates used on the line because the counter must go through at least 128 bits every 125 microseconds.

If nonlinear encoding with 24 to 26 db compression is desired, the counting speed must be higher than 400 megabits per second for a 24-channel system. Such high counting speeds are difficult to achieve.

Counting speeds may be reduced by using buffer units to store the pam signals. However, this leads to greater difficulties than using the pam circuitry.

Because of these difficulties, it was decided to use a nonlinear encoder-multiplexer that operates without pam gates, pam buffer units and pam amplifiers, shown in the block diagram on page 148.

This encoder-multiplexer advantageously trades the analog amplifiers for digital components. Existing integrated circuits are sufficiently fast to be used in such an encoder-multiplexer.

The digital memory encoder employs a sawtooth generator that is triggered at an 8 kilohertz rate in synchronism with a variable-speed counter. The maximum speed of this counter is around 16 megabits per second.

Instead of the conventional pam gate, a comparator is associated with each channel. The linear sawtooth generator feeds one input of each comparator. The other input of each comparator is fed by the audio signal on the telephone line to which it is connected.

The comparators are triggered when the amplitude of the sawtooth waveform exceeds the audio waveform. The resulting pulse transfers the digital counter's signal into a row in the memory.

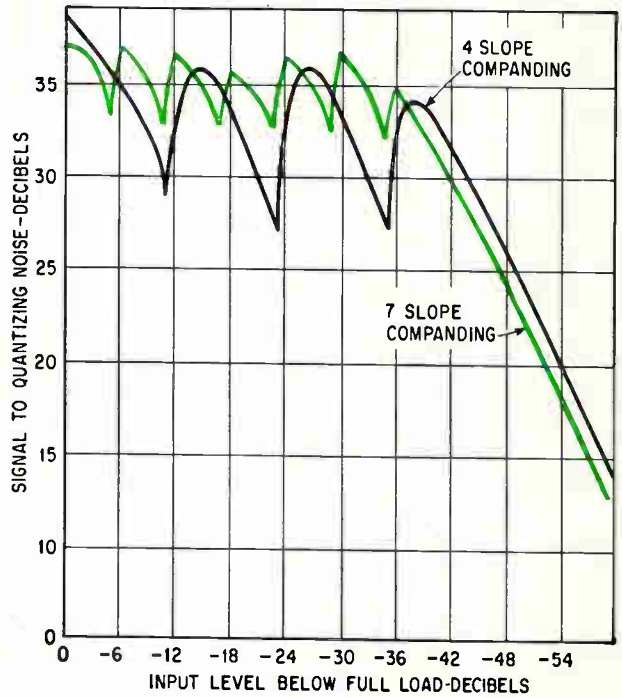
Since the counter's binary number depends on the time at which a pulse occurs, the information stored in the row of memory is the coded value of a pulse-position modulated signal. This quantity and signal corresponds to the audio signal of a channel sampled by the sawtooth waveform at 8,000 times per second.

Signals at the inputs of the comparators will be at different levels at different times so that rows in the memory are filled in a random manner with some rows being filled simultaneously. This means the counter speed does not have to be as high as would be needed if each voice channel were dealt with separately. For transmission purposes the memory is read out cyclically.

In addition to technical advantages, the digital memory's encoder-multiplexer is more flexible than the previous nonlinear encoder. In particular, channel comparators and the associated row of memory may be added without an increase in the speed of the encoding operation.[3] Therefore more than 24 groups of speech channels can be achieved without any serious system complications.

Decoding equipment, which may be similar to the encoding equipment, requires no more analog components than the nonlinear decoder. Since they appear only in the audio part of the decoding system, the analog components are mainly filters to eliminate the intermodulation products produced by the sampling and quantizing operations.

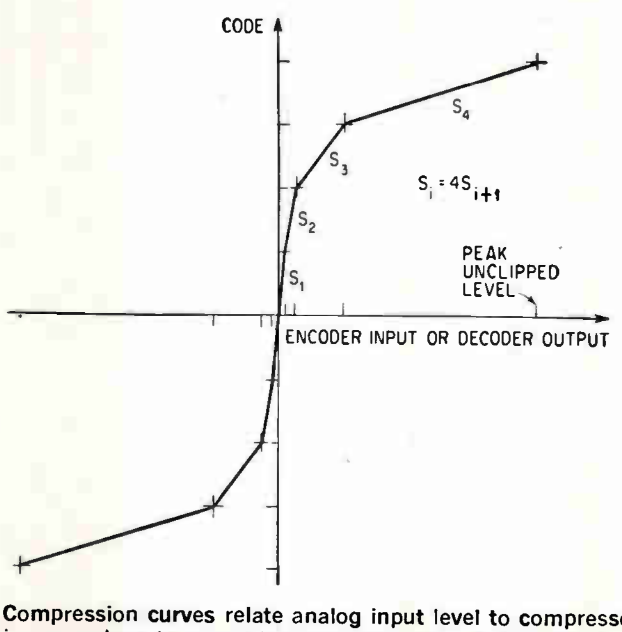
The apparent drawback of the digital memory encoder-multiplexer is that an increase in the number of speech channels requires more components than the previous nonlinear encoder; signal processing is on a per channel basis rather than by time multiplexing into a common channel. Because of the additional components, using conventional transistorized logic would create severe problems. Integrated circuits solve the problems technically if not economically but it now seems possible to integrate all the functions corresponding to a channel into a very small number of units. It is even expected that in the near future new devices such as metal oxide semiconductors will allow an entire channel to be built in one unit, cutting the cost significantly.

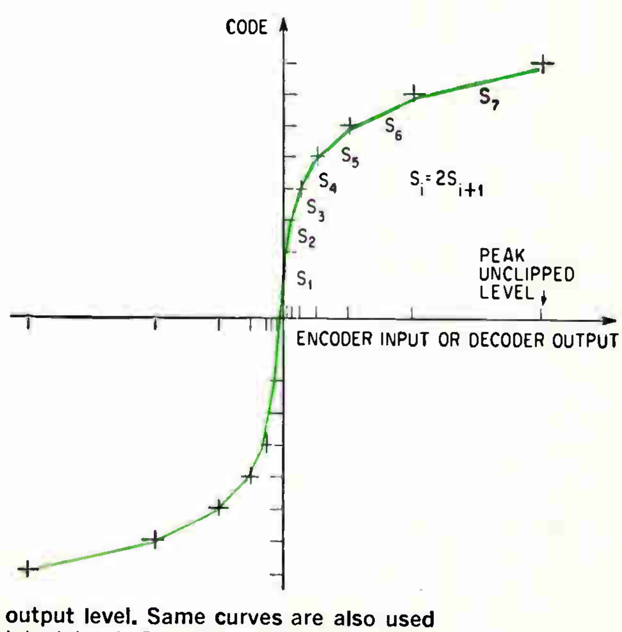


Signal-to-quantizing noise levels in transmission line with a nonlinear encoder are fairly constant over a large range of input levels. Tooth-like variations are caused by changes in slope in the companding circuits. The seven-slope compression curve in color has less variation.

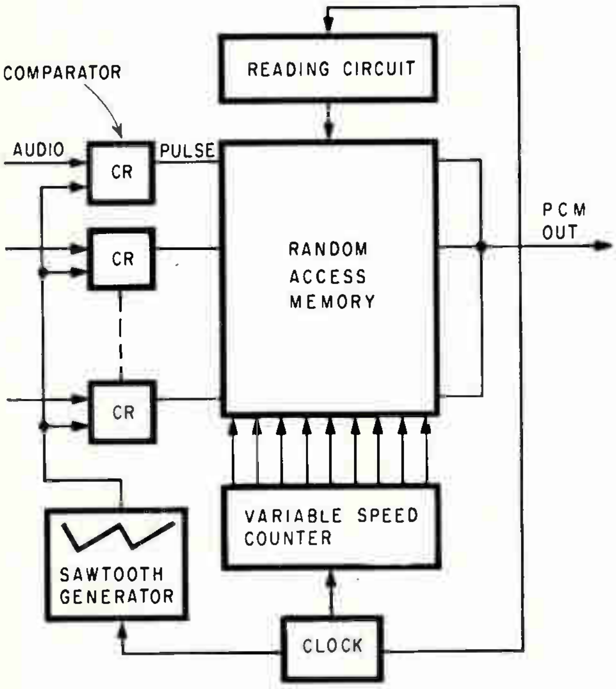
Line repeaters

Another serious technical difficulty in digital speech transmission is regenerating the digital information along the line. For instance, plans to expand a French public telephone network call for transmitting digital information at 1.5 megabits per second—corresponding to 24 speech channels —over unloaded pairs of wires. These pairs belong to multiwire audio cables designed for the transmission of voice signals. As a result the following





Compression curves relate analog input level to compressed output level. Same curves are also used in expandors to convert compressed signal back to its original level. Seven-slope curve in color produces higher signal-to-quantizing noise level than four-slope curve on the left.



Digital memory encoder and multiplexer eliminates pam gates and amplifiers. When amplitude of sawtooth generator exceeds audio input, the comparator circuit generates a pulse that gates the counter's digital signal into a row in the memory. Memory produces pcm output under control of the reading circuit.

sources of distortion and interference exist:

- Attenuation rapidly increases with frequency in all the lines in the cable.
- Attenuation characteristics vary depending on the wire pairs chosen, the ambient temperature and the quality of the line.
- The cross talk will vary in different wire pairs in the same cable.

It is only because of the digital and synchronous properties of the transmitted signals that these difficulties may be overcome. However, although the transmitted information is digital in nature, most pcm repeaters—the devices that regenerate the signals—include a very high proportion of analog components.

A repeater usually consists of input, timing extraction and gating and reshaping devices. In brief, the purpose of the input device is:

- to separate the information signals from the current that powers the regenerator.
- to compensate for the line's variation of attenuation in the operating frequency range.
- to amplify the received signals.
- to rectify the received signals when necessary.

While it is economical to use integrated circuits for the gating and reshaping circuits, only a portion of the input circuits may employ integrated circuitry. Many analog components are still necessary; mostly to equalize line-impedance characteristics.

Timing circuits must extract a periodic waveform at the bit rate from the incoming signals. The phase of this extracted waveform must not vary despite the random nature of the signals and the distortion or interference encountered on the line.

Two methods may be used for the timing extraction. The first, used in the T-1 system, employs accurately adjusted inductance-capacitance filters. The second, which LCT prefers, is the phase-locking method.

Phase locking offers two principal advantages: the system does not require a special code, for example a long sequence of zeroes may be transmitted without any difficulty; components need not have close tolerance requirements even when wide temperature variations are expected, therefore inexpensive integrated circuits can be used in this section of the repeater. Integrated circuits also replace analog circuitry in the retiming section of the regenerator.

Because the phase-locking system does not require a fixed period, it has an advantage over systems that must have accurately controlled clock frequencies; for example, when high speed data is exchanged between computers or between computers and peripheral devices whose clock frequencies are not accurately determined. Accommodating varying clock frequencies also is desirable when the frequency varies during transmission, as it would if the pcm signal were transmitted over a satellite.

A recently patented redundancy method[4] not only simplifies the retiming problem but also eases tolerances for the input circuitry. When redundancy is incorporated into the code, the energy of the signals is concentrated at the center frequencies. This shaped frequency spectrum reduces the circuit's dependency on transmission line amplitude response and reduces the problem of equalization in the regenerator's input circuit.

A few additional logic elements introduce redundancy in the terminal equipment. In this case accuracy in the regenerator's analog circuitry has been exchanged for some additional complexity in the terminal's digital circuitry.

The choice between nonlinear encoding or digital-memory encoding and possible inclusion of redundancy in the codes depends upon the requirements of the pcm system and economics. It is conceivable that a pcm system could use a number of these techniques to take advantage of their particular benefits. However, this must be weighed against the resulting increase in spare parts and extra training for personnel. The final choice must consider all these factors.

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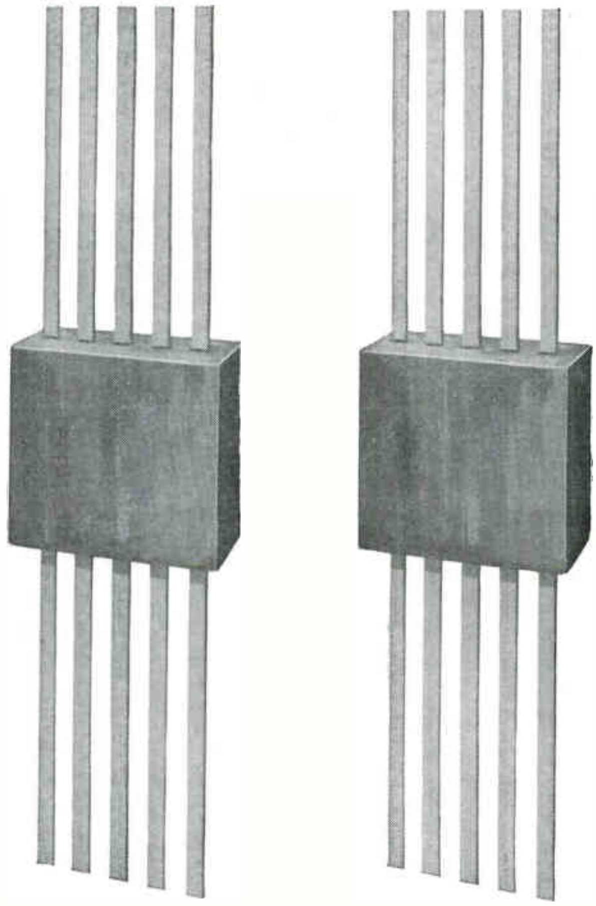

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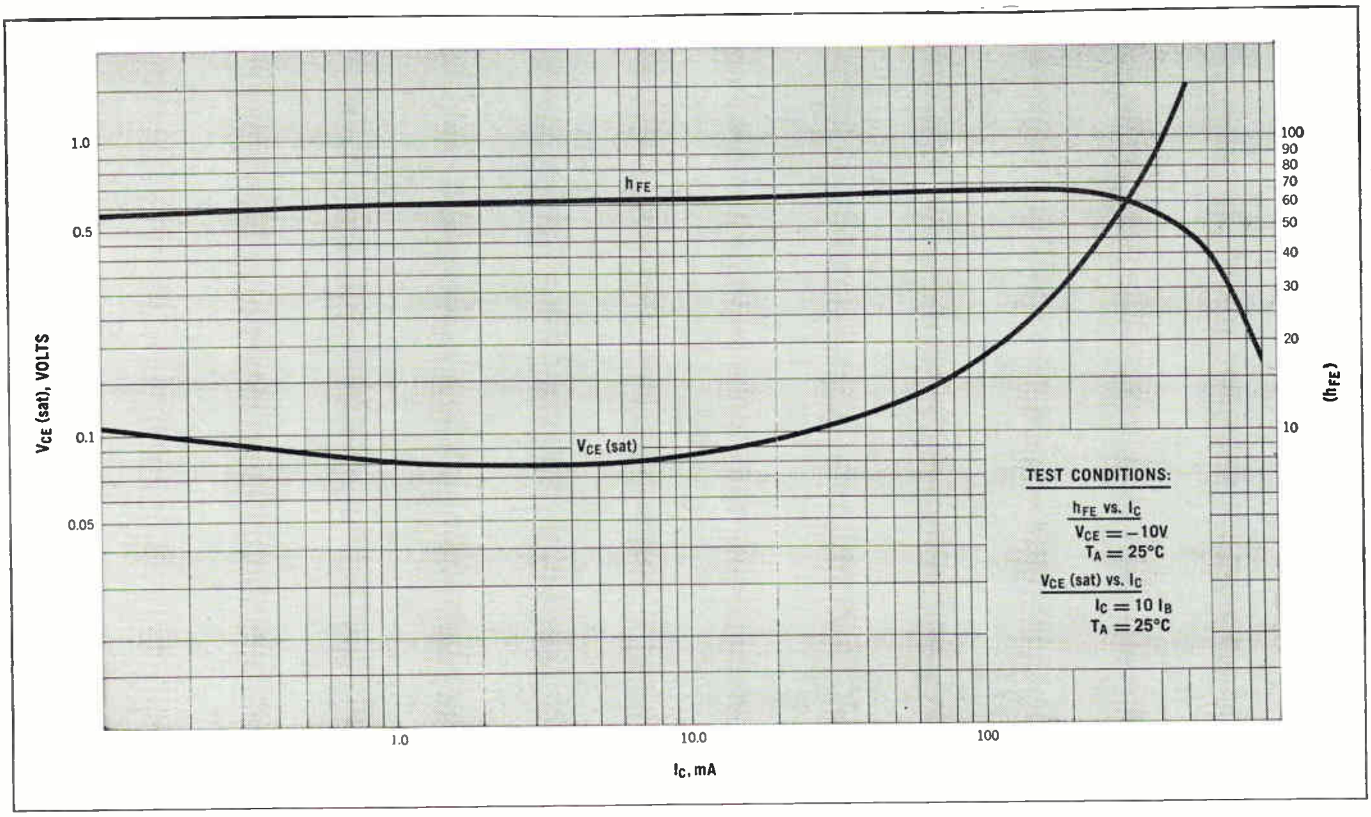

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Air navigation system testing grounded by signal simulator

Device checks out loran airborne receivers in the laboratory, ending need for costly air trials; technique may be extended to testing of other navigation systems and coordinate converters

By Robert S. Stapleton
Teledyne Systems Co., Hawthorne, Calif.

Testing and calibration of airborne navigation receivers has been an expensive, time-consuming, often inadequate procedure. It has been necessary to take a receiver on long airplane flights to determine how accurately the system can process signals from transmitters thousands of miles away and how well it handles signal distortion caused by interference, noise and doppler shifts due to the aircraft's motion.

Now the job can be done quickly and economically at a test bench with a simulator developed for the Federal Aviation Agency.

With modifications, the simulator, built to check out loran A and loran C airborne receivers, can test other hyperbolic navigation systems operating on the same principles as loran [see "Radio beacons guide aircraft navigators," p. 154].

The techniques that simulate pulse transmission over long distances—such as multiple delay lines to introduce doppler delays and precision pulse timing and a unique combination of digital techniques and delay lines to eliminate the requirement for a high-frequency oscillator—may also apply to the testing of communications and radar systems.

Although hyperbolic navigation systems such as loran (long-range navigation system) have been in use since 1940, only static test equipment has been available. The loran A and C signal simulator built by Teledyne Systems Co. is the first system capable of testing these complex devices dynamically in the laboratory.

It generates loran A or loran C test pulses that are fed into a receiver, making the receiver seem to be in an aircraft flying on some predetermined course at speeds up to 2,000 nautical miles an hour—equipment destined for supersonic transport planes can be tested now. The accuracy of the simulated timing pulses is equivalent to the real-time loran transmission error of ±0.1 microsecond. In addition, appropriate sky waves, radio-frequency interference and continuous-wave interference can be generated to complete the duplication of loran signals received at any point on the earth.

Good for others

The family of accurately timed digital signals can also dynamically test other types of equipment. The growing field of coordinate converters, for example, introduces a broad range of new navigational aids, many still under development. The loran simulator presents a valuable tool for analysis and test of these new systems.

A coordinate converter is a device which accepts time-difference signal inputs in the hyperbolic system of coordinates—such as those used in the loran system—and shows them on a display that depicts receiver and position in latitude and longitude. Since the simulator provides a continuously updated set of coordinates for position computation, the ground testing of converters is

The author

Robert Stapleton is a project engineer on the self-contained navigation and short-range station-keeping system for the Integrated Helicopter Avionics System that Teledyne is making for the Navy. He helped develop the digital interface unit of that system's computer.

superior in many ways to an expensive flight test.

The simulator only requires minor modifications in timing to make it suitable for testing other navigation systems. For example, any r-f pulse envelope may be duplicated by substituting appropriate modular circuit cards for the loran C (100 kilohertz) or loran A (2 Mhz) modulators in use. Replacing a plug-in oscillator changes the carrier frequency. Rewiring one or two gate cards modifies the pulse repetition rate and even a complex change such as revising the pulse sequence involves little more than a change in the wiring of 8 or 10 gate cards.

One modulator or three

The simulator contains loran C and loran A modulators; only the loran C configuration is shown in the block diagram at the right, but the loran A configuration is essentially the same. Loran A requires three modulators, for a master and two slave stations; the loran C simulator has one.

The loran C modulator accepts digital signals defining pulse generation times and phase coding and a continuous-wave 100-kilohertz signal directly from a timing source. Using these inputs, it generates a pulse which is described by the function:

$$f(t) = t^2 \epsilon^{-2(t-1)}$$

in which t is time. The function describes the passage of a loran C pulse from the transmitter to a receiver. The loran A modulator accepts digital timing pulses and a c-w carrier at one of the four standard frequencies and generates the loran A pulse, which is essentially gaussian.

The simulator system has four primary functions when used to evaluate loran receiver performance:

- To test the dynamic response of time-difference tracking circuits in the receiver with realistic aircraft motions.
- To measure and record receiver time-difference readings in all forms of operation for calibration purposes.
- To test the receiver's ability to extract signals from noise, interference or sky-wave returns.
- To see if the receiver operates at all basic and specific repetition rates and recognizes slave and master transmitter "blinking" and phase coding [see p. 154].

Making waves

The simulator operates under the control of a punched tape that contains in digital format the pseudo airplane flight and the loran C signals which the simulator processes. The information is inserted through a high-speed tape reader to load the seven digital registers seen along the side of the block diagram at the right. The latitude and longitude registers drive readout devices directly through decoding networks. The master delay, slave X delay, and slave Y delay registers, in conjunction with an elapsed time register, generate trigger pulses for each pulse group. The triggers are digital pulses timed to within 10-microsecond increments. For loran C the trigger pulses generate loran C pulses which pass through two highly accurate tapped delay lines, called fine delay lines, to provide the delays of 1 to 9.9 microseconds and 0.1 to 0.9 microsecond needed to fulfill system accuracy. After separation into M, X and Y pulse groups, the signals pass through electrically variable delay lines and attenuators. These provide sky-wave delay and doppler shifts that simulate the signal received by a moving aircraft.

In loran A operation, the digital pulses which trigger the signal pulse generator are passed through the same type of delay lines and then are used to generate loran A signal pulses.

After each discrete pulse or pulse group is generated and delayed, the master pulses, slave X pulses and slave Y pulses are amplified individually, summed, and sent to a filter/mixer network, where the composite loran signal is mixed with noise or radio-frequency interference and presented to the receivers under test.

Sky waves are generated by taking the final r-f pulses for loran C or digital pulses for loran A and passing them through precision magnetostrictive delay lines with a length selectable from 0 to 700 microseconds. The output of the delay lines are summed with the ground wave signals to provide the composite loran signals.

To connect the simulated signals to the antenna input of the receiver, a matching network that has the proper antenna impedance is used. Otherwise the direct simulator output (50 ohms impedance) is used.

To simulate a loran C station the equipment can operate at any of the standard repetition rates or any desired repetition rate and deliver signals having either a 500- or 1,000-microsecond pulse spacing. In addition it can operate in either a multipulse or single-pulse mode at the 100-kilohertz loran carrier frequency. Loran C simulated signals are phase coded according to loran standards and provision is made for "blinking."

Display subsystem

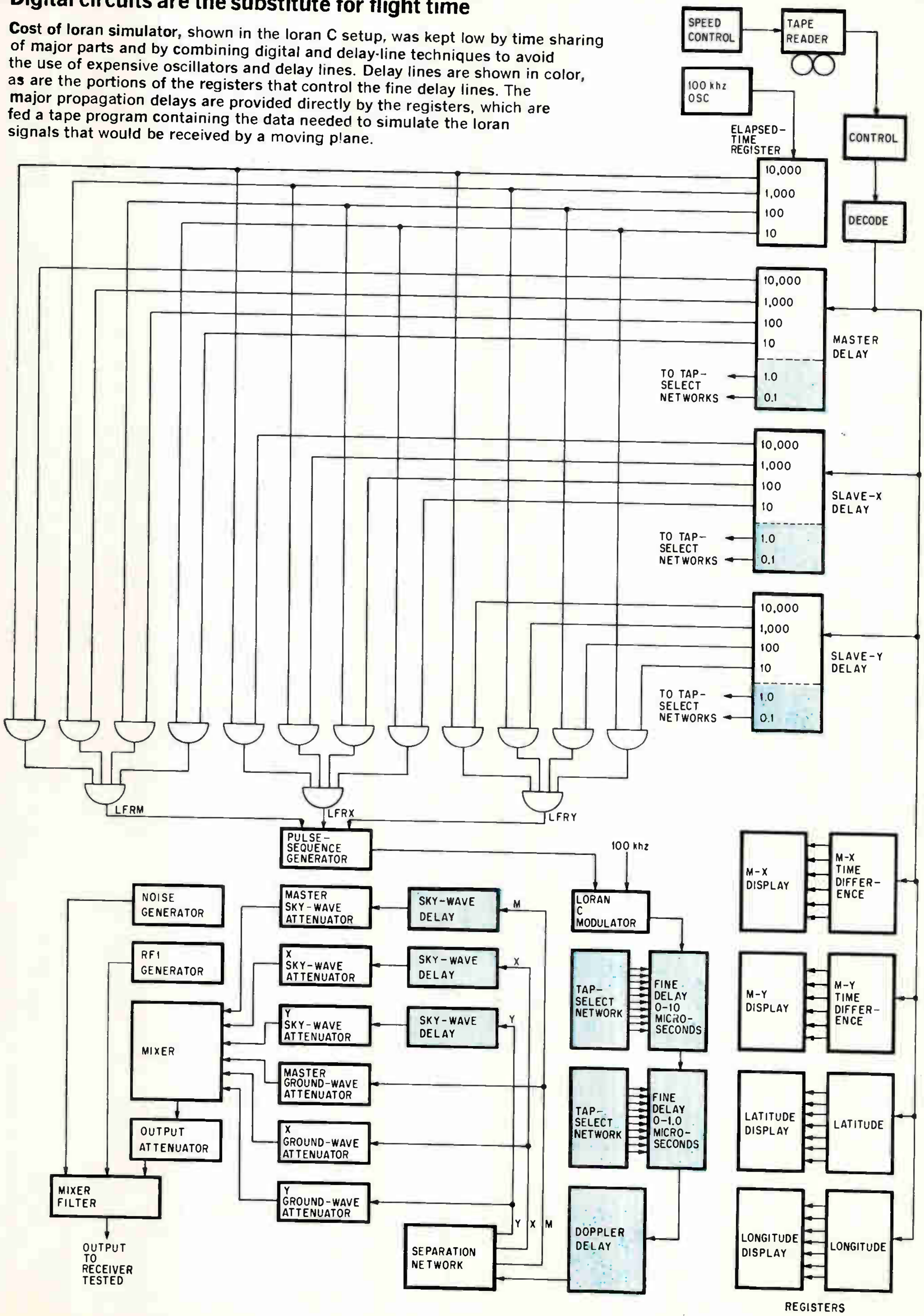
In addition to simulator control, the computer-generated tape data also lights four sets of numerical readouts (Nixie tubes). These show the operator the master-X station time difference, master-Y station time difference and latitude and longitude (in degrees, minutes and seconds) as the simulated flight progresses. The pulses displayed would be identical to those displayed if the receiver actually was at the location shown.

A flight can be halted at any point and the prevailing conditions used in extensive examination of receiver response.

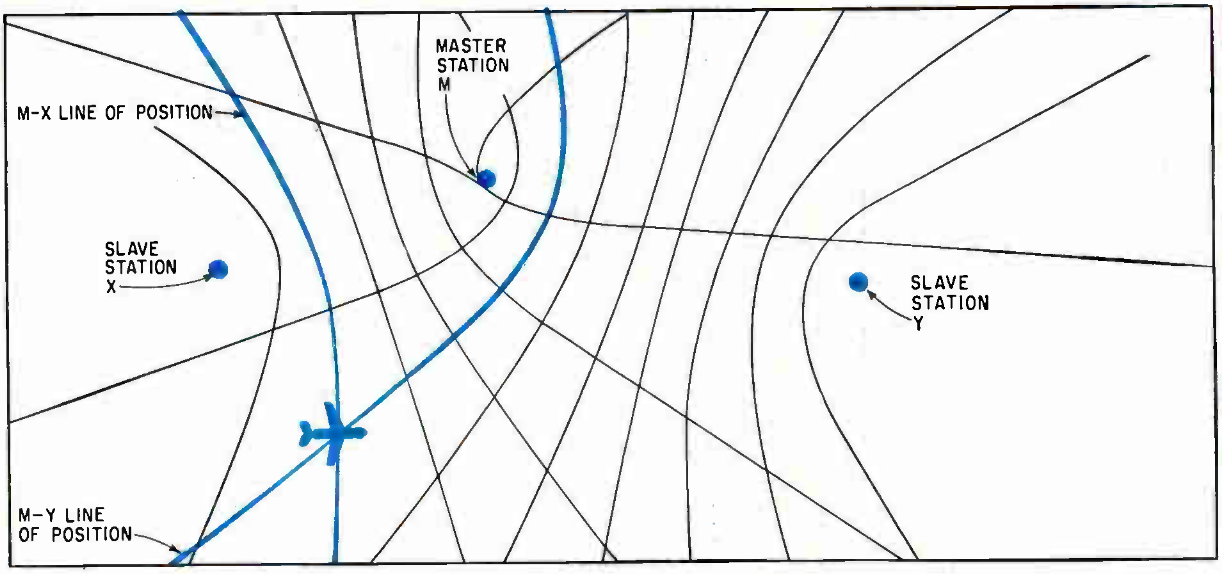
Two Beattie Varitron cameras provide a check on receiver time-difference display versus simulation time-difference display. One camera, with a wide angle lens, is on a mechanical support bar directly in front of the simulator's Nixie tube display. A second, on a tripod, is directly in front of the receiver or receivers under test. Both are electrically operated and driven by identical sig-

Digital circuits are the substitute for flight time

Cost of loran simulator, shown in the loran C setup, was kept low by time sharing of major parts and by combining digital and delay-line techniques to avoid the use of expensive oscillators and delay lines. Delay lines are shown in color, as are the portions of the registers that control the fine delay lines. The major propagation delays are provided directly by the registers, which are fed a tape program containing the data needed to simulate the loran signals that would be received by a moving plane.



Radio beacons guide aircraft navigators



Loran C is one of several hyperbolic-coordinate navigation systems that fix the position of an aircraft or ship by measurement of the differences in the times it takes radio signals to travel from a set of transmitters to a receiver.

The time differences for signals received from a pair of transmitters indicates that the receiver is somewhere along a line drawn on the earth. This line passes between the two transmitters and is approximately a hyperbola. Measuring the time differences for a second pair of stations gives a second hyperbola, intersecting the first one at the receiver's location.

Loran C is a modification of this basic arrangement. Instead of four transmitters, three—called a loran triad—are used. A master station, M, triggers two slave stations, X and Y. Precise time delays and signal codes are used to prevent ambiguity about which station is farthest from the receiver and which station sent a signal.

The hyperbolas generated by loran C triads are plotted on charts, providing navigators with coordinates as definite as lines of latitude and longitude.

Taking pulse. The stations transmit pulse groups on a 100-kilohertz carrier signal. The phase of the carrier signal is varied from pulse to pulse. For example, the master station may transmit a pulse group in which pulses 3, 4, 6 and 8 are out of phase with the other pulses in the group. In the next pulse group, only pulses 2 and 3 would be out of phase. These two pulse groups would alternate. Each of the slaves would transmit in a different code; in alternate groups, pulses 6 and 7 would be out of phase, then pulses 2, 4, 7 and 8.

If a slave station is not transmitting reliably, it indicates this by "blinking"—the station's pulse groups are delayed by 300 microseconds for one second, then return to their normal position for a half second.

Ground-wave signals from a loran C triad have a usable range of 1,200 nautical miles. Sky waves extend this, but accuracy is less since sky waves are subject to more variables than ground waves. Sky wave fixes at ranges up to 3,500 nautical miles, accurate to about 2,952 feet (±2 microseconds) are not unusual.[1]

nals so that the pictures are taken simultaneously. Exposures may be made once a minute, 10 times or 60 times a minute.

Moving through air

To reflect an aircraft's motion, the loran signals are individually doppler shifted in accordance with the aircraft's motion with respect to each of the three simulated loran stations.

The time delays are calculated from an initial set of programed conditions derived once the precise flight path and location of the transmitters are known. Based on the flight path, a circular or geodetic program is chosen for the computer [programs are outlined on the next page].

The geodetic program simulates the movement of a receiver from an origin to a point along a geodetic line. The position incrementation is derived from equations which modify the receiver latitude and longitude according to the distance traveled by light in 0.1 microsecond, leading angle of the receiver and the ellipsoidal distance to the destination. The initial calculations are further modified to correct positions, distances and headings for the ellipticity of the earth.

The circular program generates tapes that move the receiver around a point at a constant distance from the point. For both types of programs, the propagation distance is then calculated as the distance, on a sphere, between the receiver and a loran transmitter, again corrected for the ellipticity of the earth. The distance is also corrected for receiver altitude, since the line-of-sight distance is needed, and the amount of path along the earth's surface and in the air is also determined.

Propagation time determination, the most important single calculation in simulating transmission over long distances, is made in two parts: one for the path near the earth's surface and another for the altitudes at which only atmospheric refractivity is a factor.

The surface propagation time equals the surface distance divided by the velocity of light at the surface. To this is added the secondary delays resulting from land and seawater conductivity [see table of constants, p. 156].

Finally, total surface delay is added to total atmospheric delay to obtain total propagation time between a transmitter and the receiver at each increment of receiver motion. The atmospheric delay is calculated by dividing the atmospheric path length by the velocity of light at half the given altitude. The decrease in refractivity per kilometer of altitude equals $7.32(0.005577N_s)$, where N_s is the measured surface refractivity. Assuming this decrease is linear, taking the half altitude provides the average atmospheric delay.

Reading the tape

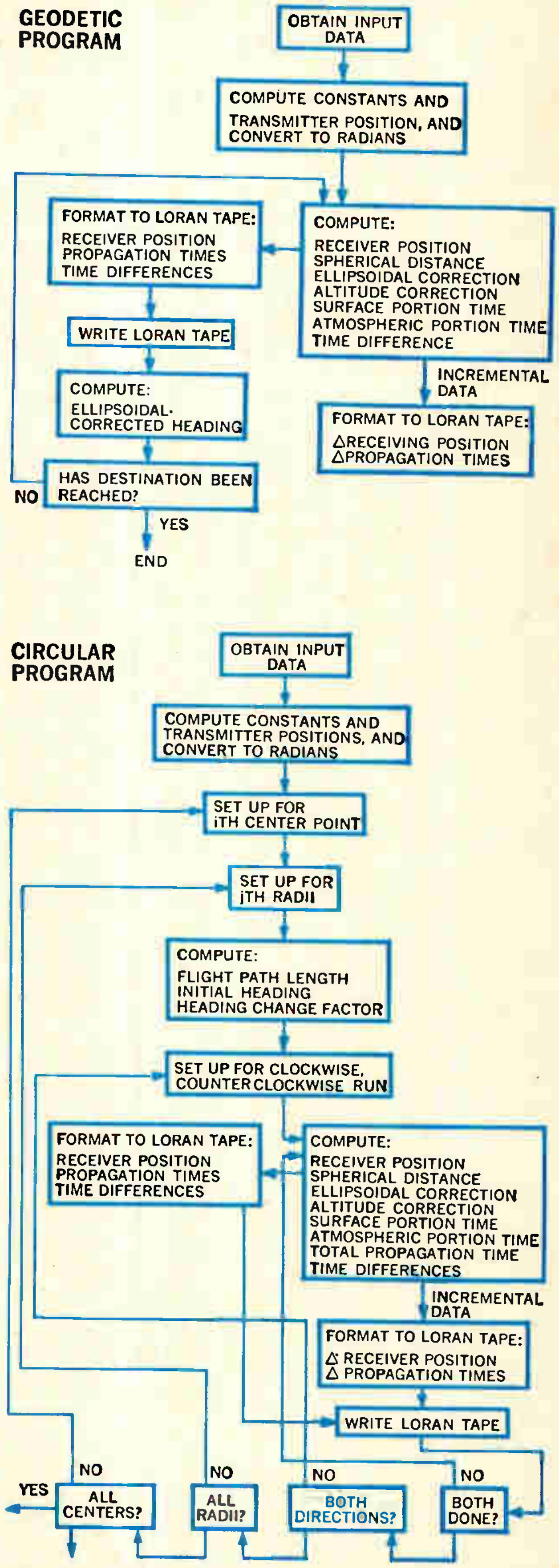
Rather than storing binary quantities on the tape and reading them into digital registers, a method was chosen in which digital registers are set to initial conditions and thereafter are updated incrementally. There are seven registers which require initial conditions: master delay, slave X delay, slave Y delay, latitude, longitude, M-X time difference and M-Y time difference.

The number fed into the master delay register corresponds to the propagation time (in microseconds) of pulses that travel from the master transmitter to the receiver.

The number in the slave X delay and slave Y delay registers corresponds to their relative propagation times, plus the coded delays normal in loran operation. As these numbers are installed in the delay registers, the difference between the time in the master delay register and the time in the slave X delay register is inserted into the M-X difference register; the corresponding M-Y time difference is installed in the M-Y difference register. When the initial latitude and longitude numbers are inserted, the setup is ready.

From this point, only the numbers in the three delay registers and in the latitude and longitude registers need be updated to reflect receiver movement. The digitally coded program tape changes the numbers in the latitude and longitude registers uniformly, allowing a smooth movement of the airborne receiver along the simulated flight path. The five incremental channels supply these instructions: count up, count down and no count, which require two coding bits. Therefore, two characters are used for each incrementing instruction.

To obtain accuracy in delay time, a count in the least significant stage of the delay registers and time-difference registers is taken to mean a 0.1-microsecond delay. Therefore each increment coded has a meaning of ±0.1 microsecond depending upon simulated direction. Since each count is equivalent to 0.1 microsecond there are 20 counts in two microseconds on any of the delay registers. Since two characters are required for a single count, the system's tape reader must read approximately 66 characters a second to



Geodetic and circular programs that prepare with a computer the simulator-control tapes. The tapes reproduce the movement of a receiver in an airplane flying in a prearranged path at speeds up to 2,000 miles an hour.

Constants for tape program generation

Flattening of the earth	1/297
Semimajor axis of the earth	3,963.33863 miles
Velocity of light (vacuum)	0.1862831068 miles/ microsecond
Velocity of light (20,000 feet altitude)	0.186274538 miles/ microsecond
Refractivity (earth's surface)	1.000338
Refractivity (20,000 feet altitude)	1.000046
Conductivity (land)	0.005 mhos/meter
Conductivity (sea water)	5.0 mhos/meter

Transmitter location in west longitude and north latitude

Master—77° 54′ 47.2″; 34° 3′ 45.61″
Slave X—80° 6′ 53.71″; 27° 1′ 57.32″
Slave Y—69° 58′ 40.51″; 41° 15′ 11.98″

simulate an aircraft traveling 2,000 nautical miles per hour. The character speed is not difficult for tape readers—a Tally Corp. model 424 is used.

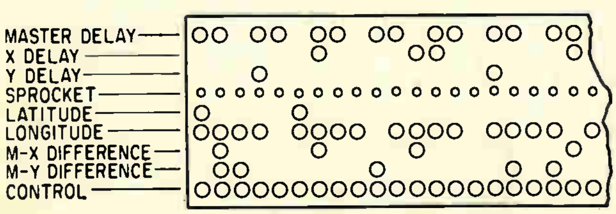
Flip-flop counter

An eighth channel on the tape contains the control signal, which tells whether initial conditions or incremental data is being supplied to the simulator. It controls the configuration of the seven registers since each must act as a shift register during setup and as up-down counters the rest of the time.

Since two characters define one count period, a flip-flop in the reader for each incrementing channel can define the character on which the count should be made. When this flip-flop is turned off, no count can occur but flip-flops connected directly to the tape reader circuits on the five incrementing (delays, latitude and longitude) can each pick up the first bit of the two-bit code. When these flip-flops are turned on, a count signal may be generated in those five channels. These control flip-flops are synchronized to the tape.

The first bit of the two-bit code which is stored in each delay-channel flip-flop indicates (when it's on) that a count is to be made. The second bit, which is taken directly from the tape, indicates the count direction; an on signal makes the register count up, and an off causes a count down.

As the simulated path approaches the North or South Pole, the rate of change of the longitude register must increase faster and may increase without bound. Although the problem of updating the longitude register near a pole cannot be solved completely, a small modification in decoding extends the region over which the longitude register can accurately be updated. The 0 1 code, unused in the other channels, indicates a double count. The count direction is the direction taken on the last single count code. This direction is stored in a flip-flop.



Simulator-control tape format. The latitude, longitude, loran pulse time delays and transmitter station time differences are punched in digital code.

The latitude register and the three delay registers, which can note only one count per count period, use only the first count time. The longitude register and the two time difference registers, which can count one or two counts per count period, use both the first and second count times.

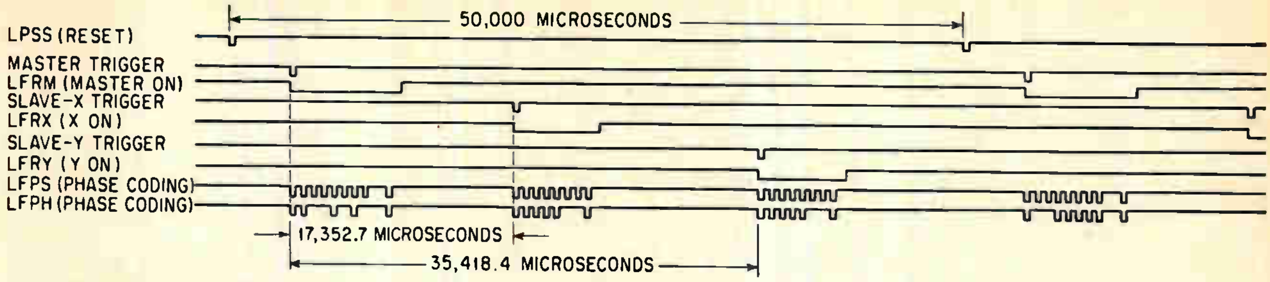
Time-sharing system

The schematic on page 153 illustrates that outputs of the three delay registers are coordinated with the elapsed-time register output to determine when pulses are transmitted from each simulated station. The turn-on signal for each station comes in the proper sequence, from the flip-flops designated LFRM, LFRX and LFRY, respectively. An on signal from LFRX, for instance, defines the region (time interval) for generation of the slave X pulse or pulses.

By defining the region of master, X and Y pulse generation in this way, time sharing of a large portion of the system is possible by using LFRM, LFRX and LFRY to control all time-shared circuits, since only one signal can be present at a time. The three signals are generated in an identical manner, so the processing of the master-slave X station signal will be used as an example.

The elapsed time register, which is basically a four-stage counter, acts as a digital timing reference. Each stage is itself a decade counter having four flip-flops. The elapsed time register counts 100-khz pulses supplied by the system timing source, a Hewlett-Packard Co. model 101A frequency standard oscillator. Therefore, each count in its least significant stage represents 10 microseconds. The succeeding stages count 100, 1,000 and 10,000 microseconds respectively. The gating circuit of the register is interlocked with front panel switches that control the repetition rate of the transmission being simulated. These gates reset the counter to zero at the end of a specified interval. For example, if the loran C repetition rate known as S-3 were to be a part of the simulation, setting the repetition rate selector switches to S and 3 would cause the elapsed time counter to reset each time it had counted to 59,700 microseconds, since this is precisely the period for rate S-3. Designated LPSS, the reset pulse is precisely at the beginning of each repetition period [see timing diagram at the right, above].

Signal LFRM is turned on when the number contained in the master-delay register is identical to that in the elapsed time counter. As explained, the number in any delay register is in digital form and is equal to the delay time in microseconds between the beginning of the pulse repetition



Simulator timing for the loran C mode, rate SO. The simulator is generating pulse time differences of 17,352.7 microseconds for the master-slave X stations and 35,418.4 microseconds for the master-slave Y stations.

cycle and the initiation of an r-f pulse or pulse group. Each time the elapsed time counter is reset to zero it begins immediately to count the repetition period. Therefore each stage of the elapsed time counter is being compared constantly with the master-delay register. When the two numbers are equal, the proper master delay time has elapsed and a trigger is generated which turns on LFRM.

Depending upon whether the simulation is multipulse or single pulse, logic circuits will turn off LFRM after the proper interval of r-f pulse generation. The elapsed time is counted in 10-microsecond increments so the two least significant bits in the delay register corresponding to the microsecond number and the tenths of microseconds number will not be reflected in the generation of an LFRM trigger. These two decade stages of the delay registers are termed the fine delay and in another part of the simulator provide the delay needed to keep the r-f pulses accurately timed.

The method was chosen with an eye to economy, since two more decade stages would be required in the elapsed time counter if it were necessary to compare the two least significant bits of each register. More important, it would then be necessary for all count registers to run at a 10-Mhz rate—not an easy requirement. Further, a 10-Mhz oscillator would be required in addition to the precise 100-khz generator for the loran C carrier. Finally, shielding would be a big problem at the higher frequency.

Picking a time delay

Comparison of an elapsed time register with each individual delay register automatically causes the simulated pulses to be delayed by the proper amount (to the nearest 10-microsecond interval). This same register comparison technique could have been used to provide a delay to the nearest 0.1-microsecond interval but at a considerable increase in system complexity and cost. The technique developed for the simulator achieves the results by using accurate delay lines and selecting the delay length digitally.

Pulses, delayed to the nearest 10-microsecond interval are fed into a 10-microsecond delay line, tapped every 1.0 microsecond. Tap selection is done by relays under program control. The digital number contained in the "microseconds" decade of a register is decoded and used to select one of 10 relays which in turn select one of 10 taps, each one having a delay a microsecond longer than the preceding one. The signal out of the delay line, now delayed to the nearest microsecond, is then fed into a 1-microsecond-long delay line, similarly tapped every 0.1 microsecond. Proper tap selection, then, will introduce the additional 0- to 9.9-microsecond delay required.

For example, to delay a pulse train exactly 16,498.1 microseconds from the time reference, a 16,490-microsecond delay would be provided by the trigger from the pulse sequence generator. The required 8.1-microsecond additional delay is obtained by passing the pulses through an 8-microsecond delay in the first delay line. Next, the pulses are sent through the second delay line, tapped at 0.1 microsecond. With this technique, any delay from thoretical zero to the complete duration of the repetition period can be provided to an accuracy of 0.1 microsecond.

Delay lines manufactured for the loran A carrier frequency, approximately 2 Mhz, are expensive. Therefore an alternate method was chosen for the additional delays required by loran A pulses. Where loran C pulses are slowed by passage through a delay line, the same delay required in loran A transmission is brought about by passing the digital signals that initiate the loran A pulses through the delay lines and then using the appropriately delayed digital pulses to generate the loran A pulse. It requires additional loran A modulators but still represents a savings over delay lines with highly accurate taps and wide bandwidth. The technique has worked out quite satisfactorily since economical delay lines of relatively narrow bandwidth can provide delays in r-f pulses of widely varying frequencies.

As in a plane

From the fine delay lines, the pulses are sent to the doppler delay line. This variable-length, electrically controllable delay line simulates the doppler shift in a pulse picked up by a rapidly moving receiver. The doppler-shifted pulse is passed through a variable-length delay line whose delay is a function of current passing through its control winding. The control signal is a linear current ramp obtained by sampling the receiver's course and speed with respect to the loran station. Ramp magnitude and direction are determined by a special counter and digital-to-analog converter.

The signal that emerges from the doppler delay line is the simulated ground-wave signal, ready for mixing with other components, such as noise, c-w and interference, to make up the system output. Simulated sky waves are provided by still another set of delay lines. These, however, are 700-microsecond magnetostrictive lines, tapped every 25 microseconds. A manually variable 25-microsecond section is included so that any delay from 0 to 700 microseconds is selectable by means of rotary switches. By passing a sample of the ground-wave signal through these lines, sky waves can be simulated and sent to the attenuator-mixer circuits.

Sharing the black boxes

Because of the normal delays between the master and each slave transmission in a loran chain, and because there is never an overlap in the time of the master, slave X and slave Y pulse trains, it is possible to use some common equipment including the pulse sequence generator, fine delay lines and doppler simulator. However, to properly route and sequence the pulses, it is necessary to define the regions of signal operation. The diagram on page 157 shows the timing of critical digital signals which form loran pulses. The signals shown are those produced when the system generates a 17,353.7-microsecond M-X and a 35,418.4-microsecond M-Y time difference in loran C mode, rate SO.

Signal LPSS defines the pulse repetition period. In the example, it occurs once every 50,000 microseconds for loran C rate SO. The rate is controlled by the rate switches on the control panel.

The master, slave X and slave Y triggers define the start times for the pulse trains. From the triggers, the pulse-region definition pulses LFRM, LFRX and LFRY are generated. These pulses are used throughout the system to separate pulse trains in circuits that are time shared.

During the definition pulse period, a separate 300-microsecond pulse is generated for each loran pulse. This is used by the modulator circuits to provide properly shaped loran A or C pulses at the correct time. Also, from the pulse sequence generator comes a signal designated LFPH, which is used in the loran C modulator to insert the proper phase code. An on signal from an LFPH flip-flop coincident with an on signal at LFPS will create a normal loran C pulse. The absence of an LFPH signal in the presence of an LFPS signal will cause the modulator to generate a pulse 180° out of phase with the normal pulse. Phase coding is used in the loran C system to help prevent ambiguity.

Making the tests

A multitude of very detailed and demanding receiver tests, such as threshold, sensitivity and noise-rejection tests are possible with the special attenuators built into the simulator's output circuits. All generated pulses, master, slave X and slave Y ground waves and sky waves are amplified and subjected to manually controllable attenuators. Each attenuator, built in three sections: a 100-decibel unit, adjustable from 0 to 100 db in 10-db steps; a 10-db unit, with 1-db steps; and a 1-db unit continuously variable from 0 to 1 db. Any signal component from 500 millivolts to a few microvolts may be attenuated.

After the first attenuation, the ground-wave and sky-wave signals are summed and passed through a second three-stage attenuator for over-all signal level control.

At the output, selected noise and c-w interference are mixed with the simulated signals to produce a true loran-like radio wave. The white noise is provided by a General Radio Co. model 1390-B noise generator; c-w interference is produced in a selectable two-band variable frequency oscillator. The bands cover the loran C range (80.8 khz to 120 khz) and loran A (1.5 Mhz to 2.0 Mhz). Control of r-f interference as well as noise signal level can simulate almost any set of signal conditions.

The velocity of the simulated flight is manually adjustable from zero to 1,935 knots. Since the velocity is simply a function of how fast incremental data is processed by the system, velocity can be simulated by controlling the speed of the tape reader. The upper velocity limit of the system is a parameter of the tape reader now in the system. However, the system proper, exclusive of tape reader, is capable of processing data at rates far greater than the simulated 2,000 knots.

Future simulators

Integrated circuits will minimize the size of the simulator. The present model is built with discrete components and occupies 15 square feet of floor space. A complete avionics system built with integrated circuits could reduce the size by at least a factor of 10. For instance, the master delay register requires six flip-flop cards and 12 gate cards, each card approximately 5 inches by 6 inches. The register occupies a space of approximately 187 cubic inches. The same register can be built in a space only slightly larger than 0.1 cubic inch, using techniques developed for the Integrated Helicopter Avionics System.

Eventual size of the system will depend almost entirely on the degree to which components such as the delay lines, tape reader, noise generator and power supplies can be miniaturized. A bench model, truly portable, is possible.

The system could be used in many more ways with the addition of a digital differential analyzer, memory section and arithmetic computational circuits. These would eliminate the tapes, tape program and tape reader; self-contained programs for specified flight paths could be reprogramed to provide any new flight path.

Reference

1. "The Loran C System of Navigation," Jansky and Baily division of the Atlantic Research Corp., Washington, D.C., February, 1962.

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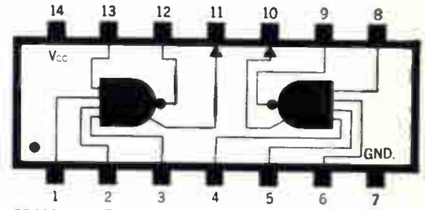

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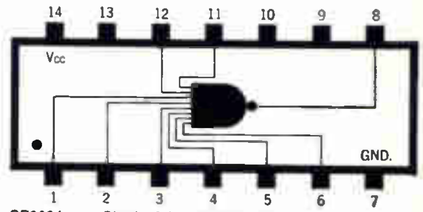

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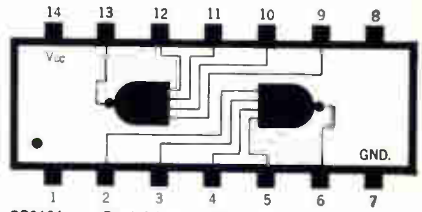

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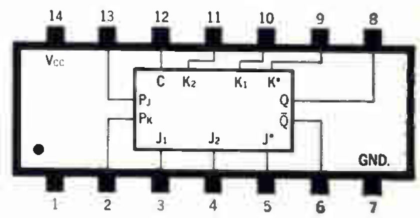

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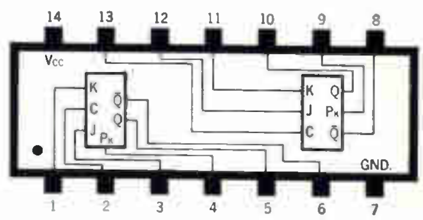

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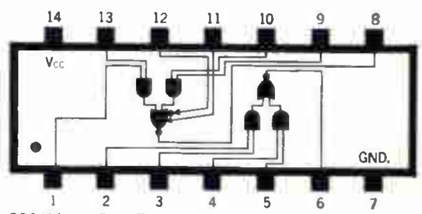
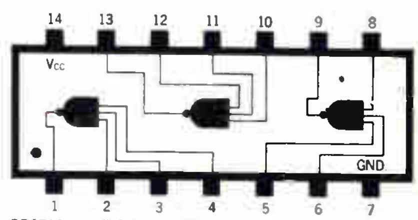
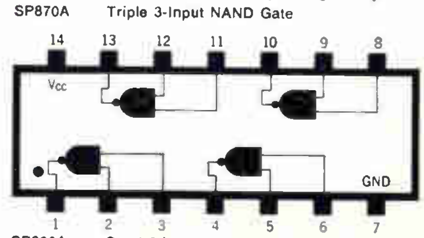


SP840A Dual Exclusive-OR Gate



SP870A Triple 3-Input NAND Gate



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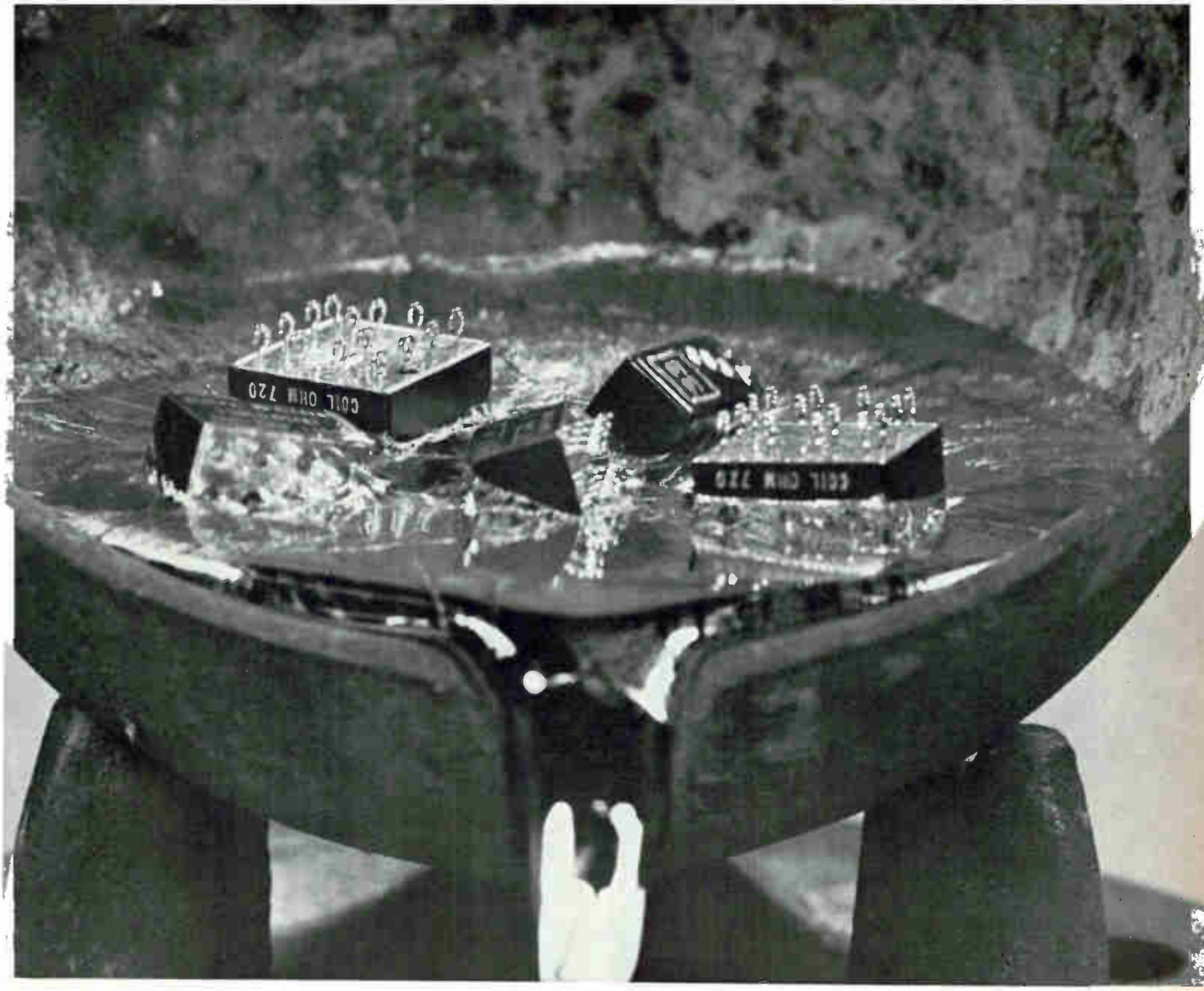

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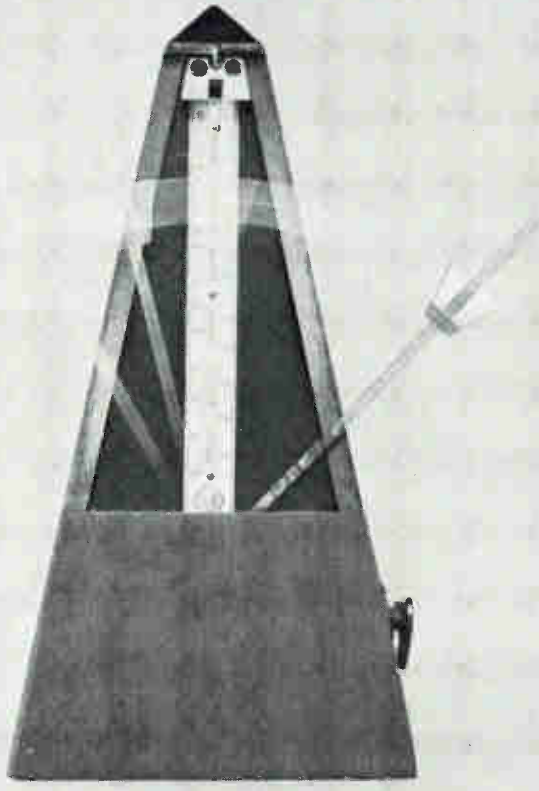

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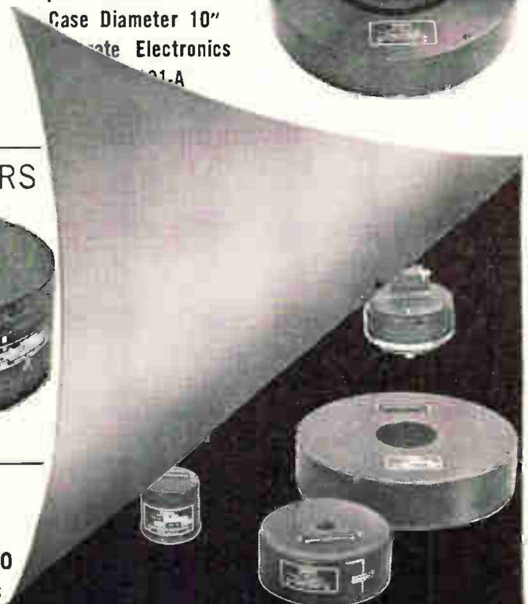

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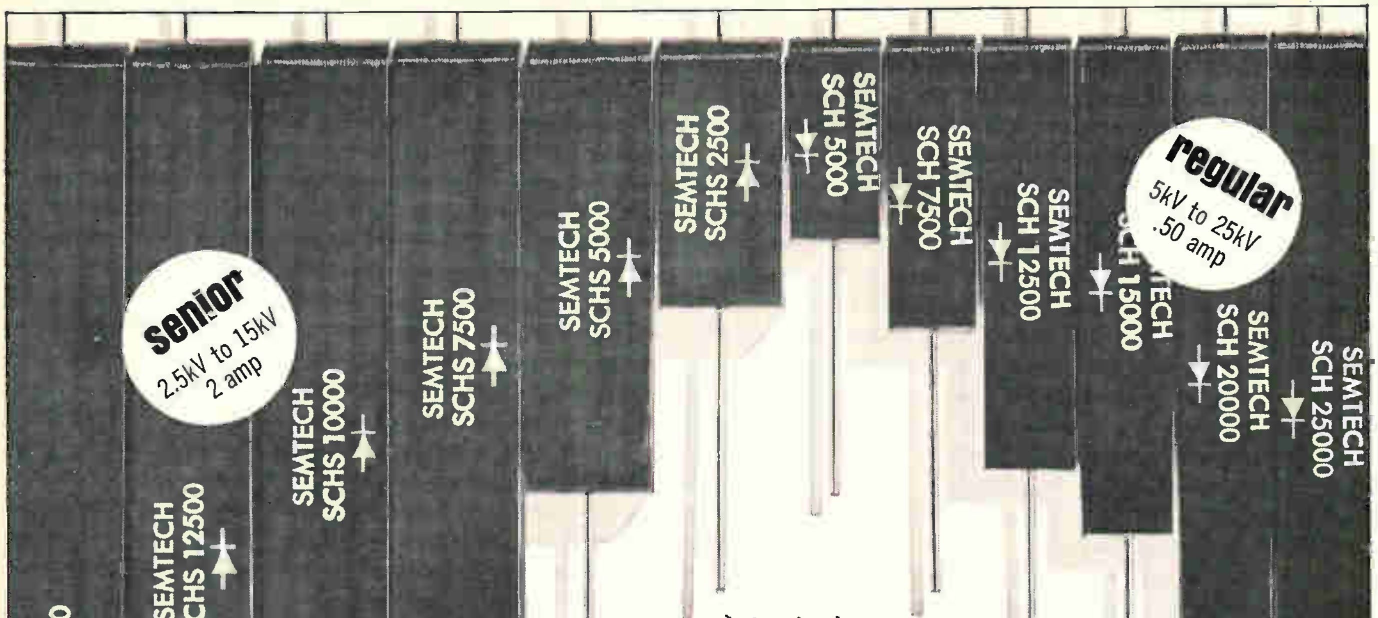

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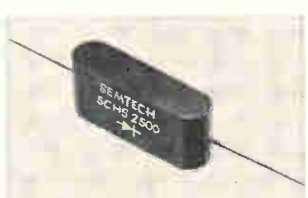

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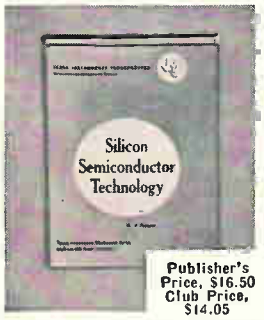

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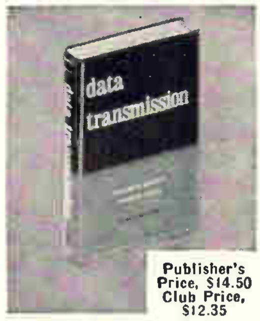

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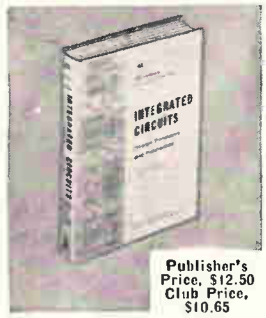

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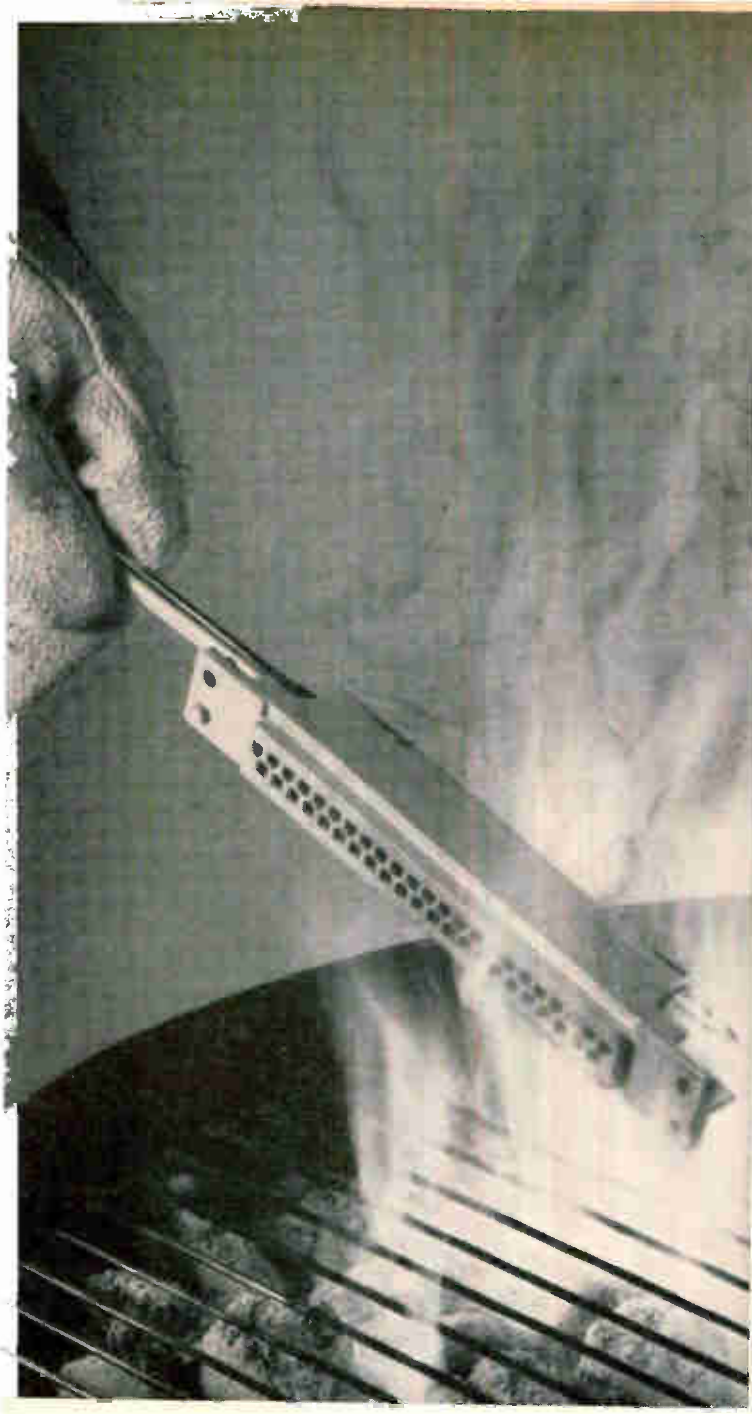

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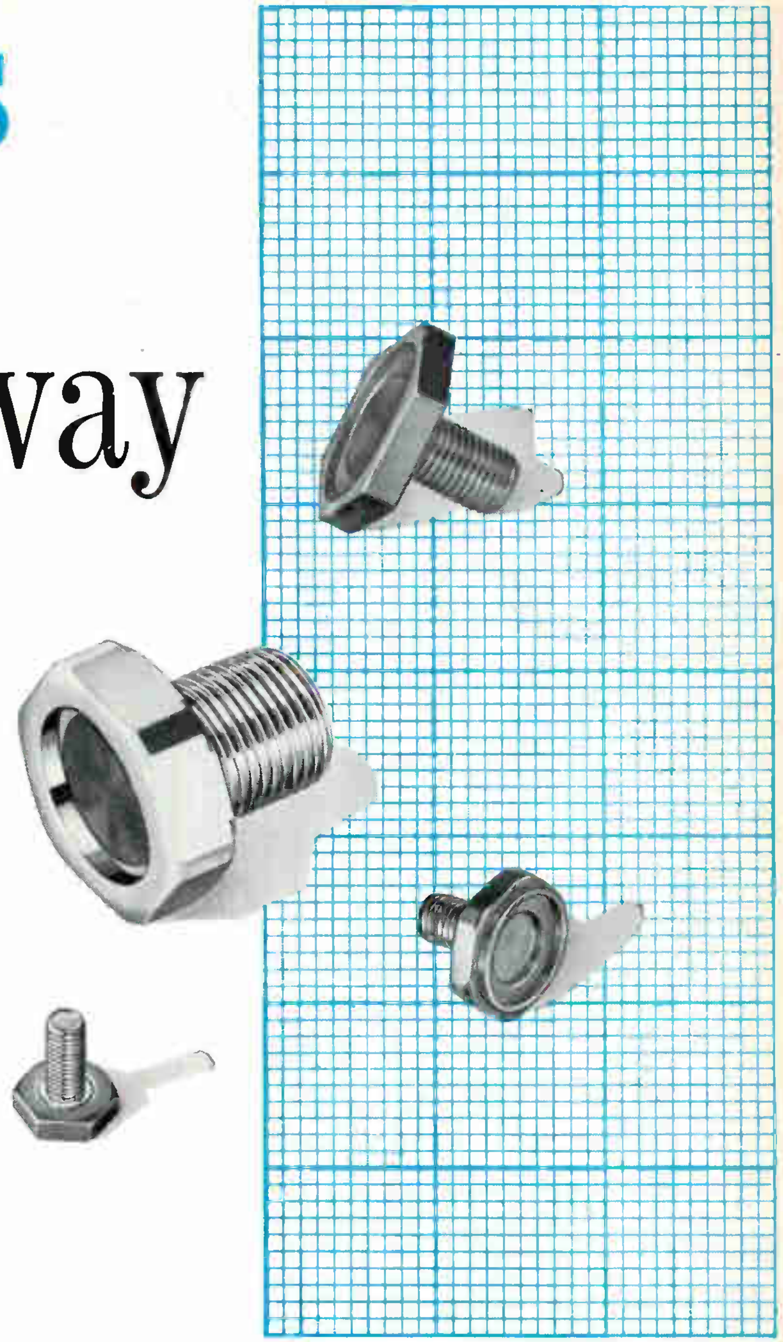

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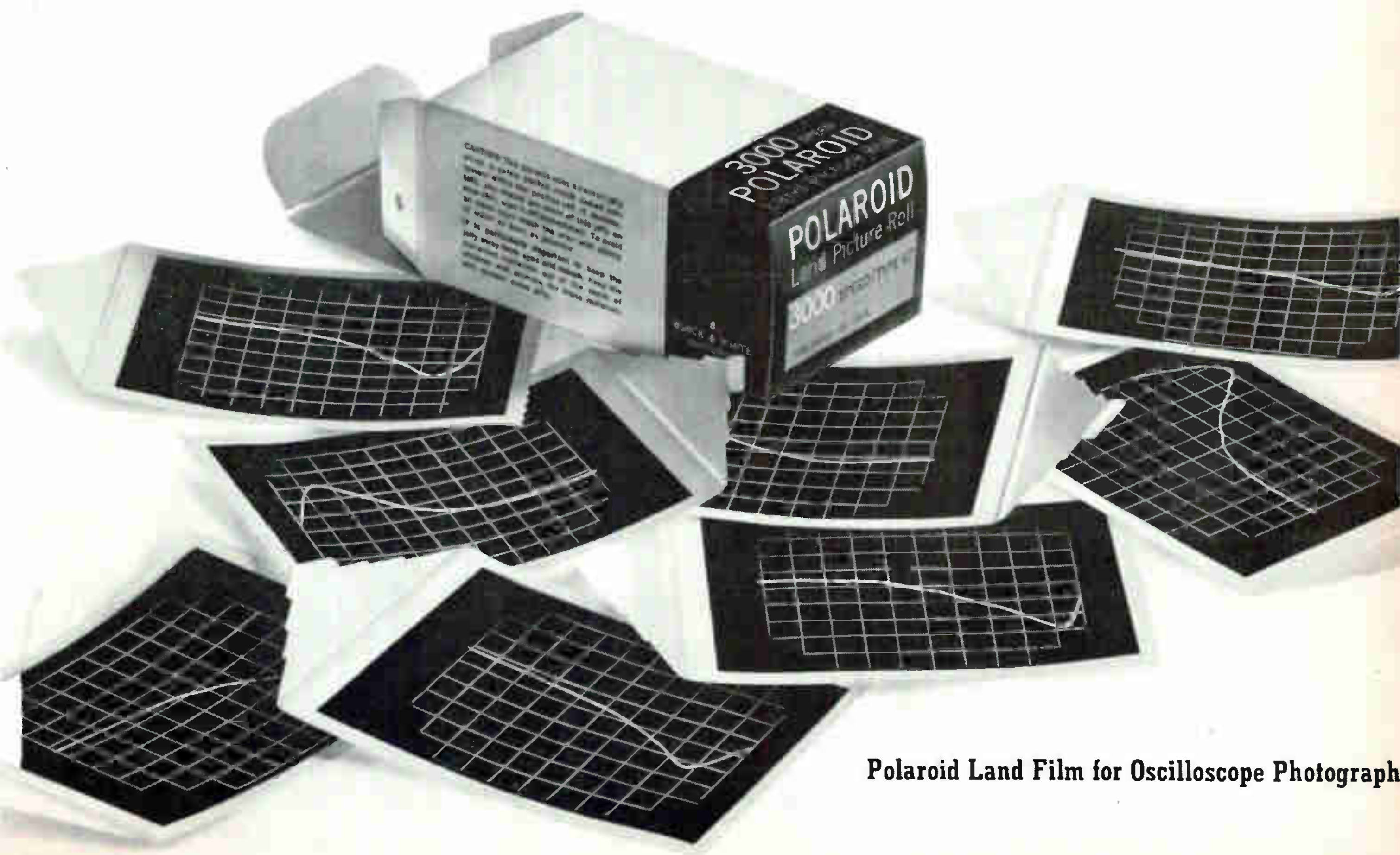
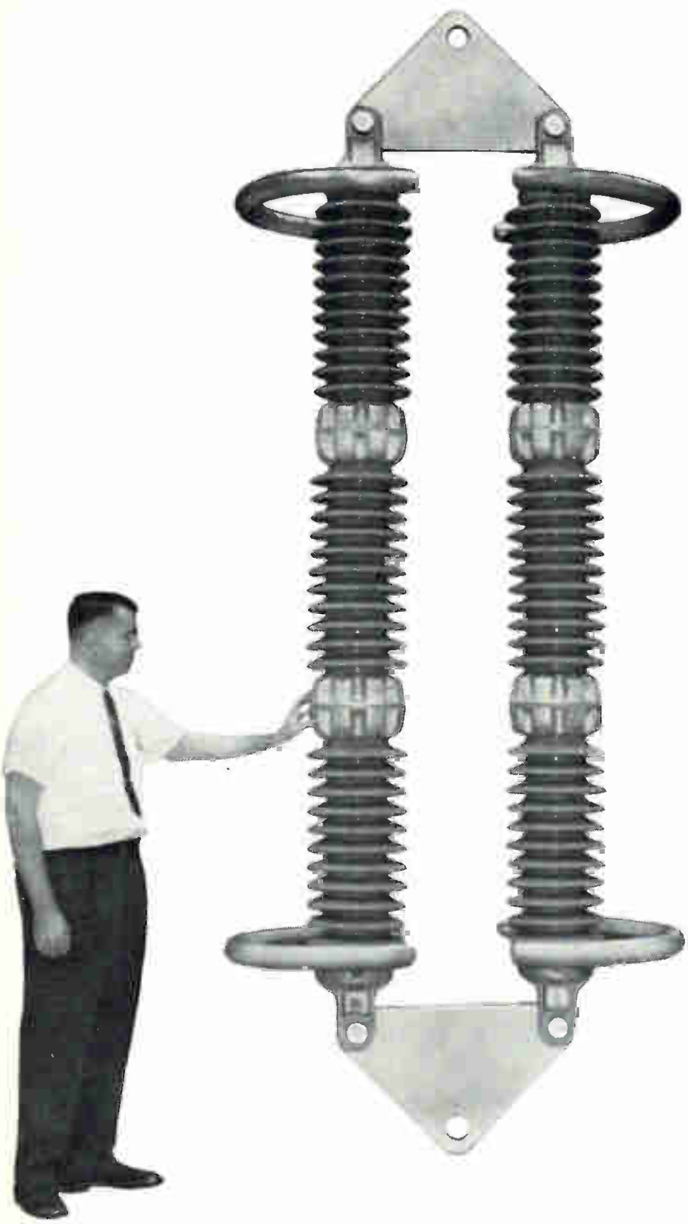


Polaroid Land Film for Oscilloscope Photography.

Antenna strain insulators of 240,000 lbs. ultimate strength?



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The double-strain insulator assembly shown here tested to 240,000 lbs. ultimate strength. It isn't the biggest either. Already designed is a similar triple-strain insulator with a strength of 360,000 lbs. Lapp also has delivered compression cone guy insulators as high as 620,000 lbs. ultimate strength, and has designed them to 750,000 lbs. strength.

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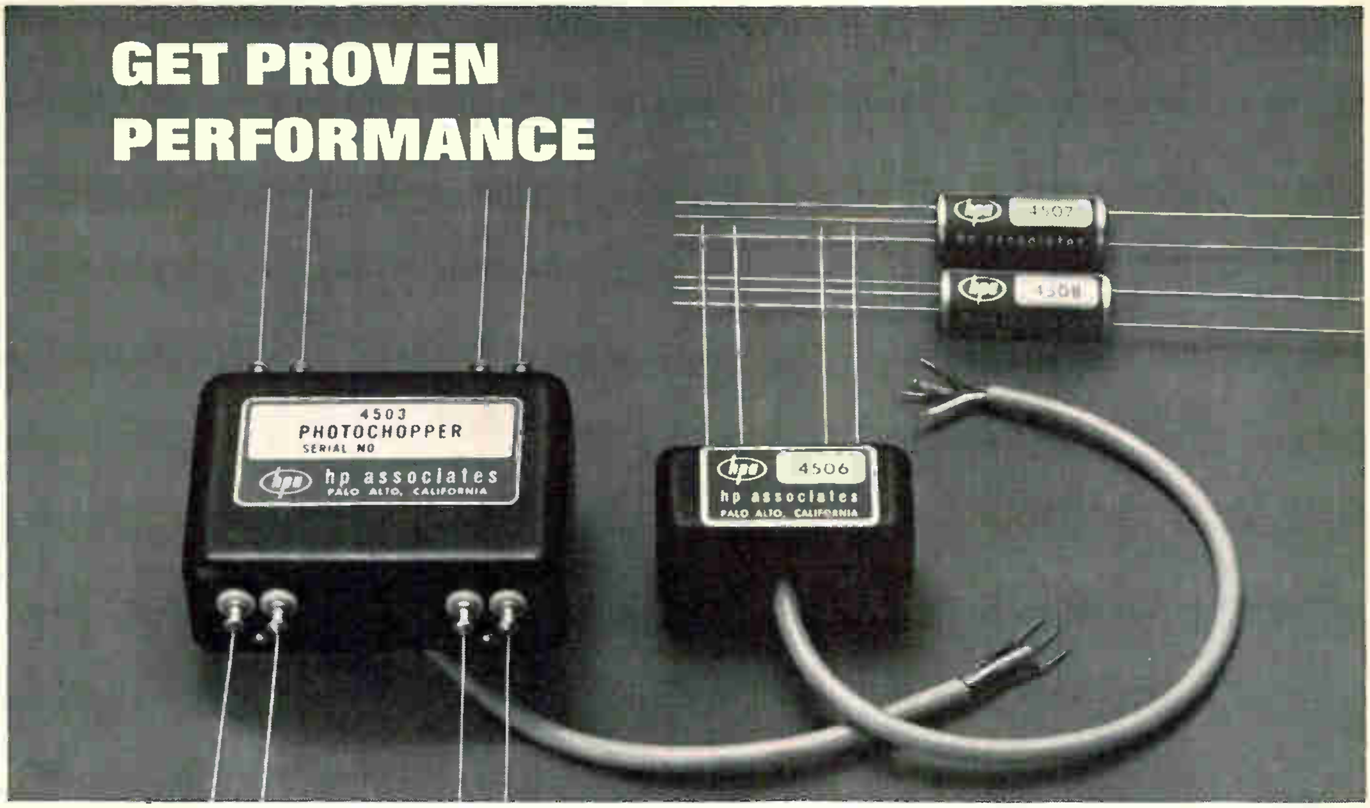

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4502	DPDT 4-cell Mod/Demod Internal Oscillator Low Z Modulator	Mod. Input 150KΩ Mod. Output 7.5KΩ Demod. Output 25KΩ	250V, 2.5mA DC Internal Oscillator 95Hz	$39.50 33.50
4503	DPDT 4-cell Mod/Demod for Ext. Oscillator High Z Modulator	60Hz chopping freq. Mod. Input 5MΩ Mod. Output 125KΩ Demod. Output 30KΩ	170V peak 2.5mA 1kHz max.	$37.50 32.00
4504	DPDT 4-cell Mod/Demod for Ext. Oscillator Low Z Modulator	60Hz chopping freq. Mod. Input 200KΩ Mod. Output 5KΩ Demod. Output 30KΩ	170V peak 2.5mA 1kHz max.	$37.50 32.00
4505	SPDT 2-cell Mod. only High Z	200Hz chopping freq. Mod. Input 2MΩ Mod. Output 125KΩ	170V peak 2.5mA 1kHz max.	$22.50 19.00
4506	SPDT 2-cell Mod. only Low Z	200Hz chopping freq. Mod. Input 75KΩ Mod. Output 5KΩ	170V peak 2.5mA 1kHz max.	$22.50 19.50
4507	SPST PCR High Z	"ON" R 150KΩ "OFF" R Min.100MΩ	150V peak 1kHz max.	$ 8.00 6.80
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DC Screen Voltage	800 V
Peak AF Screen Voltage (for 100% Modulation)	800 V
DC Grid Voltage	–800 V
DC Plate Current	29 Amps
DC Screen Current	3.6 Amps
DC Grid Current	1.8 Amps
Peak RF Grid Voltage	1200 V
Grid Driving Power	2.5 kW
Plate Output Power	292 kW

EIMAC
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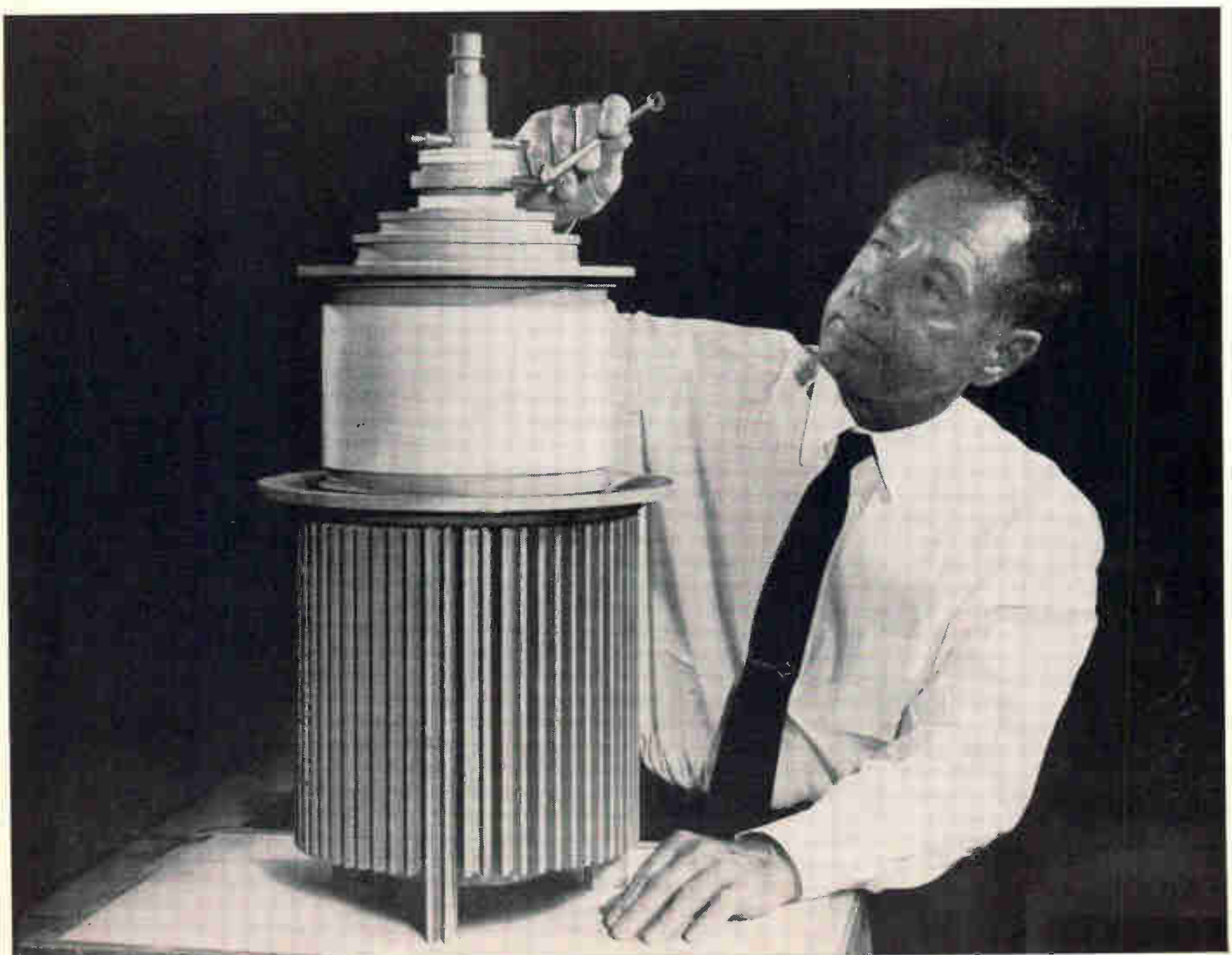

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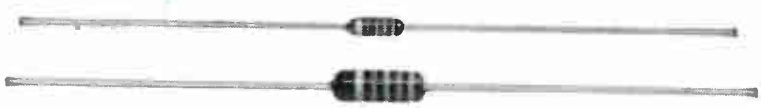

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Think of the dollars this true multi-use resistor can save you—in the paperwork of purchasing and in the lower unit price you enjoy on quantity orders for a single part. Think how it can simplify your inventory and simplify handling in assembly. Our new CORNING C-Style Resistors can make your job a whole lot easier, your circuits a whole lot better. Look at the classic CORNING Glass Tin Oxide Film Resistor performance documented in the table. Then send the coupon for your test samples and data.

PERFORMANCE CHARACTERISTICS

Characteristics	New CORNING C-Style Resistors			Mil-R-22684B	Mil-R-10509F Characteristic D*
Temperature Rating	70°C	70°C	125°C	70°C	70°C
Wattage C 4 (RL07S) Resistors, 51 ohms to 150 K	¼	⅛	1/10	¼	⅛
Wattage C 5 (RL20S) Resistors, 10 ohms to 499K	½	¼	⅛	½	¼
Load Life △ R	1.0%	0.5%	0.5%	2%	1%
Design Tolerance △ R	−2 to +4%	+2.8%	−1.5 to +3%		
Temperature Coefficient from −55°C to +175°C		±100 ppm		±200 ppm	+200 −500 ppm
Dielectric Withstanding Voltage △ R		±0.10%		±0.50%	±0.5%
Moisture Resistance △ R		±0.50%		±1.50%	±1.5%
Short Time Overload △ R		±0.25%		±0.50%	±0.5%
Temperature Cycling △ R		±0.25%		±1.00%	±0.5%
Effect of Soldering △ R		±0.10%		±0.50%	±0.5%
Low Temperature Operation △ R		±0.50%		±0.50%	±0.5%
Shock △ R		±0.10%		±0.50%	±0.5%
Vibration △ R		±0.10%		±0.50%	±0.5%
Terminal Strength △ R		±0.10%		0.50%	±0.2%
Voltage Coefficient		±0.001%/Volt			
Shelf Life △ R		±0.10%/Year			±1.0%

*For type-marked, military lead Mil-R-10509F, Characteristic D, Resistors, specify CORNING NA-Style Resistors.

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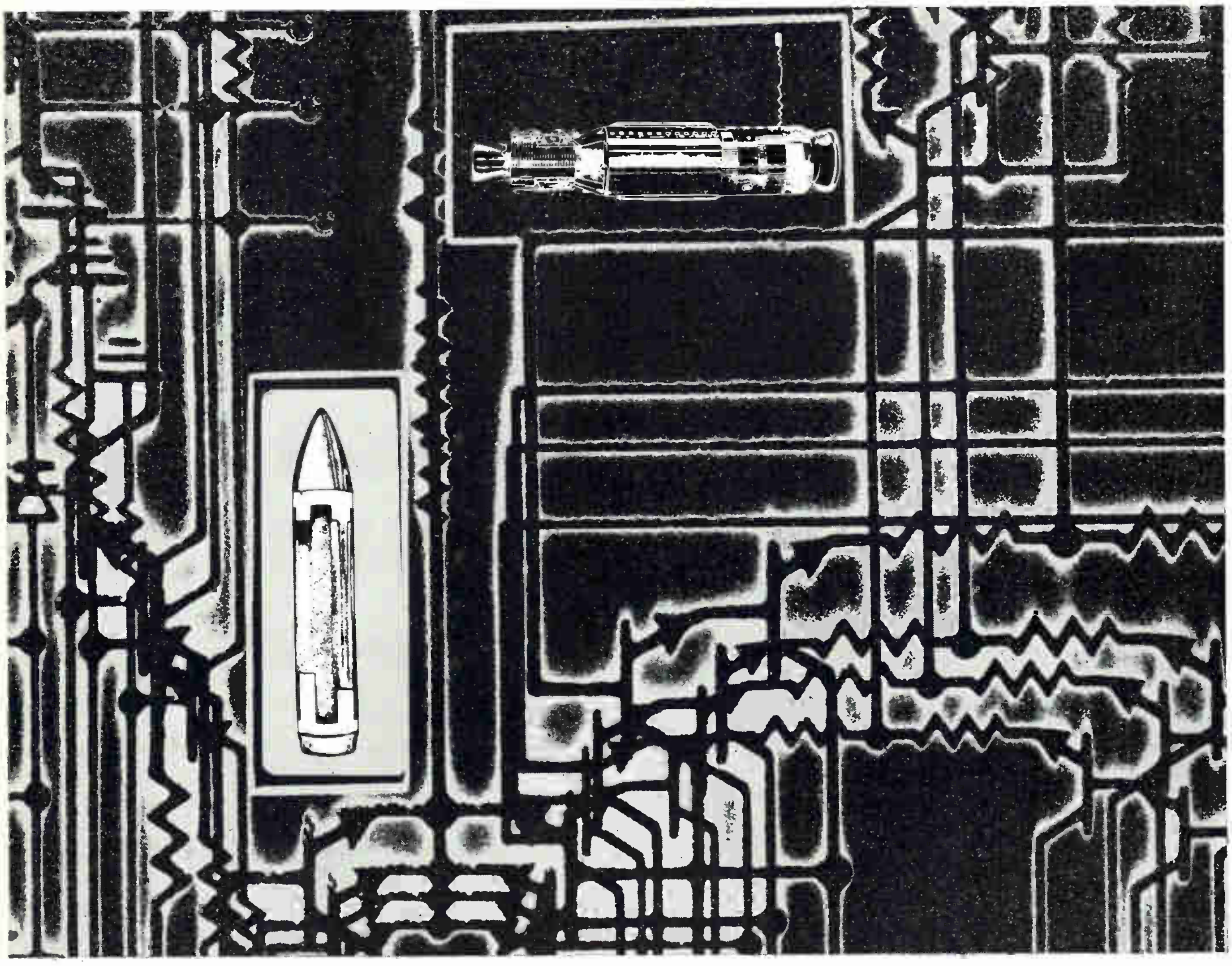

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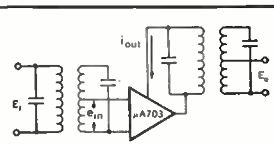
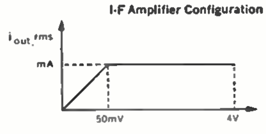


I-F Amplifier Configuration



Unsaturated Limiting Characteristic

Specifications ($T_A = 25°C$; f = 10.7MHz)

Operating Voltage Range	7-20V
Stability Limited Gain	41db
Reverse Transadmittance	0.003mmhos
Forward Transadmittance	35mmhos
Output Conductance	0.02mmhos
Input Conductance	0.3mmhos
Output Voltage Swing	10V
Power Gain @ f = 100MHz	20db

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Probing the News

Advanced technology

Laser gyro comes in quartz

Navy to try out loop of light encased in rugged material; bulky rotors of old-fashioned spinners are eliminated along with drift caused by friction

By Donald Christiansen
Senior Associate Editor

That passenger getting the VIP treatment on a Convair headed for the West Coast last week wasn't a movie star; it was a first-of-its-kind laser gyroscope on its way to the Naval Ordnance Test Station in China Lake. And it was being tested in flight.

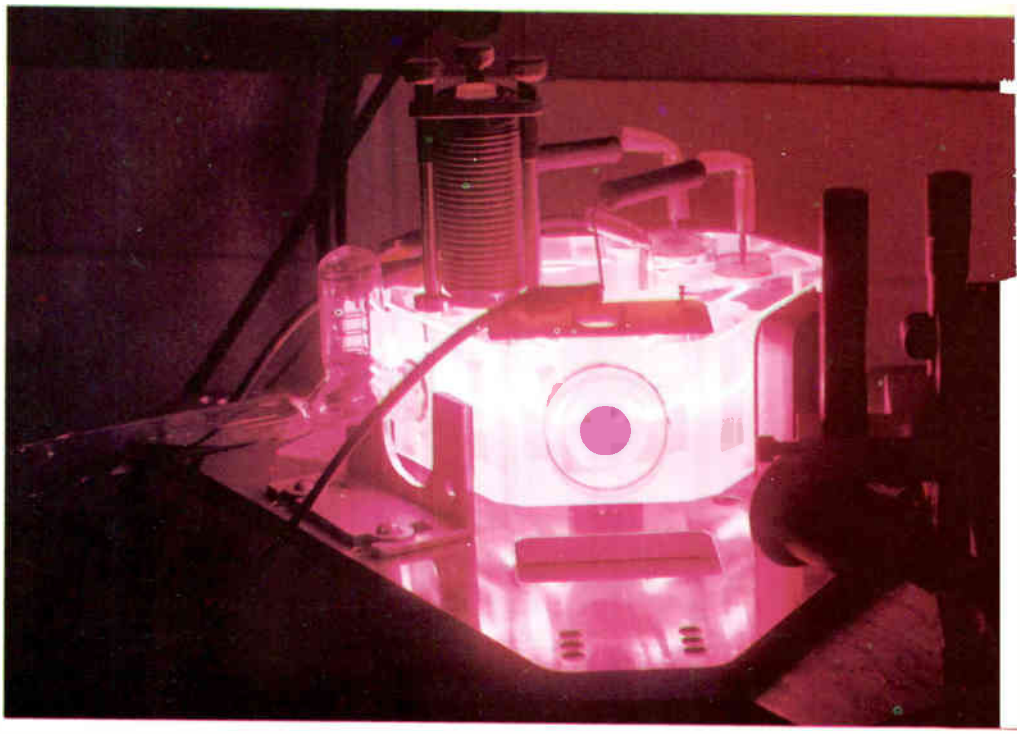
Honeywell Co. was delivering a laser gyro drilled from a solid block of quartz to make it compact and rugged. Up to now, laser gyroscopes were unwieldy, fragile and sensitive to shock and vibration.

An important asset of laser gyroscopes is their ability to sense extremely high rotation rates—because they have no rotors and no friction to cause drift.

The new quartz gyro was developed under a year-long Navy contract at Honeywell's Systems and Research Center, St. Paul, Minn. The Navy intends to test the unit for shipboard use. It contains three planar or single axis gyros, one to sense rotation in each of the three orthogonal axes. A three-dimensional laser gyro—containing three planar ring gyros in a single spherical block — is considered the next step in development.

The concept upon which the laser gyro is based dates back to classical optics studies in the 1920's by A. A. Michelson, H. G. Gale and others. Their work was based on conventional light sources. In more recent years, the Air Force was keeping close tabs on the optical gyro even before the laser came on the scene.

In August, 1961, A. H. Rosenthal, an optical scientist with the Kollsman Instrument Corp., described the use of a laser beam as a rotation rate sensor in a paper presented to the Optical Society of America. The Sperry Gyroscope Co. and Honeywell began independent experiments with laser gyros in 1962.



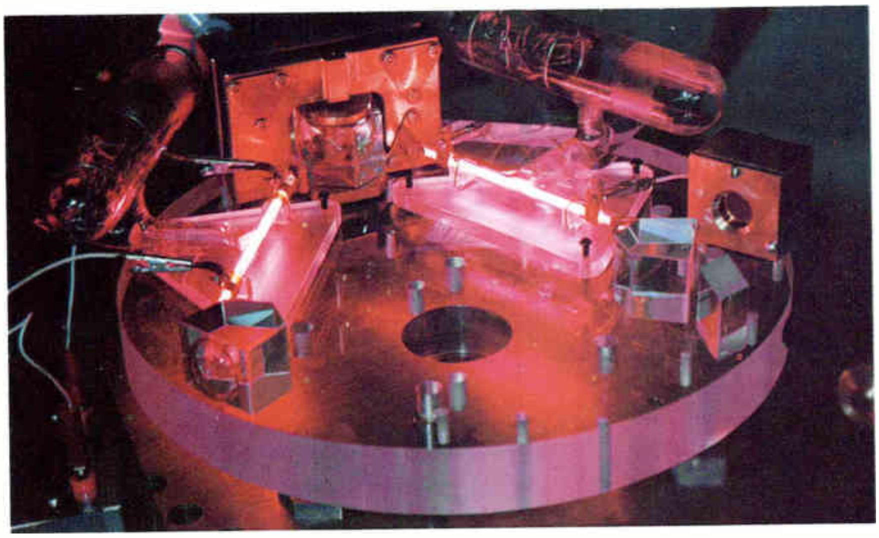
Honeywell's laser gyroscope is fabricated in a solid block of fused quartz, making it rugged enough to withstand very high gravity forces.

I. Advantages and uses

The laser gyro has an advantage over the conventional spinning gyroscope in that it has no spinning mass or rotor.

Rotor friction and rotor unbalance in an electromechanical gyro can lead to parasitic torques. Magnetic and temperature effects can also wreak havoc with a rotor gyro. The result is unwanted torques which cause drift, or random displacement from an initial position, of anywhere from 100° to 500° per hour. There are ways to bring drift down to as low as 0.001° per hour, but they are costly. For example, the rotor can be floated in a liquid or gas, or in electrostatic or magnetic fields.

The laser gyro has no major moving parts, bearings or temperature-sensitive flotation fluids. It has great dynamic range compared with the conventional gyro. Honeywell engi-



Earlier laser gyros, like this, had many separate elements that were fragile and hard to keep in adjustment. The bright tubes are laser gain tubes.

neers believe that low rotational rates, ranging down to zero, should be theoretically measurable to accuracies of better than 0.001° per hour. And rates as high as 75 revolutions per second can be measured with high accuracy.

These high rotational rates suggest use of the laser gyro in gimballess aircraft navigators, where the gyro sensors are mounted or "strapped down" to the vehicle and rotate with it. In aircraft, instant starting and freedom from frequent trimming would be advantageous. A conventional gyro can take anywhere from 15 minutes to a half hour to get up to speed and to reach temperature stability.

The new gyro might also be considered for use in missiles that undergo extremely high acceleration during takeoff and maneuvering. Its rugged construction enables it to withstand high gravity forces and, unlike conventional gyros, its operation is unrelated to g and g^2 terms.

II. Operation

In the laser gyro, called a ring laser sensor or a laser integrating gyro, two laser beams, one aimed in a clockwise direction and the other one counterclockwise, are generated within a common closed loop. If the optical path is stationary, the two beams take the same time to traverse the loop. But if the path is rotated about its axis, the effective path for one beam is shortened while the path for the other beam is made longer. As a result, the frequencies of the beams differ and this difference (Δf) can be detected and interpreted without difficulty. If the beams were generated by conventional thermal light sources they would exhibit a phase shift under the influence of rotation but a phase difference would be difficult to detect, even if the device were made exceptionally large.

Three-axis laser gyro unit mounted on this test stand was delivered to the Navy for shipboard tests.

The laser gyro can also be thought of as an oscillator operating at optical frequencies, with its oscillating frequencies determined by the length of its cavity.

Readout. To measure the gyro's rotation, the outputs from the two laser beams are combined so that the beams are nearly parallel. The beam wavefronts will interfere with one another to create a fringe or bar pattern. In effect the waves are mixed and a beat note results.

The bars will move in a direction determined by the direction of rotation of the laser gyro, and the number of bars per unit of time will be proportional to the rate of rotation. Each bar then represents an angle through which the gyro has moved. A pair of photocells can sense the rate and direction of rotation. If the photocells' output is fed to a pulse counter, an integrating rate gyro results.

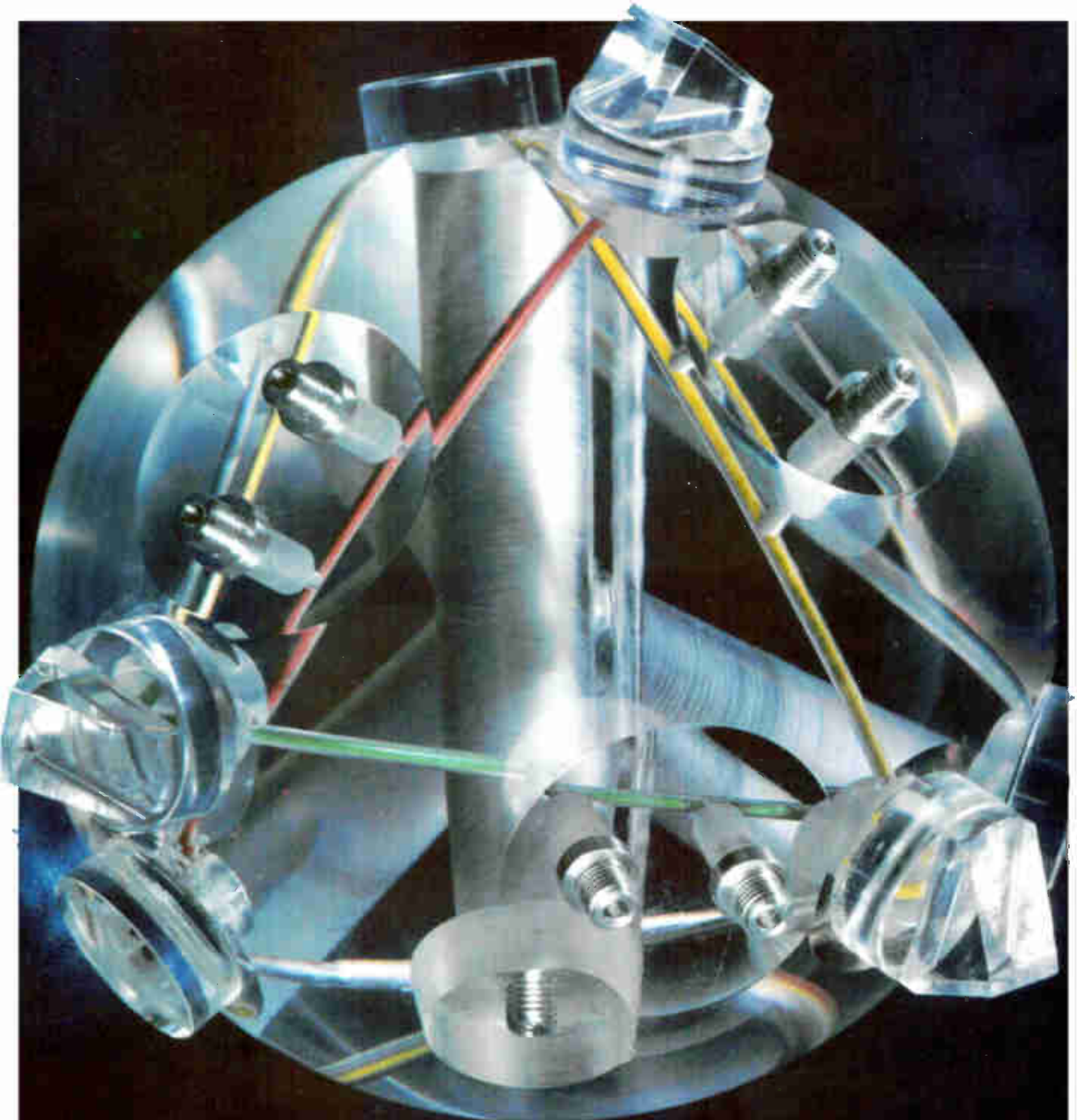
Handle with care. Fragile laser beam tubes and independently mounted mirrors caused early experimental units to lose adjustment easily. A separate, bulky frame was needed to provide a firm mounting base.

Although Honeywell's laser gyro has three sides, this configuration is not mandatory. Sperry, for example, has constructed both three- and four-sided units. The salient point is that Δf is directly proportional to the area enclosed by the configuration: $f = K As/L\lambda$ where A is the area enclosed, s is the rotation rate, L is the optical path length and λ is the wavelength.

Both Sperry and Honeywell have now settled on the triangular configuration for two reasons. First, an odd number of mirrors will be self-aligning in the horizontal plane and second, fewer parts mean easier alignment and less light scattering.

III. Monolithic quartz block

The success of the Honeywell development is based on the use of a solid block of high quality fused quartz. Holes and cavities are machined into the block for the beam paths, the anodes, cathode and fill port. The mirrors are mounted to



Model of triad laser gyroscope comprising three orthogonal "planar" gyros in one solid quartz sphere. The three separate laser beam paths are distinguished by different colors. The three readout prisms are evident.

. . . mirrors are molecularly mounted to give rugged construction . . .

the corners of the block by molecular adhesion so that the mirrors and block together form a rugged unit. To achieve the molecular adhesion, the contact surfaces of the quartz and the mirrors are ground flat and highly polished.

The interior of the quartz block is pumped down and filled with a helium-neon mixture to a pressure of about 5 millimeters of mercury. About 1,000 volts is applied between cathode and anodes to provide lasing action.

Physical tolerances of the block must be close enough to guarantee that lasing will occur automatically. Honeywell engineers say they overcame some tough problems but that the machining is within the state of the art. The simplicity of the quartz block construction could mean that laser gyros will be a fifth the cost of conventional gyros.

IV. Not all roses

Some limitations are inherent in the laser gyro, but there are ways to get around most of them.

As the gyro rotates more and more slowly, the effect of unwanted coupling between the counterrotating beams becomes more serious, until at some threshold value of Δf the beams lock: Δf goes to zero abruptly. A way around this is to bias the beam, or effectively create an artificial Δf when the gyro is at rest.

Without biasing, sensing rotation below several thousand degrees per hour is difficult. With biasing, rates as low as 0.01° per hour even in small gyros are thought to be feasible. But, Honeywell engineers are quick to add, internal biasing schemes bring on secondary problems such as the need for higher gain to overcome added losses, additional backscatter that will raise the threshold Δf even higher and the requirement for bias stability of about one part in 10^6. As a result, Honeywell feels that external biasing schemes are far more satisfactory.

Another limitation of the laser gyro is null shift — an unwanted shift in the input-output zero. Its effect can be minimized by a counterbalancing discharge current. Noise may be introduced when the beams oscillate at more than one mode, but careful design or adjustment of gain can usually avoid th problem.

The input-output curve is ex tremely linear up to very high r tation rates (above 75 revolution per second), at which point it d viates about one part in 10^6 fro a straight line.

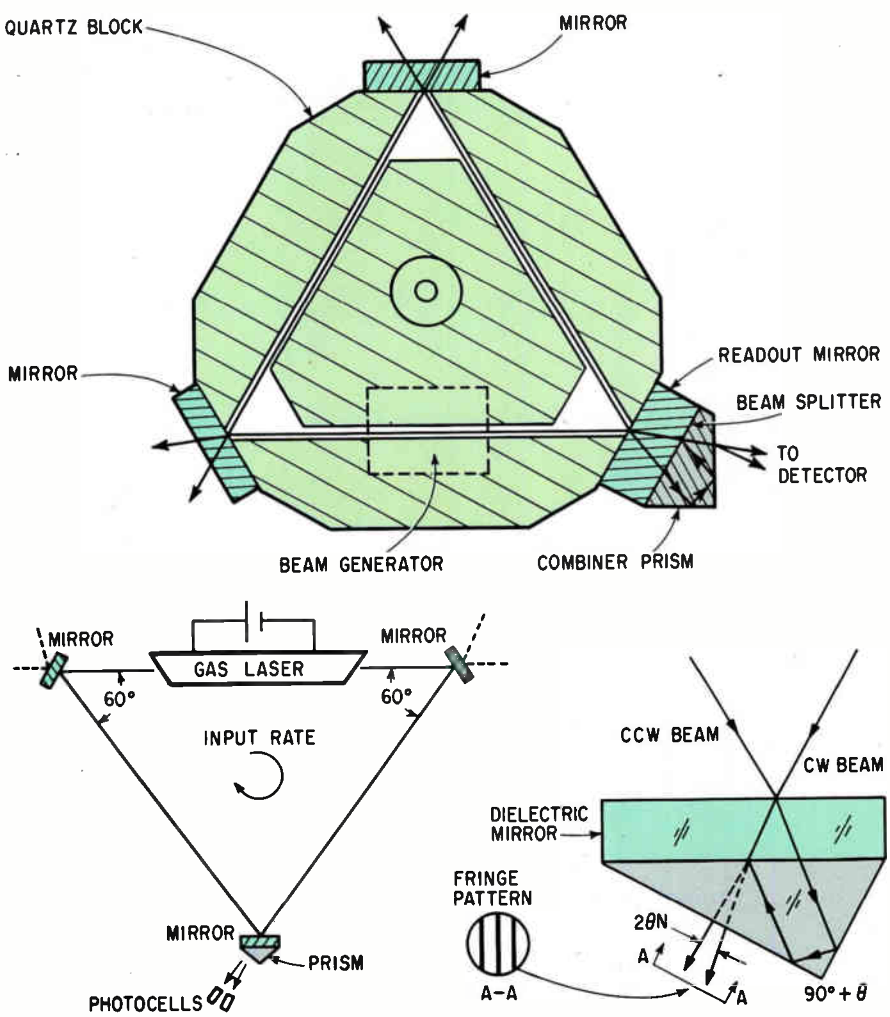
Readout techniques haven't caugh up to the high sensing speeds o which the laser gyro is capabl Honeywell reports. At Sperry, en gineers put temperature stability the head of the list of problems t overcome. Honeywell confirms this pointing out that the laser gyro i instant starting from a mechanical electronic standpoint, but tha thermal effects are still a problem

V. Triple threat

For some applications, Honeywel thinks, the construction of the thre sensing axes in a single quartz bloc could be an advantage. In the mode of a triple-axis spherical laser gyr shown on page 185, each triangul path is identified by color. One rea son, Honeywell notes, for selectin three separate single-axis compon ents mounted orthogonally is tha one unit can be replaced easily.

The concept of the spheri three-axis laser gyro was originate by Honeywell. It may be pursue in a $500,000 contract awarded the company by the Advanced R search Projects Agency. The con tract will be managed by the Arm Missile Command.

The ring laser principle is not li ited to gyroscope applications. Spe ry is studying the device for measu ing gas flow where true mass flo



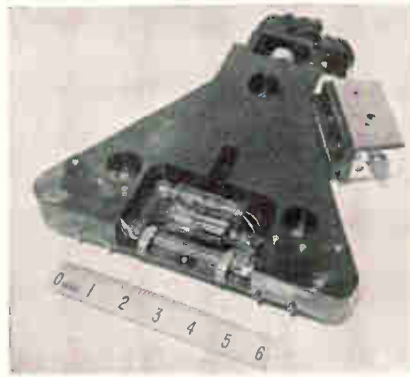
Ring laser sensor is built in a solid quartz block. Holes for laser gain tubes are drilled through the quartz; corner mirrors are affixed by molecular adhesion. A schematic, lower left, shows how the laser gyro is rotated about its axis. Detail of one optical readout technique, lower right, shows how beams provide interference fringe pattern.

. . . laser gyros have been delivered to the Air Force and NASA . . .

would be recorded. Sperry is also considering the ring laser sensor as a precise incremental shaft encoder and as a precision anemometer.

Drag effect. In flowmeter experiments conducted by Sperry, use is made of the fact that light propagating through a moving transparent medium undergoes a change in velocity, or a dragging effect, proportional to the velocity of the medium. In Sperry's work, the drag effect was used in a ring laser to produce frequency mode splits, or differences, when sensing the movement of solids, liquids and gases along the axis of the laser beam. The frequency differences are caused solely by the axial component of velocity of the moving medium. To measure accurately the flow velocity, the density of the medium must be known, since the frequency split is proportional to its refractive index. The measurement technique shows great promise since it avoids the pressure drops, turbulence, corrosion and cleaning problems of conventional flowmeters.

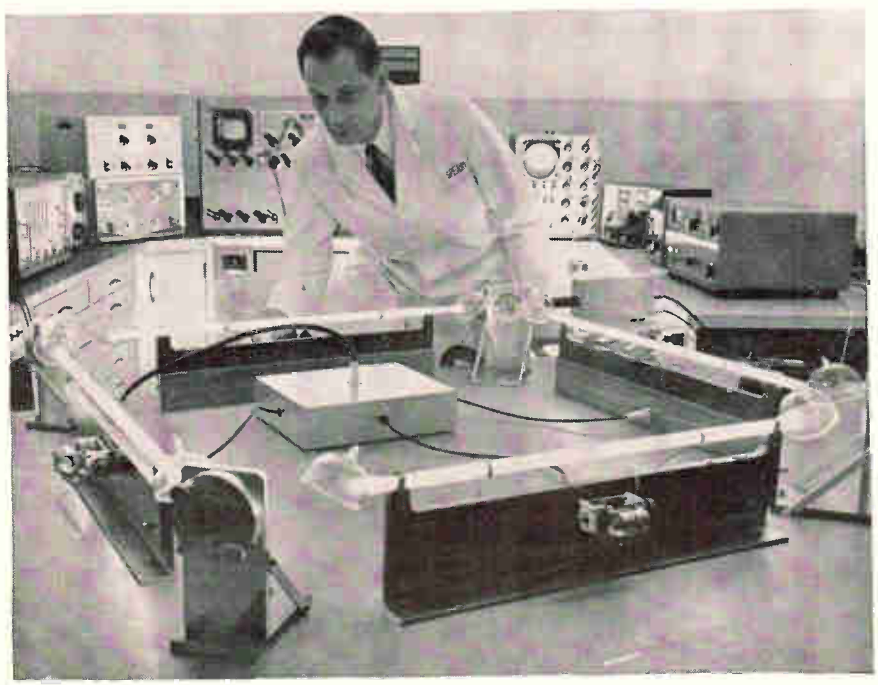
Other ways. Though they have not built a quartz block laser gyro like Honeywell's, Sperry engineers have refined their ring laser to a small-perimeter, rugged unit. Sperry has delivered laser gyros to the Air Force and to the National Aeronautics and Space Administration and is working on a three-axis unit.



Settling on three-sided configuration, Sperry has built small rugged units.

As a rotation rate sensor, Sperry says, its units can handle up to 600° per second, compared to 30° per second for a typical, strapped-down, conventional gyro. On the other hand, the threshold sensing rate for its laser units ranges from 100° to 300° per hour, compared with 0.1° per hour for the others.

Sperry concludes that the laser gyro is superior where high rates are experienced, but that it must give way to the spinning gyro—for the present at least—where low rates must be measured.



First experimental ring laser by Sperry was outsized: it had a perimeter of 4 meters. The square configuration required a laser tube at each side.

The devil's advocate

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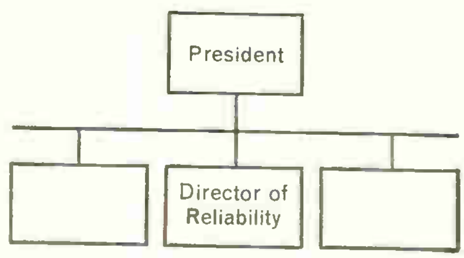

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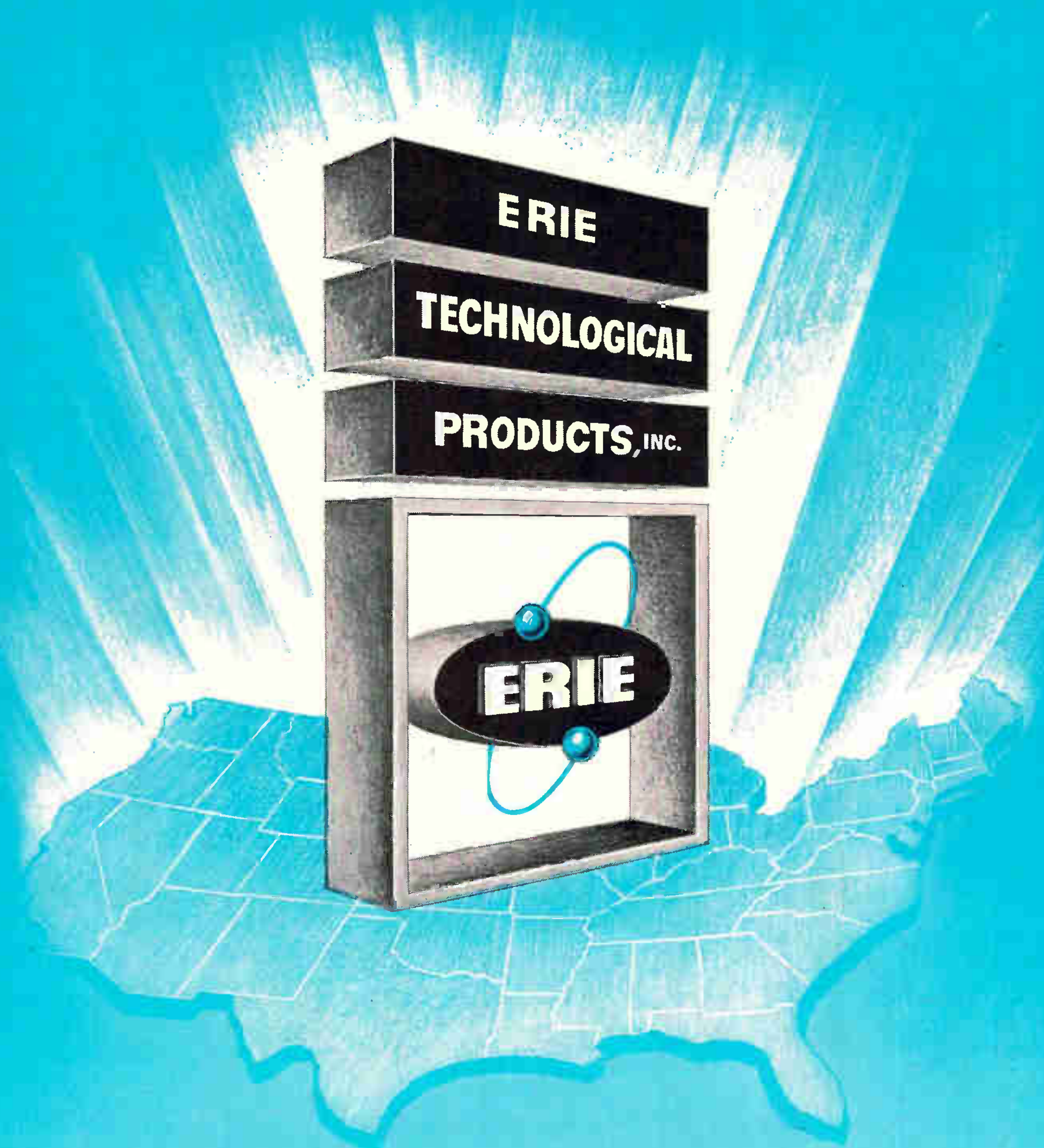
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Components

Transistors face an invisible foe

Can a cheaply made film of glass do the work of two transistors? New patent for junctionless semiconductor switch says it can

By George Sideris
Senior Editor

In 1963, the head of a small electronics laboratory in Troy, Mich., announced he was developing a radically new semiconductor device, an alternating-current switch. Unlike conventional semiconductor switches, his had no rectifying junction and was made of homogeneous film.

Was it a true bulk-effect device, sought like the philosopher's stone by semiconductor researchers, or were there two transistors in that little black box? The man, Stanford Ovshinsky, wouldn't say how the switch worked nor identify the material. The device got little publicity, coming as it did on the heels of his Ovitron liquid switch and his ball relay, neither of which got off the ground.

Until now, Ovshinsky has kept the secret to himself, his staff and his licensees, one of which is the giant International Telephone & Telegraph Corp. Secrecy clauses are written into the license contracts. At ITT, the word was passed that any employee caught leaking information on the development project would be fired.

This month, Ovshinsky got a patent (number 3,271,591) and was able to let the cat out of the bag. His company, Energy Conversion Devices, Inc., calls the device by its trade name, Ovonic.

Molecular circuits. The films, often so thin they are invisible, are amorphous compounds. For all practical purposes they are glasses made from semiconductors and other materials. The semiconductor mechanisms are akin to those described in the article on page 129 of this issue, but magnified many times by avalanche effects similar to those in zener diodes. When a threshold voltage starts an avalanche of carriers, the glass's resistance drops as low as 30 ohms from as high as 300 megohms, and the glass conducts current.

Ovshinsky predicts his invention will shake the semiconductor industry. His devices can perform a-c or d-c switching or logic, measure temperature and pressure, make nondestructive-memory elements and adaptive components. And he says he is working on bulk-effect oscillators, modulators and filters. The switches are already being sold commercially.

If the others pan out, the molecular devices will span most important classes of electronic circuits. The technical and financial stakes are huge, as indicated by Isidor I. Rabi's joining ECD's board of directors this month and financial backing of the enterprise

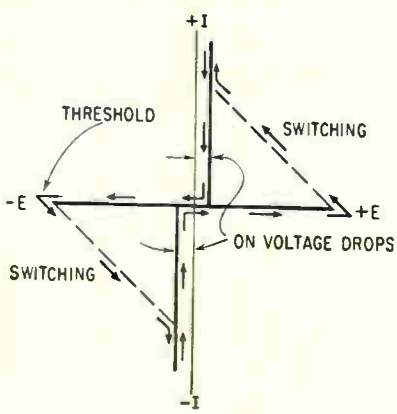
Switch, switch, who made one first?

Besides his patent, professional pride prompted Stanford Ovshinsky to talk.

During the editing of the article on page 129, a striking similarity was noted between the announced characteristics of Ovshinsky's devices and elemental glass devices reported by the Bell Telephone Laboratories, Inc., in 1962 [see p. 135]. This raised questions about who invented what first and indicated Ovshinsky also used elemental glass. The editor wanted to insert an explanatory footnote. Queries drew this reaction from Ovshinsky:

"Nobody's going to use my work as a footnote to somebody else's work! It's entirely different. Look at the Lissajous patterns. Come on out to Detroit and I'll tell you all about it."

In his book-lined office in Troy, a suburb of Detroit, he said that although Bell Labs patented a



glass memory device, it is not the same as his. The switch resemblances are only superficial, he continued, as indicated by the diagrams above and on page 135. Voltage-threshold devices like his were never reported by anyone, he maintained.

Ovshinsky claimed his work antedates Bell's by many years, that he got the idea for a two-terminal a-c switch in the early 1950's. As a designer of machine tools, he knew such a device did not exist, but would have wide use as a control. In 1956, he went on, he made his first amorphous semiconductor, tantalum oxide, and was granted a patent for it in 1961. The patent granted Sept. 6 was applied for in 1961, a year before the Bell Labs paper referenced on page 135.

His final argument was that his company's licensees didn't go to Bell Labs, but sought him out. If Bell had continued its work on glassy semiconductors, he said smiling, it might have been a different story. "Now, if they want to reenter the field, they will run up against our company's inventions and patent rights."

. . . the whole idea of a homogeneous film is to eliminate the convenient p-n junction . . .

by the National Lead Co. Rabi won the Nobel Prize in 1944 for his work in atomic physics.

Mum's the word. The company's licensees are primarily major manufacturers of communications equipment. Besides ITT, there's ITT's British affiliate, Standard Telephones and Cables, Ltd., L.M. Ericsson & Co., of Sweden, and Danfoss AS, of Denmark. How far they have progressed has not been disclosed.

Apparently keeping to the letter of the secrecy clause, an STC spokesman disclaimed knowledge of the devices. Ericsson says that it doesn't fully know the properties of the devices, nor how to make them, and that Ovshinsky is the man to ask. Stewart Flaschen, reportedly the ITT project chief, isn't answering his telephone.

I. Two for the price of one

"Our patent," Ovshinsky contends, "will dominate the entire field of nonrectifying switching"—an enormous field because of the almost universal use in industry of a-c power.

The switch is far cheaper to fabricate than devices made by a sequence of junction-formation steps, he says. Devices such as transistors are inherently rectifiers handling d-c, he adds, and it usually takes a complementary pair to control a-c. Ovshinsky figures he has at least a two-to-one price edge.

He also asserts that any junctionless two-terminal switch is covered by the patent. "Our device puts the phenomena between two electrodes, so the patent is as simple and as broad as possible."

Ovshinsky was so insistent about retaining patent control that he asked, and got, licensees of ECD to agree to feed back development information to him.

Submicron, subnanosecond. "The whole idea of using a homogeneous film is to eliminate the conventional p-n junction or barrier," he explains, thus eliminating junction hot-spot problems and finite junction size so the glass devices have neither size or power limits. The devices, including lab models, handle up to 100 volts and 10 amperes and can survive 75-amp surges, he says.

Stanford Ovshinsky, the inventor

Switching speeds range from several microseconds to subnanoseconds. The switching action occurs through the film, which need be only 0.1-micron thick versus about 1 micron for junctions. "We will be able to build integrated circuits handling watts, not microwatts," he says.

The empty can. The potential versatility of the "Ovshinsky effect" was his reason for secrecy. The effect is a natural one that can't be patented, but now the patent covers devices that exploit the effect. He feared that early disclosure would prompt competing inventions, citing commercial introduction of a Gunn-effect device by a company that did not do the research [Electronics, Aug. 8, p. 221], as a case in point.

He has avoided government contracts because they would require disclosures. The Air Force wants to try the switches as drivers for electroluminescent displays, he says. Another military use could be memories, since the glass memory switches do not lose data if power fails nor if they are irradiated.

One way he has baffled investigators is to deposit an invisible film inside a transistor case. Anyone dissecting the package, he says with obvious satisfaction, thinks the device operates by some sort of legerdemain.

Deposited dots. Only a few people are needed on a production line. The mixtures are melted, cooled and vacuum deposited as dots on the ends of electrodes. The dots on two electrodes are fused while the device is encapsulated in insulating glass.

To make multiswitch devices, the glass could be deposited on a steel-strip common electrode. The number of switches would depend on the number of contacts or wiring cross points on the glass side. Such arrays could be formed behind an electroluminescent plate to switch in the a-c power needed to produce patterns of thousands of glowing spots for a tv-like display.

One switch's input voltage can't trigger an adjoining switch, Ovshinsky says, because of the high resistance of the intervening film. Ovshinsky says he can make devices of glass thread. He showed experimental ones made of powder, paint and a rubbery mixture. The powder device sometimes rectifies, the only one that does. The rubber is a transducer whose output is varied by squeezing it.

II. Avalanche of carriers

The jargon of a semiconductor physicist is required to explain the semiconductor action. Some terms are explained in the article on page 129. However, the hopping mechanism believed to cause electronic conduction in other semiconducting glasses does little work in his materials, Ovshinsky says. "Our carriers don't hop, they pole vault and leapfrog." Impurities, basic promoters or deterrents of semiconduction in crystals, have no effect, he adds.

He selects materials with strong covalent bonds. This locks the carriers—electrons and holes—into position. The amount of locking depends on the energy band-gap structure of the materials. In turn, this determines the amount of field, or threshold voltage, required to knock the carriers out of position.

"The carriers are grabbed by the field, hit other carriers and knock them loose, causing avalanche multiplication of carriers." The glass becomes a conductor, allowing current to rush through it.

Ovshinsky believes the effect is basically a hot-carrier one like the Gunn effect. Most physicists think a periodic structure of atoms in a crystal is needed, but Ovshinsky thinks the job is done by definite spatial relationships among atoms in glass's local structure. Theorists in Russia indicate this, he says.

Free carriers may want to hop in the glass, but can't move through the over-all disorder of the glass until a field breaks their bonds. A temperature rise initiates conduction but not enough to cause switching. Thermal conduction is exploited in temperature transducers. The voltage is held just below threshold and heat kicks off the avalanche. Squeezing the atoms closer together does the same in pressure transducers.

Switchbacks. Carrier collisions and thermal effects that cause electrons and holes to recombine can stop mobility in crystal semiconductors. Apparently, this doesn't happen in the glasses as long as the field is on. Ovshinsky believes the very high mobility lowers the carriers' effective mass, causing them to whiz past or through recombination centers. Recombination asserts itself when the voltage drops below threshold. The avalanche subsides and conduction stops.

The memory materials form polymeric chains. Initially, the chains are disordered. A surge through the glass aligns the chains, providing an easy direction of current flow that remains after the voltage is removed. To switch a memory cell, a disrupting pulse is sent into the glass in a different direction.

The alignment of chains in adaptive cells can be increased or decreased with varying amounts of voltage. Ovshinsky likens this to formation of crystals with electrical stimuli, and thinks the effect will lead to electronic neurons.

Lock and key. Ovshinsky gave no formulas, but says that the compositions can be figured out by using the bonding and band-gap "lock and key" principles. Basic materials include the elemental and intermetallic semiconductors and any of a large number of other materials, including aluminum, oxides, boron and mixed-valence transition metals such as tantalum and iron. For a memory device he might mix boron or oxygen with some combination of arsenic, germanium, silicon and aluminum, then add tantalum oxide to prevent crystallization of other oxides.

It is essential, he says, to find the right combination of atomic bonding and band structures, and to balance materials that excite crystal formation with those that inhibit it.

Anti-Gunn effect? Ovshinsky

only hints at how a glass oscillator might work: it would be an avalanche device; carriers would move from one energy level to another and be excited; the glass's capacitance would sustain oscillations of less than a nanosecond. "If I'm right, it will compete with the Gunn effect."

What about filters? "All I care to say is that we do have resistance and capacitance in the same device." And modulators? "All that requires is breaking up a sine wave."

III. Amplifiers and controls

Lionel Robbins, vice president of the company, says the switches could be used in a class-D audio amplifier [Electronics, July 25, p. 43]. The circuit would lower battery drain in portable equipment. The pulse-width modulation can be done, he says, by using a capacitor and a switch as a relaxation oscillator. The time it takes the audio signal to charge the capacitor to the switch firing voltage is the pulse width. This pulse would trigger a dual-switch amplifier that would draw current from the battery only when it is on. The switch-amplifier can be made, he says, as a three-terminal device: film on a metal control electrode, with two contacts on the film. The device, still experimental, functions like a pnpn diode.

Simple a-c logic controls for industrial use have been made in model form. For example, when the voltages on two transformers add up to switch threshold level, the switch becomes an AND gate that closes each time the sine wave crosses zero. Another major use, Robbins expects, is a-c phase control, now a stronghold of silicon controlled rectifiers. Picking a switching voltage level on the sine wave serves the same purpose as picking a phase angle.

Timepiece. One idea that intrigues Robbins is to arrange contacts on a film to form a series of switches that fire in sequence according to pulse times set by an oscillator or tuning fork. A set of these ring counters would tick off seconds, then trigger minute counters, which trigger hour counters. As the switches fire, they would also activate an electroluminescent display. Voilà—a solid-state watch.

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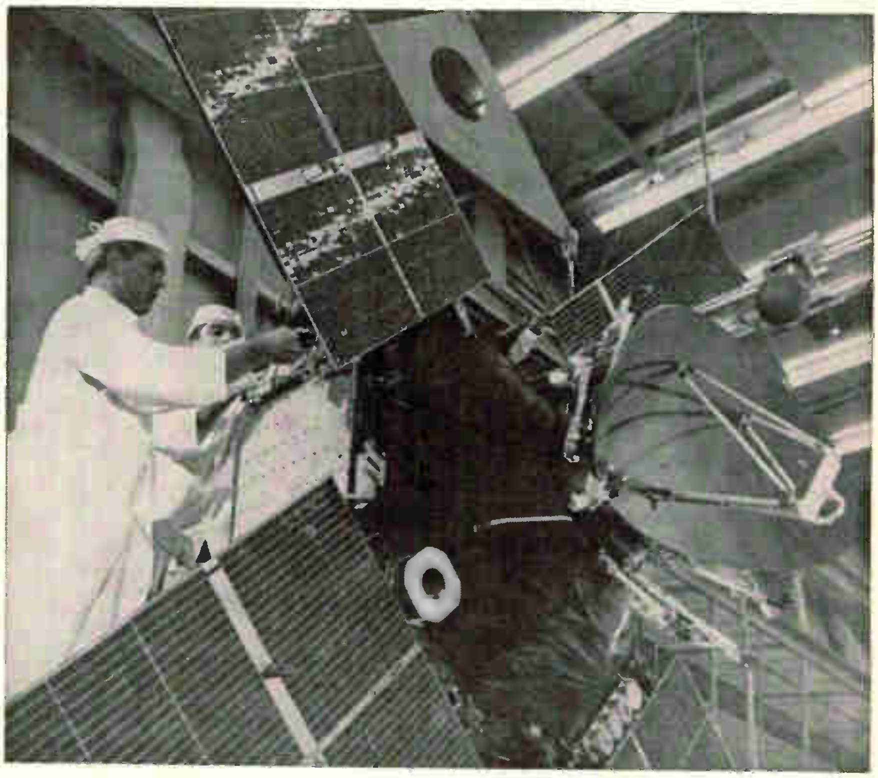
Mars flyby drawing closer

The space agency has almost finished choosing the contractors to build the Mariner '69 spacecraft for a close flyby of Mars in 1969

By Robert Henkel
Electronics Washington Bureau

The industry team should be assembled by next month to build the spacecraft for the next Mars exploration mission—the Mariner launch that sprang forth late last year out of the ashes of a 1971 Voyager mission. The spacecraft, an upgraded brother of the Mariner 4 which successfully sent back photos of the red planet last year, will be launched in 1969.

The National Aeronautics and Space Administration hadn't planned any additional Mariner flights following the successful fly-by of Venus in 1962 and Mars in 1965. But last year the follow-on Voyager program was pushed back two years to 1973 because of a NASA budget squeeze caused by the rising cost of the war in Vietnam. The space agency—with some prompting from Congress—decided this was too long a gap in its planetary exploration program and added the Mariner-Mars '69 mission. It also dusted off a spare Mariner spacecraft left over from the 1964 Mars shot to try for a single Venus flyby in 1967.



Like father, like son, Mariner '69 will look almost exactly like Mariner 4, above. NASA officials use Mariner 4 drawings and pictures to brief officials. However, updating the spacecraft will cost from $95 million to $111 million.

New breed. Mariner '69 is a "different breed of cat" than any previous Mariner, says Newton W. Cunningham, Mariner-Mars '69 program manager at NASA headquarters. It will be "much more ambitious" than the 1964 Mariner 4, he adds. The spacecraft will weigh at least half again as much and carry more sophisticated experiments.

But the space agency doesn't have enough time or money to do a complete redesign job on the old Mariner 4. Even so, total cost of updating the design and building the spacecraft for the 1969 mission will run from $95 million to $111 million.

A bigger, improved version of Mariner is possible because of a more powerful booster, the Atlas-Centaur. The Atlas-Agena vehicle left no room for margin in lifting the 530-pound Mariner 4 and this resulted in most of the subsystems being weight limited. "We took more risk than we'd like because of this." Cunningham acknowledges.

Because the 800-pound 1969 spacecraft will not tax the full lifting capability of the Atlas-Centaur, there is no urgent need to lighten the payload by going to microminiaturization. Integrated circuits will be used in many parts of the spacecraft for the gain obtained in over-all reliability, not for any reduction in size or weight.

I. After Mariner comes Voyager

Cunningham points out that everything NASA is doing with Mariner '69 is aimed at the multibillion-dollar Voyager program, the United States' major unmanned planetary exporation effort to soft land on Mars and Venus in the 1970's. For example, the primary object of the 1969 launch is to find out more about the atmosphere and surface of Mars for the Voyager spacecraft, which is now in the preliminary design stage. Current Voyager plans call for three modules—a bus orbiter, a retropropulsion system and a soft landing capsule.

The larger and more sophisti-

... NASA plans to keep Mariner 2,000 miles away from Mars; any closer and craft would crash ...

cated Voyager will perform a detailed study of the atmosphere, surface and body characteristics of Mars and Venus. With Voyager, NASA hopes to learn about such things as the origin and history of the solar system and whether there is some sort of life beyond earth.

Industry's part. In contrast with earlier Mariner efforts, industry will get most of the dollars and a larger say in the design of the Mariner '69 spacecraft. All earlier Mariner spacecraft, including the one for the 1967 Venus shot, were designed and built totally in-house at the Jet Propulsion Laboratory in Pasadena, Calif. It's a different story with the 1969 model.

"We're making greater use of industry by letting them help us in the design, and we've broken out each major subsystem and set it up as a separate contract," Cunningham notes.

About one-third of the Mariner '69 dollars will go to 10 subsystem contractors and another $25 million or so will go to industry for subsystems for the scientific experiments. In Mariner 4, no one company was responsible for a complete subsystem. In the power subsystem, for example, all items, such as logic and solar cell panels, were designed in-house at JPL. This time a contractor will be in charge of the entire subsystem, including such things as screening parts, a task JPL has had trouble with before.

Shortcut. The interplanetary trip will be shorter for the new Mariner than it was for Mariner 4, since Mars will be much closer to earth in 1969. Mariner '69 will take about six-and-a-half months to make the journey compared with Mariner 4's eight-and-a-half months. NASA also will aim a lot closer to Mars this time. Plans are to fly within 2,000 miles of the planet sometime in late August or early September, 1969. Any closer and the spacecraft would be pulled into the planet by gravity.

Biggest boon from the shorter distance between the two planets during the Mariner '69 flyby is that a stronger radio signal will be received on earth which means NASA can go to a higher bit rate for digital transmission. Mariner 4 sent back information at $8\frac{1}{3}$ bits per second. In 1969, the bit rate at encounter will be $66\frac{2}{3}$ bits per second. This is based on the same 85-foot ground antennas used in the 1965 flyby.

There are no plans to use NASA's new 210-foot antenna at Goldstone, Calif., even though the giant dish picks up an 8-decibel increase in signal. Money has never been allocated to build the two additional 210-foot receivers needed to complete a global network.

II. Mariner '69 on tight schedule

Six Mariner '69 spacecraft will be built: three for proof test, structural test and thermal test, and three flight models including a spare. Because the opportunity to launch a Mars mission comes only once every 25 months, NASA will launch two identical spacecraft to Mars, as it did in 1964, during the 30-day 1969 window.

NASA hopes to complete detailed designs for the entire spacecraft by July, 1967. The proof test model should be ready about January, 1968. "Then we'll start putting flight hardware together about mid-year," Cunningham says. In January, 1969, JPL will begin tests and ground operations with flight models.

Contracts awarded. Late in June, NASA picked the first subcontractor, the Northrop Space Laboratories of Northrop Corp., Hawthorne, Calif., to design, develop, fabricate and test the engineering subsystems, including the craft's flight electrical cabling, mechanical devices and temperature controls. Northrop, which was building an advanced Ranger series for JPL before the program was cancelled to save money, was one of the three firms to bid on the $5-million contract. The others were the Sperry Rand Corp. and the General Dynamics Corp.

Several other contractors have now been selected and most of the others are scheduled to be awarded shortly.

- Texas Instruments Incorporated, Dallas, has won a $1.25-million award for ground, checkout and test equipment, as well as the on-board gear to process data from scientific experiments. TI also is designing and building the data storage subsystem on the 1969 craft under a contract in excess of $2 million.

- Motorola Inc.'s Western Electronics Center in Scottsdale, Ariz., is designing and building the command subsystem for the 1969 mission under a $2-million award. Motorola is also scheduled to get a $2-million award for the central computer and sequencer on the spacecraft. These will initiate spacecraft events in the mission, such as launch, mid-course correction and encounter.

- Philco Corp.'s Western Development Laboratories will design and fabricate the radio subsystem, including a transponder, transmitter, receiver and high and low gain antennas. Philco, a subsidiary of the Ford Motor Co., has a contract for more than $2 million for the work. This equipment will "not be too different" from the Mariner 4 equipment, according to Earl Glahn, program engineer at NASA headquarters, since NASA is not planning any increase in transmitter power. One change is that the 1969 version will carry two 10-watt, traveling-wave tubes. The Mariner 4 hybrid system had one twt and one triode. The 1969 spacecraft will use the same S-band frequencies: 2,113 megahertz to receive and 2,295 Mhz to transmit.

- Honeywell, Inc., Minneapolis, has been selected to build the attitude control and scan control subsystems. Costing in excess of $5 million, this equipment consists of inertial and optical reference gear and a cold gas stabilization system.

III. More experiments planned

Due to be awarded shortly is the contract for the power subsystem. NASA is still working out power requirements and is in the process of defining the subsystem. "What we'd like to do is not have to redesign the solar cell panels," Glahn said. "But we can't be sure until we get the power requirements nailed down." More power will be neded, however—as much as 25% more. This could mean adding more solar cell area, changing the power distribution system or perhaps using more than one battery.

Some 28,224 solar cells covering 70 square feet converted solar energy into electricity on Mariner 4. Mariner 4 required anywhere from 147 watts during picture playback to 197 watts during encounter; Mariner '69 will need as much as 250 to 300 watts. Mariner 4 solar cells could deliver about 310 watts at Mars encounter.

Also to be let is the contract for the data automation system that will control and synchronize the experiments. "This will be a bigger job than Mariner 4 because there will be more scientific experiments on board the 1969 mission," Cunningham says. The request for proposals on the last subcontract to be awarded—propulsion—will go out either this month or next. This subsystem will be identical to the JPL-built Mariner 4 motor.

All six experiments on board Mariner '69 will be seeking data only during the relatively short Mars flyby. Mariner 4, on the other hand, had only two flyby experiments—S-band occultation and television—while the other six were principally cruise experiments to make measurements on the long trip to the red planet.

Twins. Dual recorders will give Mariner '69 much more storage than its predecessor, says Glahn. The 1969 mission will take "considerably more pictures," he says, the exact amount depending on the allocation of bits among the experiments. Mariner 4 sent back 20 photos of Mars and had an endless loop tape recorder with a storage capacity of 5.2 megabits. Mariner '69's capacity will be 200 megabits.

Mariner '69 will have a 200-line, low resolution tv camera "very similar" to the JPL-built Mariner 4 system to take pictures as the spacecraft passes the planet. A second television camera will take 500-line pictures, or about 10 times the resolution of the 20 pictures received from Mariner 4.

NASA expects to pick up features on the Martian surface as small as 500 feet in size. Just who will build the advanced tv camera is up to the principal investigator, Robert B. Leighton, of the California Institute of Technology, Pasadena. JPL will build the low resolution unit.

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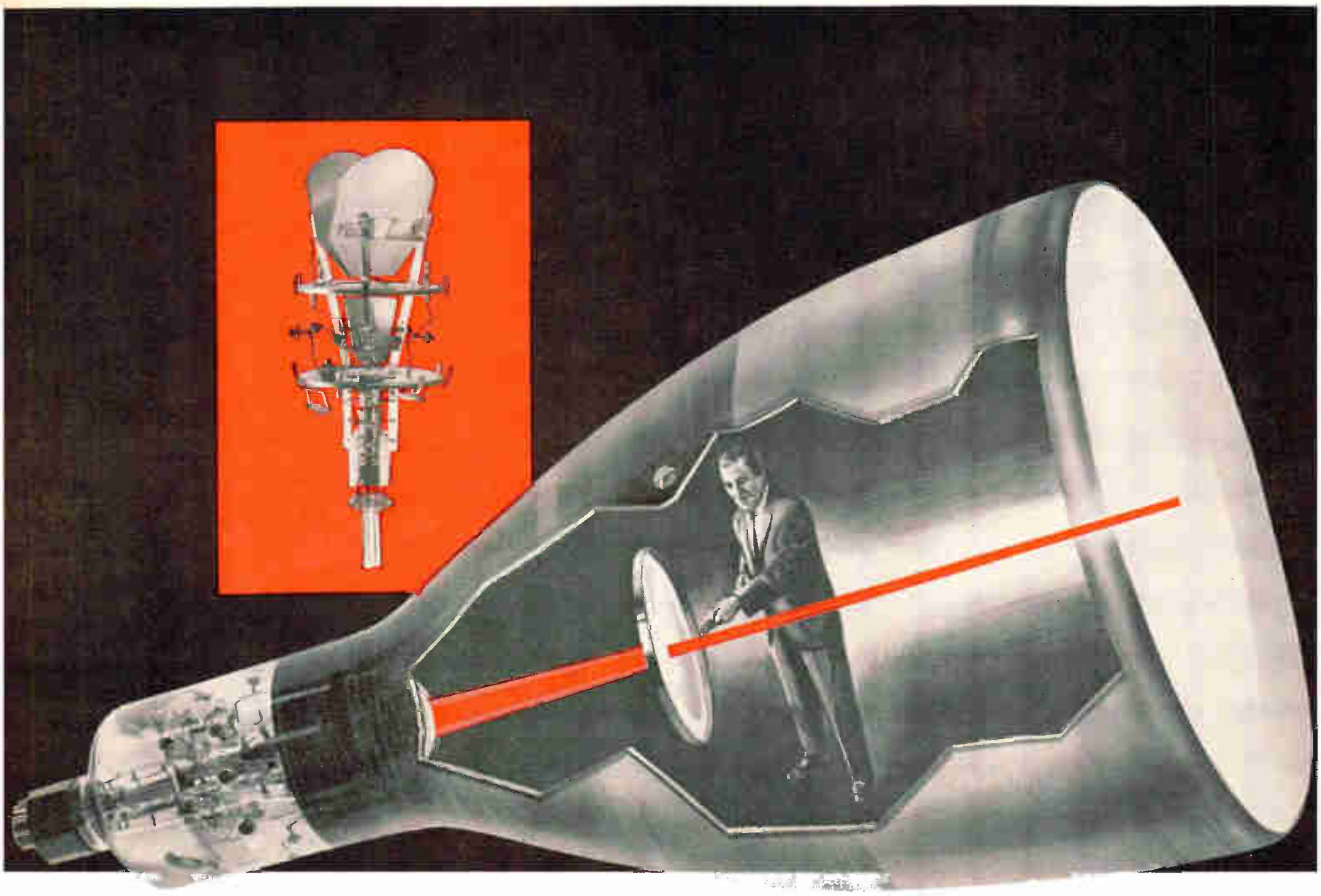


Air Force junks custom-built computers in 473L command information system

Pentagon official says special-purpose data processing equipment for large command-and-control systems is outdated by the time it's operational; industry-sponsored machines are cheaper and do the job better

"We bought three Edsels. It was a bad mistake but we're doing something about it."

The Air Force colonel at the Pentagon was referring to three large-scale, custom-made computers, built to be the backbone of 473L, the top Air Force command information system.

Whether the fault lies with the Air Force or the manufacturer isn't clear.

The computers were incompatible with the way the 473L was evolving, the colonel explained. Also, he said, the system was not reliable once it got to the Pentagon. A third problem, he cited, was that the manufacturer, the Librascope division of General Precision, Inc., had decided to quit the large-computer business, leaving the Air Force without technical support or a follow-on computer. Librascope denies this. It says it has no plans to leave the large, special-purpose computer field.

The solution, decided upon about a month ago, was to junk the Librascope computers. Other government agencies can pick them up if they want to—"possibly for some kind of research."

Two of the three computers are at the Pentagon and the third is at the Librascope plant in Glendale, Calif., for development of peripheral equipment including a self-diagnostics program. The three machines cost $7.2 million.

Other companies affected by the Air Force decision are the International Business Machines Corp. responsible for systems analysis and programing; ITT Federal Laboratories, a division of International Telephone & Telegraph Corp., for the display system; and Bunker Ramo Corp. for communications consoles and display buffers. Mitre Corp. is technical advisor to the Air Force Electronic Systems division, Bedford, Mass., which manages development and procurement of the 473L system.

Replacement. In place of the Librascope computer, which the company calls the L-3055 and the military has designated the AN/FYQ-11, the Air Force will rely on the smaller capacity 1410 made by IBM. The 1410 has been operating for two years in the Pentagon as part of a scaled-down 473L for training purposes and to provide an interim capability.

Program plans had called for the larger L-3055 eventually to take over full system operation. Instead, additional 1410's will be installed alongside the existing machines, advancing the system beyond an interim capability. According to the Air Force, the two additional 1410's—which cost about $900,000 each—will give 75% to 90% of the performance expected with the FYQ-11. They will be used until follow-on development of the 473L begins in the 1970's.

I. Incompatibility

The Air Force and Librascope hold widely divergent views on the cause of problems and, in some cases, appear not even to know what action the other has taken.

A Librascope official—who, along with Air Force officials, asks that his name not be used—says the company had not, as of Sept 12, received official word that its computer had been pulled out of the

Last of the breed

The Air Force experience with its headquarters command system apparently was the final blow in a series of losing bouts with tailor-made military computers.

Says Leo E. Berger, a high civilian official at the Pentagon: "In Sage (Semiautomatic Ground Environment), we developed the AN/FSQ-7 and 8, in the Strategic Air Command's 465L system we developed the AN/FSQ-31, in the 473L, the AN/FYQ-11, and other computers in other systems. In each instance, during the time it has taken us to accomplish all the steps from specification to operation of these military computers, industry-sponsored hardware development has produced a commercial off-the-shelf model with greater speed and capacity which was cheaper and more advanced."

Berger, who works for Maj. Gen. Gordon T. Gould, Jr., director of Command Control and Communications at Air Force headquarters, revealed this bit of military intelligence at the national meeting of the Armed Forces Communications and Electronics Association in Washington. Except for certain mobile and airborne requirements, he said, experience with existing systems teaches that optimum use should be made of "proven families of modular off-the-shelf, commercially available computers."

According to Berger, time was wasted and costs soared further when the Air Force tried to check out unproven hardware with equally unproven, newly developed software. The third lesson is that it is a mistake to acquire hardware from one company and the software which makes it perform from another company. "It is most difficult," he says, "to pin down responsibilities when either the hardware or the software fails to perform according to specification or advertisement."

. . . Librascope and the Air Force agree the 473L system wasn't well thought out . . .

473L system. He did say, however, that such a move is expected.

As for incompatibility, Librascope points out that this isn't its fault. The company charges, and the Air Force admits, that the 473L system was not thought out properly on a long-range basis.

If Defense Secretary Robert McNamara's program definition phase contracting requirement had been in effect when the computers were ordered, they probably would have remained compatible with the 473L system as it grew. One purpose of program definition is to spell out long-range requirements.

According to the Air Force, the computers for 473L were the first procurement made under the Pentagon's two-step formal advertising procedure. After the unpriced technical proposals were screened, three companies were asked to put price tags on their proposals: Librascope, IBM and the Burroughs Corp. Librascope's bid was lowest. Under the two-step procedure, says the Air Force, the government agency is required to select the lowest bid, since only companies with acceptable technical proposals are invited to bid.

Another example of lack of forethought was equipping the major commands with IBM 1410 computers because the computer in the interim system at the Pentagon was 1410. The units would later be incompatible with the Librascope computer at headquarters. The 1410's were installed at the headquarters of the Tactical Air Command, the Military Airlift Command, Air Defense Command, U.S. Air Forces in Europe and the Pacific.

Software packages for the command computers were developed from the software already prepared for the 1410 in the Pentagon.

To make these computers compatible with the Librascope computer would have required a massive job of program writing, says the Air Force. Of the $42 million spent on 473L, the largest dollar amount went into programing. IBM, the programing subcontractor, received $21.5 million in the last five years for systems analysis and for writing programs to Air Force specifications. A final $2-million payment is still due.

The IBM contract to provide software for the Librascope computer is being terminated and the Air Force is using its own personnel to work on the 1410 programing at the present time. The Air Force estimates that software for the expanded 1410 system will be completed in September of 1968. Programing for the full system using the L-3055 was scheduled to be ready by November, 1967.

Still another software package would have been needed for the follow-on system for the 1970's and this would have to be compatible with other military networks as well as with the existing 473L.

II. Reliability

As for reliability, Librascope says that although they've received no word that there are maintenance problems, the Air Force made a mistake in not contracting Librascope to do the maintenance work.

Although Librascope does not say that inexperience of the Air Force's maintenance personnel was responsible for any malfunctions, the spokesmen do comment that, if Librascope's self-diagnostics program had been in operation at the Pentagon the Air Force would not have had any problem keeping the equipment going.

The company points to the swing-out plates on which disk memory heads are mounted. These plates are critical, says a Librascope spokesman, and only designated persons at the Librascope plant may handle them. Yet the Air Force turned them over to regular maintenance personnel, says Librascope. The company does not admit, however, that the disk memory was giving the Air Force trouble.

Expensive. The Air Force claims an 18-month delay in delivery cost the government additional money in keeping programers on the payroll.

According to Librascope, the company received a contract to build three systems in June, 1962. The first machine was delivered in June, 1964—one year late. It was accepted by the Air Force in October, says Librascope, and the second machine, delivered in September of the same year, was accepted in December. In April, of 1965, Librascope says, the third system was completed and stayed in Glendale.

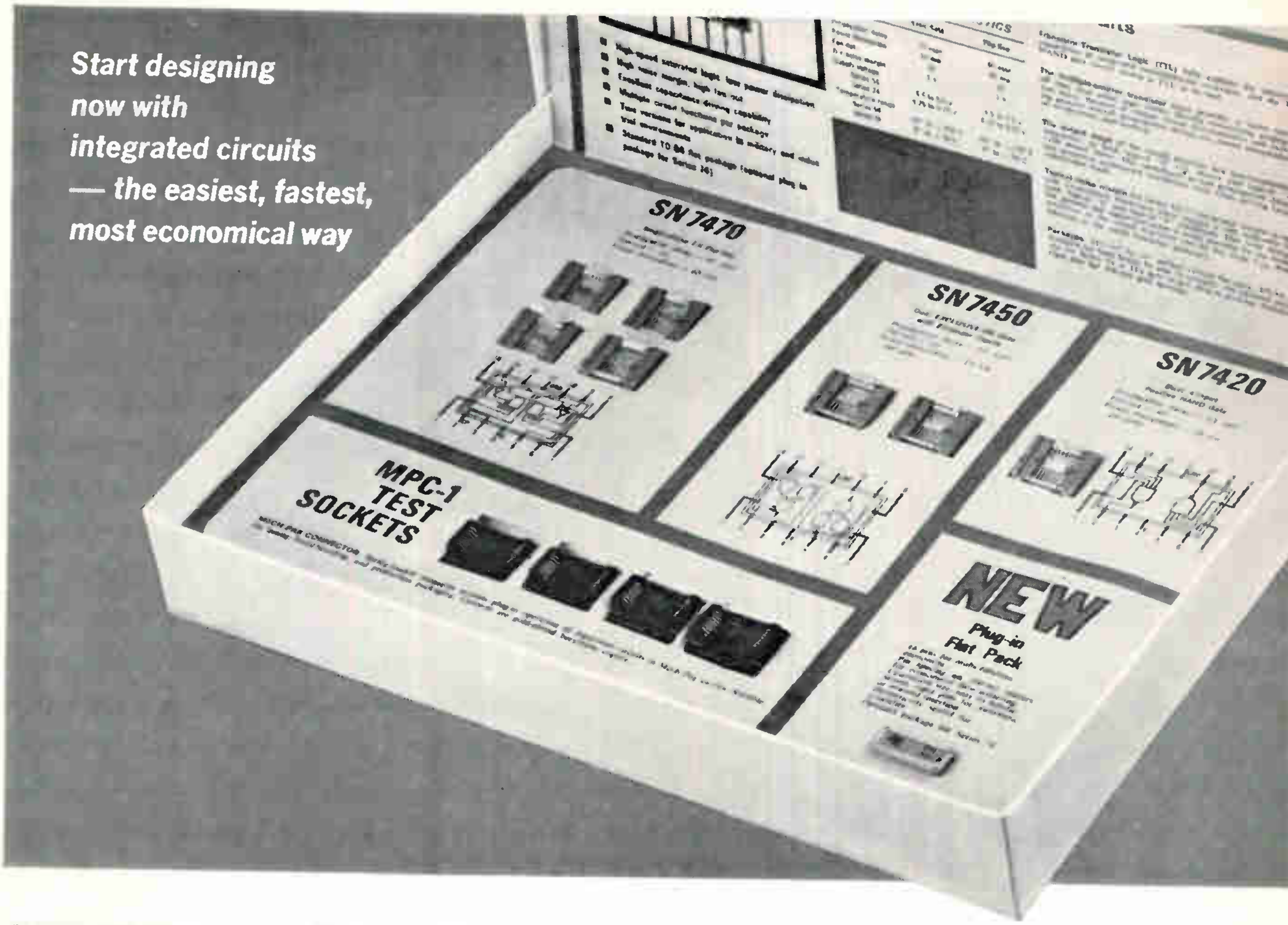
Librascope claims that add-on requirements by the Air Force were costly, sometimes constituting major design changes. The company gives this example: originally, the tape drives were intended for off-line duty where some bit error could be tolerated. Then they were made on-line and in that mode the same amount of bit error could not be tolerated. New electronics had to be installed in the drives subsystem.

The Air Force says, however, that it paid for all the changes it asked Librascope to make.

III. Predecessor.

About eight years ago, Librascope designed another large, special-purpose computer, the L-3020, for the Federal Aviation Agency. Six were ordered and three delivered to FAA's National Aviation Facilities Experimental Center at Atlantic City, New Jersey. FAA realized before the last three came in that the memory capacity was far too small for the agency's new plans. The other three computers were diverted to the Air Force and two of the computers FAA already had were sent to Utah State University. Two of those the Air Force got were sent back to Librascope to help develop the L-3055.

According to Librascope, the L-3020 helped generate wiring diagrams for the L-3055 and was used as a design aid in other ways. But there was very little transfer of design concept, one spokesman says. The 3020, he points out, is a very limited machine designed for a special purpose—air traffic control. The 3055, according to Librascope, is much more flexible and could probably be converted to general-purpose applications at a reasonable cost. Even some of the basic design concepts, such as circuit card layout, are radically different in the two machines, Librascope says.



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- 4-bit Binary Comparator
- Divide-by-5 Counter
- Binary Coded Decimal Counter

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Three SN7331 Triple 3-input NAND/NOR gates
Two SN7302 Dual J-K flip-flops with preset
One SN7360 Quadruple 2-input NAND/NOR gate
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APPLICATIONS
- Full Adder
- One shot Clock Inhibit
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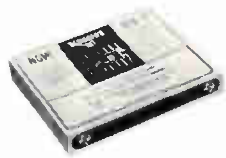

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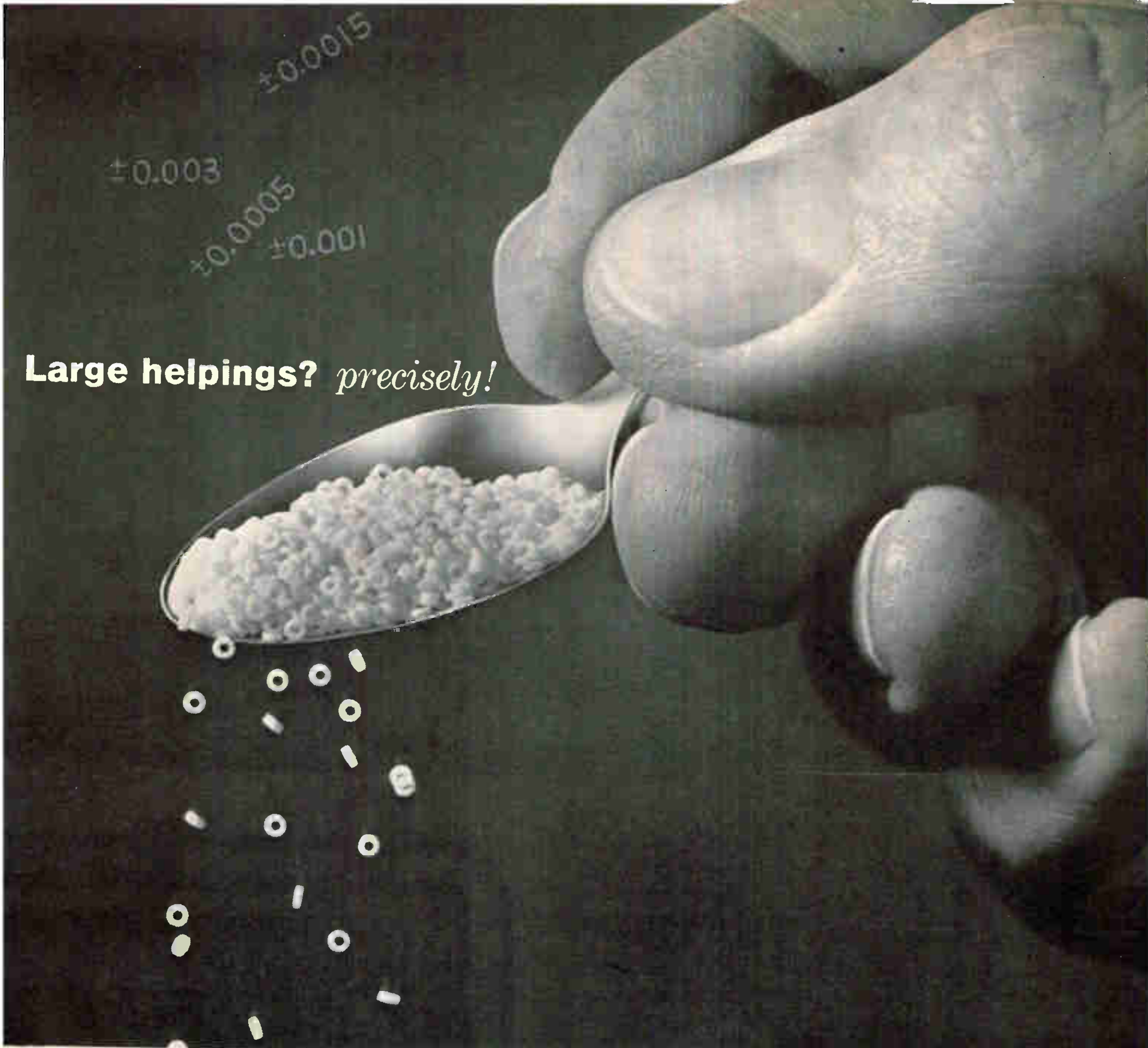

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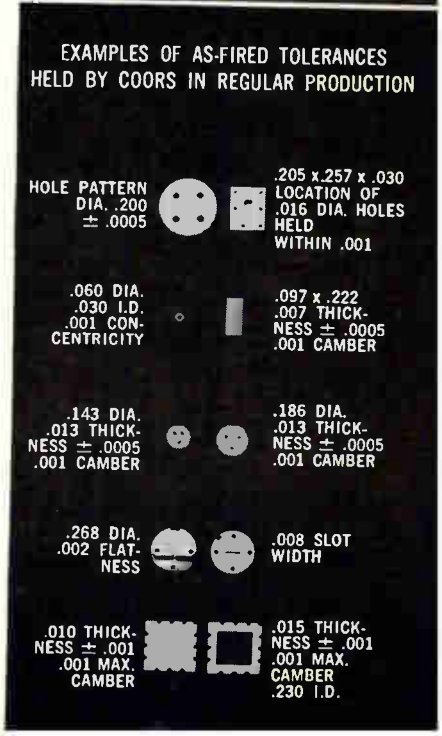

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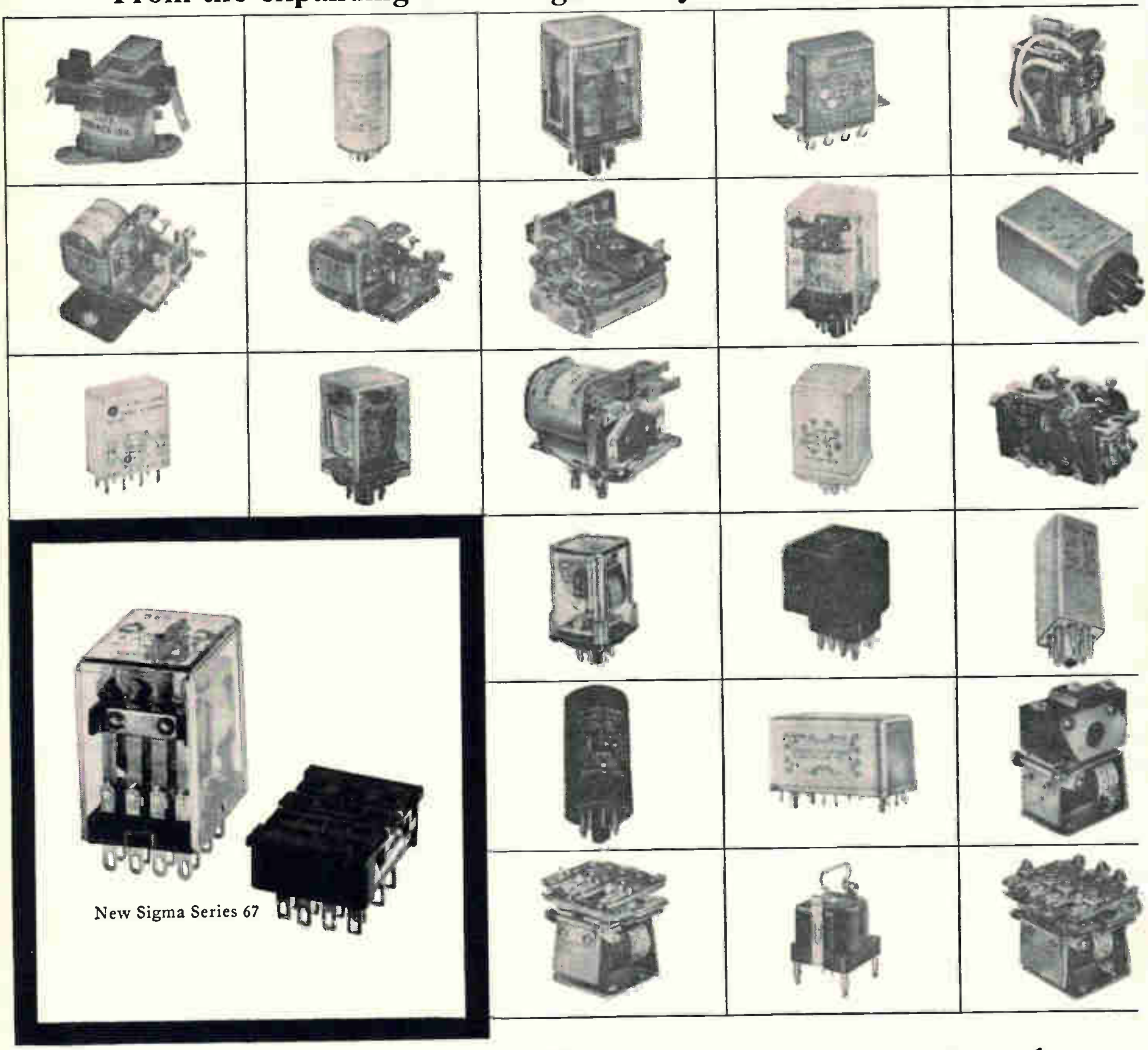

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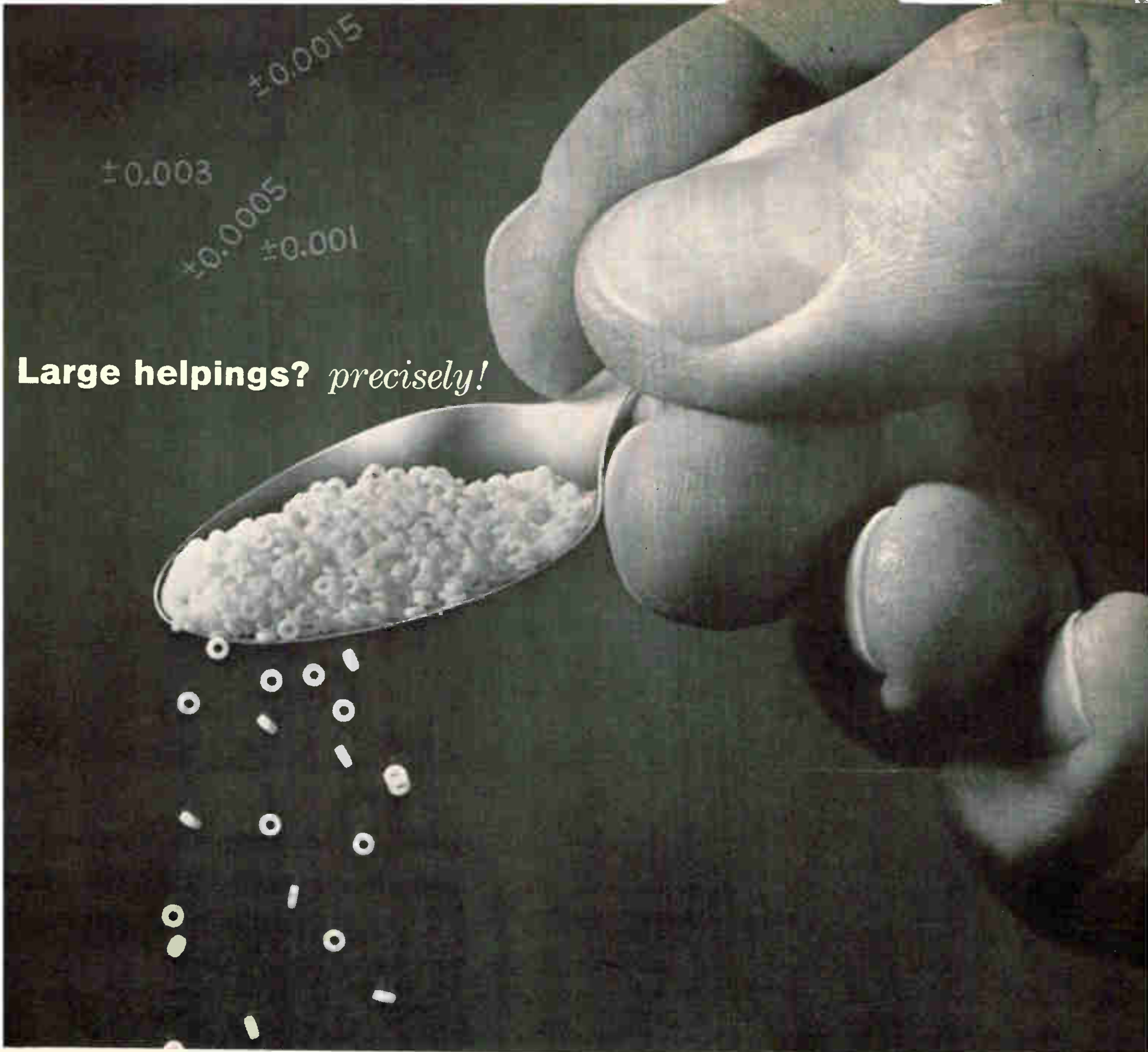
We'd like to give you a new Sigma Series 67–or any of our other standard relays. Test and compare it against the brand you may now be using. It's the best way we know to prove what we say about Sigma relay performance.

Test the new Series 67, for example. This rugged AC-DC relay, only slightly larger than a cubic inch, brings new reliability and versatility to precision switching. Each of its four poles can switch a low-level to 3-ampere load 100,000 times minimum. The relay's in-line contact arrangement extends mechanical life to 100 million operations DC, and 50 million operations AC.

Completely versatile, the Series 67 is available for either direct solder-terminal installation or fast, easy, socket mounting with choice of solder or printed-circuit-terminal connections. The socket can be installed in seconds, with no need for screws or fasteners. It simply snaps into the face of the panel and four spring clips lock it.



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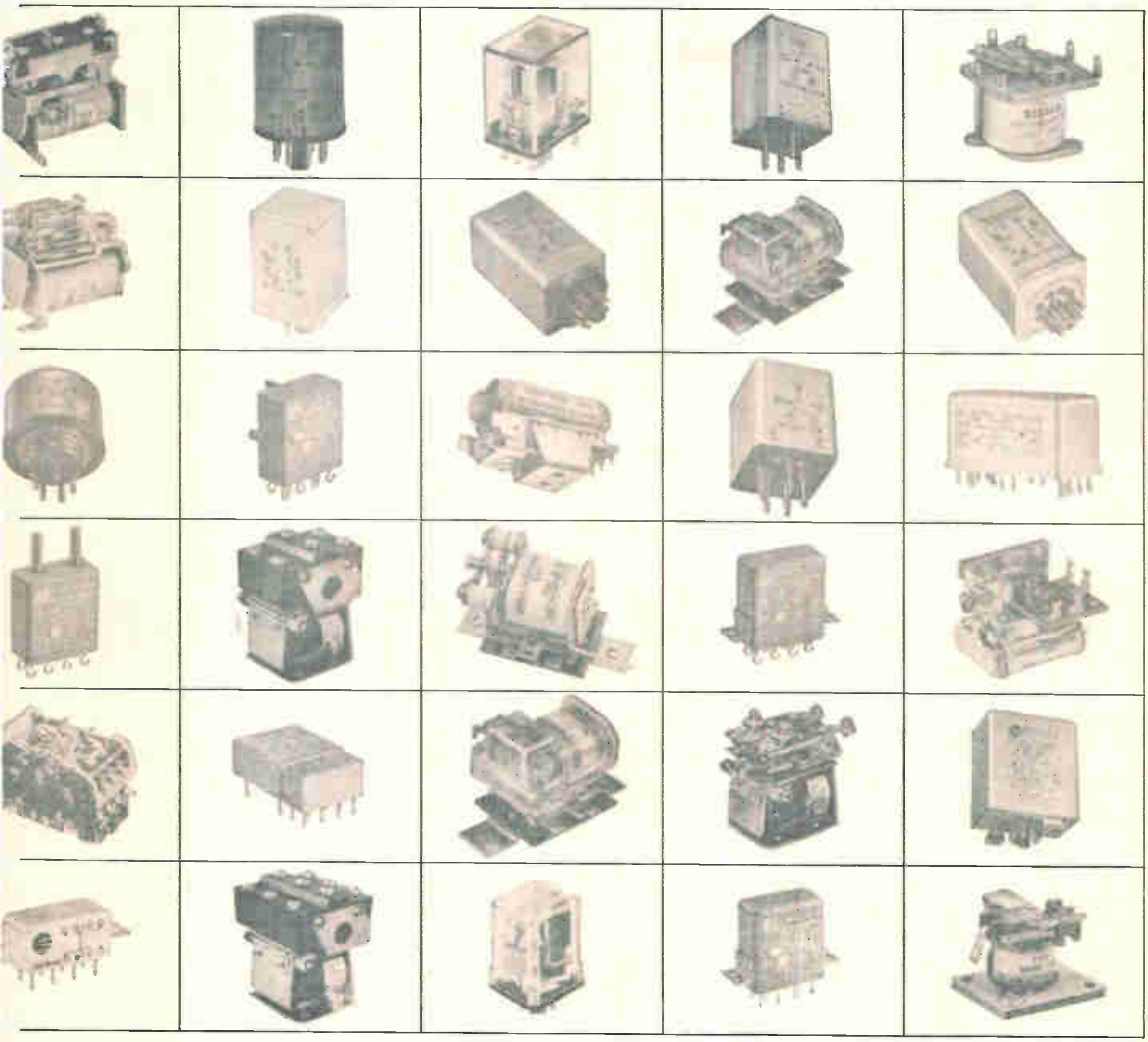
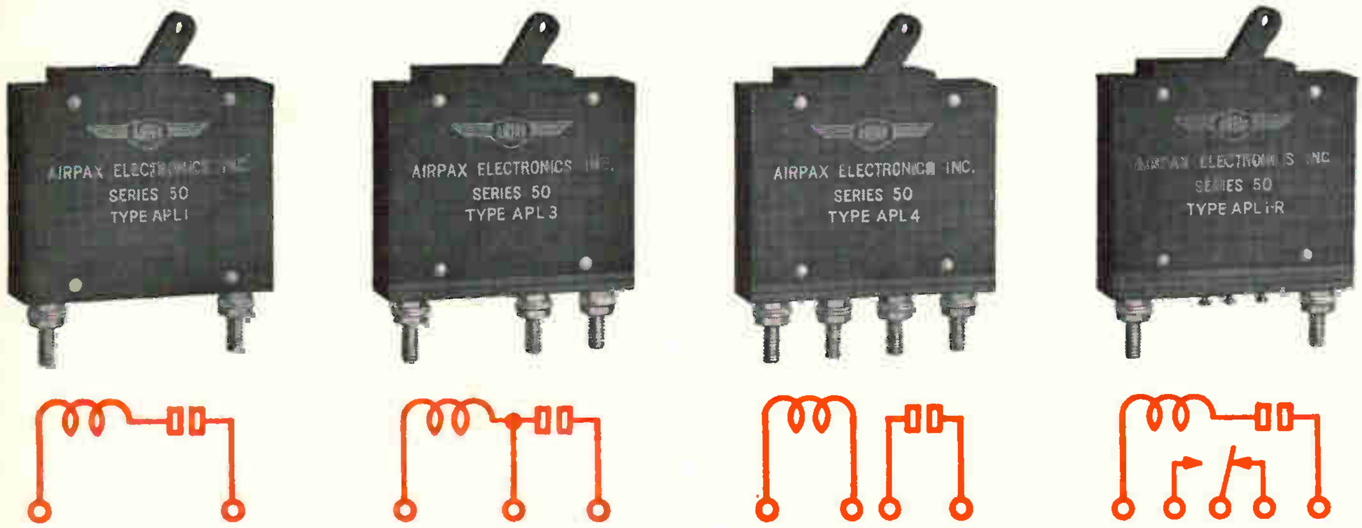


CIRCUIT CONTROL AND PROTECTION BY AIRPAX



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Delay 61	No Trip	1.0 - 6.0	.240 - .800	.040 - .180	.012 - .050	.010 - .040
Delay 62	No Trip	15.0 - 70.0	3.0 - 9.0	.30 - 1.50	.018 - .080	.010 - .040

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New Products

Boom in TTL integrateds

A second generation, promised . . .

A surge in new transistor-transistor logic (TTL) circuits is becoming evident from recent announcements by electronics firms. One manufacturer, in perhaps a harbinger of what's to come, is promising a second generation of TTL integrated circuits operating at propagation delays as much as 20% lower than of competitive saturating-type devices.

The Sprague Electric Co. says two basic circuits will be available next January in 14-lead flatpacks: a high-speed dual 4-input NAND gate, the first device of series UEX-1100, and an ultrahigh-speed dual 4-input NAND gate, the first of series UEX-1070. The propagation delay of the UEX-1100 will be 8 nanoseconds, that of the UEX-1070 5 nsec. Sprague claims the best now on the market bottoms at 6 nsec.

Later in 1967, Sprague will offer the monolithic silicon substrates in two types of low-profile dual in-line packages—one hermetically sealed and the other in low-cost epoxy. Both will plug into printed-circuit boards. Eventually a family of TTL devices is planned to include almost all the types found in first-generation TTL circuits.

Sprague also plans to produce first-generation TTL circuits and both SE800 military series and the NE800 commercial series are to be available by next month. The circuits were originally developed by the Signetics Corp.

Specifications

	1st generation	2nd generation	
		UEX-1100	UEX-1070
Propagation delay	10 nsec	8 nsec	5 nsec
Power dissipation	10 mw	35 mw	25 mw
Clock frequency	35 Mhz	35+ Mhz	35+Mhz
D-c noise immunity	1 v at room temp	1.7 v	1 v
Fanout	12	10	12
Power supply voltage	5 v	5 v	5 v

Sprague Electric Co., 87 Marshall St., North Adams, Mass.
Circle **348** on reader service card.

. . . and a fast dual J-K flip flop . . .

Sylvania Electric Products, Inc. has announced an addition to its line of TTL logic circuitry known as Sylvania ultrahigh level logic (SUHL): dual J-K flip-flops. The company, a subsidiary of General Telephone & Electronics Corp., is offering two configurations. The first, the SF-120 series, allows a separate clock input for each of the dual J-K functions in the package. This package offers the separate clock lines necessary for ripple counters in digital communications subsystems.

The second configuration, the SF-130 series, is designed with a clock line and reset line common to both J-K's in the package. This is useful for temporary storage of data trains, such as found in shift register and serial counter applications.

Available in military premium and standard units, and in industrial premium and standard units, both series exhibit the same specifications.

Specifications

Propagation delay	10 nsec
Power dissipation	50 mw
Clock frequency	50 Mhz rated, up to 70 Mhz
D-c noise immunity	1 v at room temperature
Fanout	6-15

Sylvania Electric Products, Inc., 730 Third Avenue, New York, N.Y. **[349]**.

. . . plus a new line compatible with DTL

Fairchild Semiconductor, a division of Fairchild Instrument and Camera Corp. has entered the TTL arena with a family of integrated circuits known as Transistor-Transistor Micrologic (TTμL) circuits. The circuits are electrically and mechanically compatible with Fairchild's diode transistor Micrologic 930 series (DTL) circuits. Fairchild says it operates at moderate speeds with low power consumption.

Features include a logic one level noise immunity of 1.3 volts and zero level noise immunity of 0.8 volts; two transistors in the output instead of the usual one transistor and diode, providing greater output current at a higher output voltage. The devices are available in either flatpack or ceramic dual in-line package.

Fairchild is planning to come out with a plastic dual in-line package, but has not specified the date. Pricing for industrial grade devices in quantities of 100 and up range from $6.05 to $8.95.

Specifications

Propagation delay	8 nsec
Power dissipation	12 mw/gate
Clock frequency	30 Mhz
D-c noise immunity	1.3 volts at room temp
Fanout	8

Fairchild Semiconductor, 313 Fairchild Drive, Mountain View, Calif. **[350]**

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A vital link in monitoring heartbeat and pulse rate, the tiny MICRO-K™ connectors worn by our men walking in space today are only *one* dramatic example of countless CANNON® Plugs delivering superior performance in many challenging environments. Engineers everywhere have learned when environments are tough to look to ITT Cannon Electric for production and engineering know-how ... backed by over 50 years of experience, capability and service. Whatever the environment – space, shock, vibration, corrosion, undersea, high or low temperature... and whatever the connector configuration – microminiature, subminiature, miniature, circular, rectangular ... look only to ITT Cannon for solutions! ITT Cannon Electric, 3208 Humboldt Street, Los Angeles, California 90031. A Division of International Telephone and Telegraph Corp.

CANNON PLUGS

CANNON ITT

Tiny X-ray tubes zero in

For X-ray analysis of materials and equipment in hard-to-reach places, Amperex Electronic Corp.'s Tube division is offering two tiny flash X-ray tubes. The tubes were developed last year, with the military, so that x-ray diagnosis could be made during destructive testing of weapons.

Amperex believes the X-ray tubes are the smallest available commercially. The larger of the two, designated FX-30, has a diameter of 1⅛ inches, an envelope length of 2½ inches and, with its 9 pins, an over-all length of 3⅜ inches. The FX-30M is ½ inch around and 1½ inches long, with the single pin adding a half inch.

Their sizes, project manager Jerry Prichert says, allows the source to be placed extremely close to the material being radiated, giving fine measurements. Long-distance analysis can be done, but the intensity of radiation varies inversely with the square of the distance from the source.

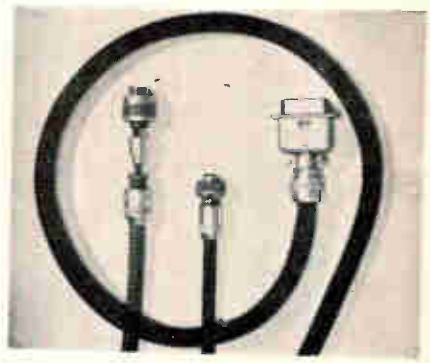
Both tubes have tungsten targets; other materials can be ordered. In air the maximum applied plate voltage is 30 kilovolts. Up to 1,000 v per millimeter can be obtained with oil or other high dielectrics.

Amperex Electronic Corp., Tube Division, Hicksville, N.Y., 11802 [351]

Specifications

Pulse duration	100 μsec
Duty cycle	1 pulse per 5 sec
Plate current	1 amp, typical
Life	1,000 exposures at rated conditions
Price	
1-10	$60 each
11-25	$54 each
26-50	$51 each
Delivery	Immediate

Wiring system permits design flexibility



Conflex, a wiring system of convoluted tubing and specially designed end fittings, terminates the tubing directly at electrical connectors. The system is offered in Teflon tubing with aluminum end fittings to accommodate all circular connectors conforming to MIL-C-5010, MIL-C-26842, MIL-C-26500 and NAS1599. Fittings are also available for rectangular rack and panel type connectors such as

New Components

DPX, DPA, DPD and D-subminiature.

The Conflex system offers all the advantages of a closed, sealed system, yet end fittings can be uncoupled for termination inspection or modifications, the manufacturer states. Additional conductors may be added and the entire system resealed by recoupling end fittings to the connectors. Significant space and weight savings are also claimed through deletion of connector end bells and potting, and reduction of insulation on wiring within the Conflex conduit.

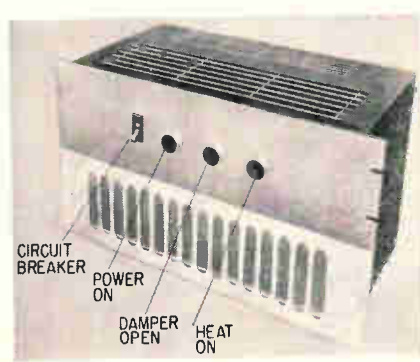
Conflex tubing is extremely flexible and can withstand continuous flexing. Long conductor life during flexing can be expected because the individual wires are free to find their own positions of minimum stress, according to the manufacturer.

Terminations of the tubing are made with a set of simple, lightweight aluminum fittings which form a tight mechanical seal. Panel and connector adaptors screw into basic fittings, as required, and special locking devices can be specified when vibration is a factor. Included in the range of fittings are units which allow for the termination of a small wire bundle in a larger connector shell size.

Teflon Conflex wiring systems can withstand severe environmental punishment.

Icore Electro-Plastics, 680 E. Taylor Ave., Sunnyvale, Calif., 94086. **[352]**

Heater-cooler for electronic systems



Model M2EB302526 cools or heats electronic systems in field installa-

all-digital weighing to .001 mg for $480.

The new Brinkmann Precision Balances are the very first all-digital Micro Torque Weighing Systems. Weighing speed is increased at least 50% over other (non-digital) systems, reading errors eliminated, and operator fatigue in serial weighings reduced substantially.

Scale ranges from 0-1 mg. (digital reading to 0.001 mg.) to 0-10 gm. (digital reading to 10.0 mg.) are available.

Mechanical taring is offered for the first time and permits instantaneous application of counterweights (to extend the scale range) or compensating weights (for pans and object holders) without risk of damage to the mechanism.

BRINKMANN INSTRUMENTS
CANTIAGUE ROAD, WESTBURY, N.Y. 11590/ED 4-7500

Circle 341 on reader service card

here's the key to keyboard reliability

PAT. PEND.

Reader Service # 488

Building your own keyboard? Then build in dependability, using NAVCOR KM Keys. Magnetically-actuated, sealed-in-glass switches insure environmental immunity and a life of over 100 million operations. Make/break bounce is less than 1 ms, and microphonic noise is eliminated by a protective hysteresis band. Exclusive human-engineering gives you key pressure of only 60 grams and an ideal 10° slope, for the finest electric typewriter feel.

KM Keys are available with contact closure or pulse output, with standard or special letters, numerals and symbols. Mounting is simple, on standard ¾" centers. Send coupon for details.

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Norristown, Pennsylvania

I'M INTERESTED! Please send me technical data and prices on your KM Keys and 1050 Keyboards.

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Title ______________________
Company ______________________
Address ______________________
City ______________________
State ______________________ Zip ________
Dept. EL-029

Keyed to the operator NAVCOR 1050 KEYBOARDS

PAT. PEND.

Reader Service # 489

Looking for answers to man/machine interface problems? Here is the solution . . . NAVCOR 1050 Keyboards with human-engineered KM Keys and unsurpassed design flexibility.

Need numeric or alphanumeric layout, special key arrangements, rack mounting or table top housing? They're all available in the 1050 Series, along with a choice of output signals, output codes, and other options, including error-free outputs at any typing speed.

Want to know how it's done? Then mail the coupon for full information on 1050 Keyboards.

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Dept. EL-029 • Norristown, Pennsylvania • 215-666-6531
DISTRICT OFFICES / Seabrook, Maryland • 301-577-2010
Garden Grove, California • 714-839-0232

Circle 213 on reader service card

New Components

tion, unheated military huts, unattended control stations and automatic telephone switching systems. The heater-cooler keeps an enclosure at an even 65° F with surrounding temperature in still air as low as 10° F. It also will flush and cool electronic cabinets when the remote thermostat indicates that cooling is required.

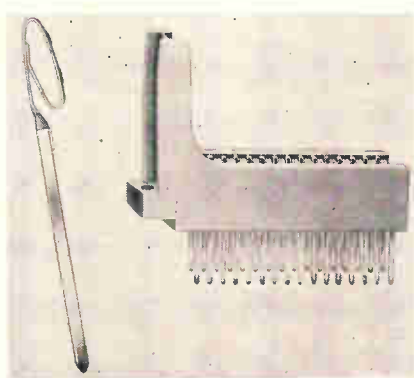
When moderate heating is required, internal dampers are changed to recirculate air within the enclosure without drawing in fresh air. Heat comes from internal electronic units. When substantial heating is required, an internal relay energizes a 1,000-watt electric heater to maintain a set temperature.

The front panel contains a circuit breaker to protect heating elements. Three pilot lights indicate when the power is on, the damper open or the heat on. A terminal trip on the rear is provided for power input and for 3-wire connection to the 2-step thermostat.

The MIL-SPEC centrifugal blowers and motors are said to provide continuous uninterrupted, service-free operation for thousands of hours. Power requirements are 115 v, 50/60 hz a-c. Dimensions are 10½ in. high x 19 in. wide x 10½ in. deep.

McLean Engineering Laboratories, 70 Washington Road, Princeton Junction, N.J., 08550. [353]

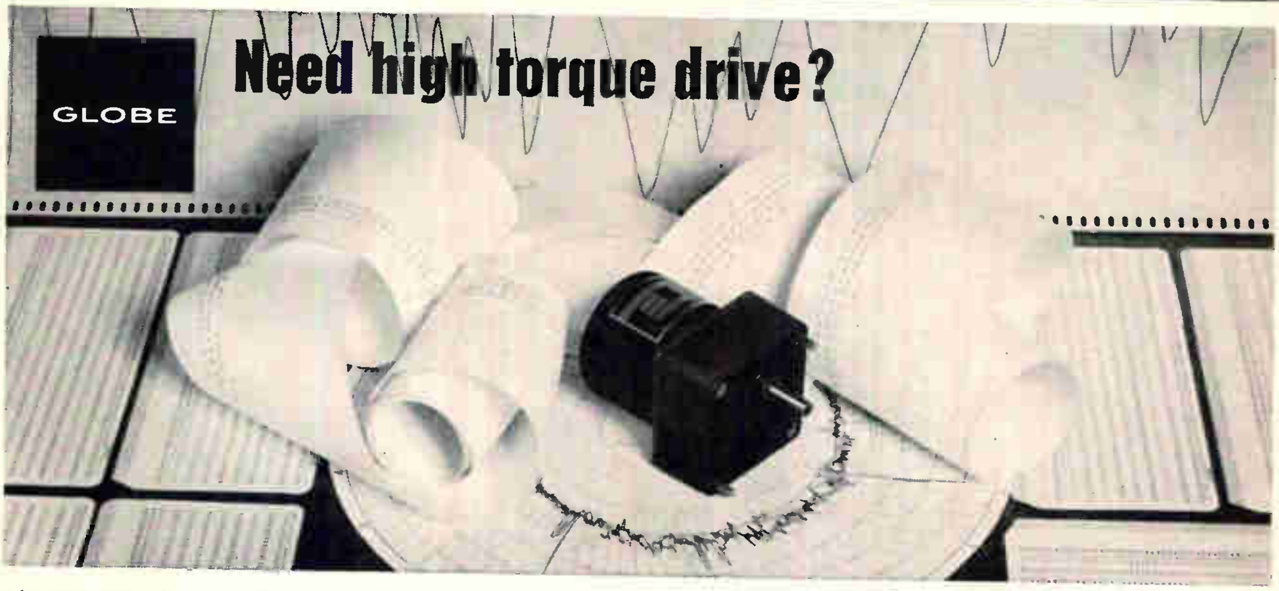
P-c connectors boast rigid terminations



A group of p-c board connectors, with 0.156-in. centers, combine the contact reliability of heavily gold-

GLOBE

Need high torque drive?



1/3 more torque—same size package. Don't be fooled by the small size of Globe's Type UCS Spur Gearmotor: It's power-packed, producing up to 10 lb. in. of torque from a package only 2⁵⁄₁₆" dia. by 3⅛" long. That's 33% more torque than same size look-alikes. If you manufacture motor-powered small equipment, check these features:

- hysteresis synchronous **or** induction
- 115 v.a.c., 60 cps **or** 230 v.a.c., 60 cps
- life-lubricated bearings (no oil holes)
- 13 standard reduction ratios, 6:1 to 1,800:1
- 1,800 and 3,600 rpm motor speeds
- interchangeable mounting

When power, compactness, economy, and unfailing dependability are important, try a Globe Type UCS Spur Gearmotor. Many units are in stock and can be shipped in 24 hours. Request Bulletin UCS.

Globe Industries, Inc.
2275 Stanley Ave., Dayton, Ohio 45404, U.S.A., Tel: 513 222-3741

Circle 296 on reader service card

Highest-quality copper-clad laminates for multi-layer printed circuits

Laminated plastics for multi-layer printed circuits have to be a special breed—very thin, made to exacting tolerances, uniform, free of voids and pinholes, suitable for etching and all soldering operations.

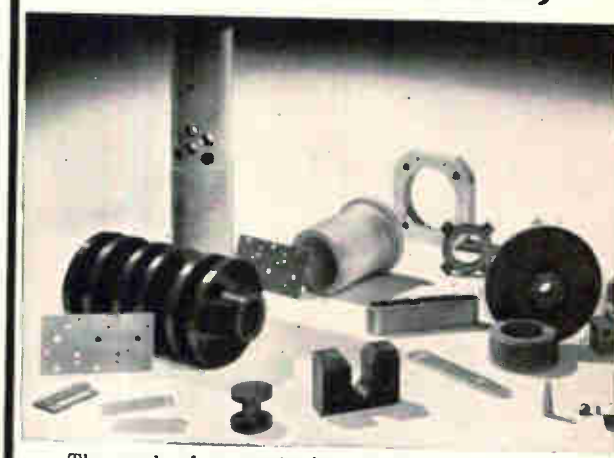
Synthane Thin Laminated grades G-10 and FR-4 are highest-quality fabric epoxy laminates. All produced under exacting clean room conditions. Write for leaflet. Synthane Corporation 36 River Road, Oaks, Pa. 666-5011 (Area Code 215).

Laminated Plastic Sheets, Rods, Tubes and Fabricated Parts

SYNTHANE CORPORATION S OAKS, PENNA.

Circle 297 on reader service card

Count on us for laminated plastics (Join the thousands who do)



Thousands of companies buy laminated plastic sheets, rods, tubes or fabricated parts from us. Why? Because Synthane is a *reliable* and continuous source of supply. In these days of strikes and shutdowns you need a source for laminated plastics you can count on. In our 37 years of operation *we have not lost one hour because of labor trouble.* 66% of our employees have had 10 years or more of experience with us. We have complete control of your part from raw materials through tools made in our own tool room to the finished part. We have a modern plant, completely fire-protected. And we maintain a tremendous inventory of materials ready to ship or process. Synthane Corporation, 36 River Road, Oaks, Pa.

Laminated Plastic Sheets, Rods, Tubes and Fabricated Parts

SYNTHANE CORPORATION S OAKS, PENNA.

Circle 215 on reader service card

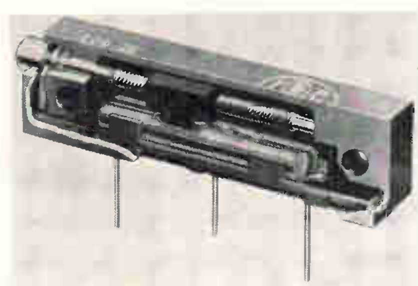
plated, flexing bifurcated contacts with the stability of a rigid 0.045-in. square-tail termination. The combination is achieved by using the appropriate flexible contact material required for the bifurcated contact section and forming it around a wire core to make the termination section of the contact. The 0.045-in. square-tail connector formed has the extremely sharp corners needed for reliable wire wrap attachment.

The manufacturer's selective process of gold plating reduces gold requirements in the contacts over 60% while maintaining contact reliability and durability of electrical performance. A 50-microinch gold plating is applied to the contact mating surface area while 10 microinches is applied to the remainder of the contact.

The connectors are designed to meet the exact wire wrap standards of such programed applications as systems control centers and data-processing equipment. Normal production handling will not bend the extremely rigid termination.

Cinch Manufacturing Co., 1026 S. Homan Ave., Chicago, Ill., 60624. [354]

Rectangular trimmer meets military specs



A precision rectangular wirewound trimmer, type 600, is designed to perform under environmental requirements of MIL-R-27208. A specially designed wiper block system, similar to the one on the company's type 400 series, effectively isolates electrical elements.

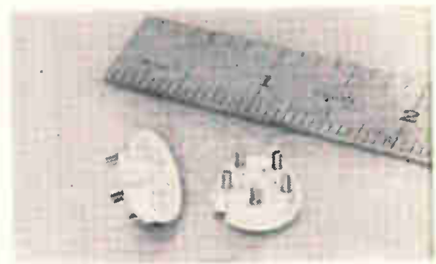
The unit is housed in a rugged, diallyl phthalate case and is offered with either printed-circuit

pins or Teflon-insulated leads.

Resistance values offered are 10 to 50,000 ohms, ± 5% tolerance. The units are rated at 1 watt at 70°C. Price is $3.56 each in lots of 100; delivery, 4 weeks.

IRC, Inc., 401 N. Broad St., Philadelphia, Pa., 19108. [355]

Transistor holder accepts 5 leads



A press-fit transistor holding device, designated RTC-0505SL, is designed to accept five-lead components contained in TO-5 packages. The component is mounted on the shoulder of the Teflon bushing while the leads are inserted into the five through holes.

On the back side of the holder, the leads are placed into mating slotted terminals and soldered into position along with additional components. Lugs are of brass, plated with silver and then gold flash. The insulation is of 100% pure Teflon in any of the 10 standard EIA colors for ease of circuit coding.

The company's circuit hardware have a common mounting method. They are press-fitted into prepared holes in a chassis. For this part, insertion tool B-42 is available for installation at production rates.

Sealectro Corp., Mamaroneck, N.Y., 10543. [356]

Reversible sync motor delivers high torque

A synchronous reversible motor has been developed for use in timing and drive applications. Series designation is 81300.

This motor delivers an output torque of 0.75 oz in. at 300 rpm di-

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Theta catalogs over 432 sizes and styles, with continuous motion, vernier control and 0.1° accuracy. Our new 28-page engineering catalog has all the details.

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Circle 308 on reader service card

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Because Cramer Lift-Lok is infinitely adjustable! Just lift the seat and stop at the most comfortable height. It takes less time than to read this sentence. Since fatigue is a critical factor in efficiency of seated workers, it makes good sense to provide tools that minimize fatigue. With Lift-Lok every worker can seek exactly his own efficient level. Available in four base types, steel, wood or plastic seats, contoured or flat, adjustable or flexible backs. To find out about the stools that qualify as production tools, write: V.P. Sales, Cramer, 625 Adams, Kansas City, Kan. 66105.

Industrial supplier inquiries invited.

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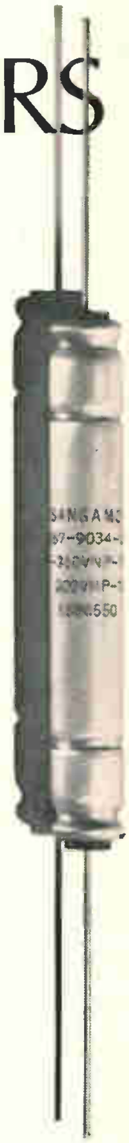
Circle 309 on reader service card

NEWS FOR DESIGNERS

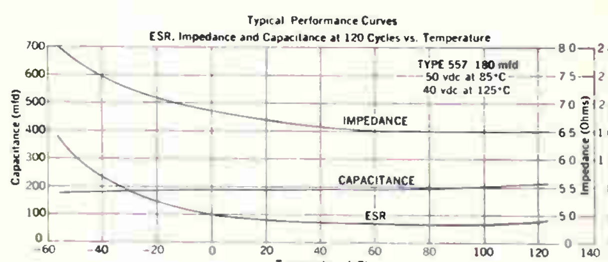


THE TEMPERATURE RANGE OF SANGAMO'S NEW TYPE 557 ALUMINUM AXIAL LEAD CAPACITOR IS

-55°C to +125°C

The new, wider range is accomplished by vacuum impregnating the capacitor with an exclusive Sangamo electrolyte. Built in accordance with MIL-C-39018, Type 557 provides these additional benefits:

■ Voltage ratings up to 250 VDC at 85°C or 200 VDC at 125°C. ■ Both positive and negative leads and tab connections are welded to prevent open circuits and high contact resistance. ■ Electrical characteristics comparable to tantalum foil capacitors.



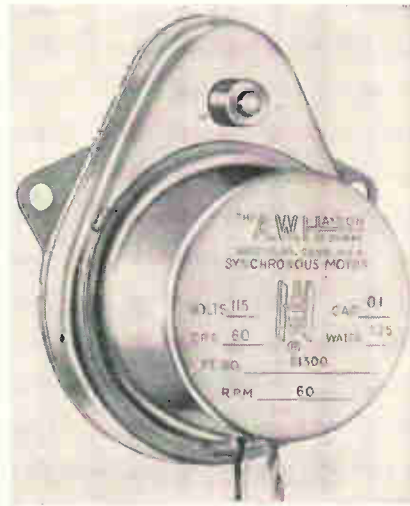
Write for Bulletin 2240 detailing Type 557 specifications.

SANGAMO ELECTRIC COMPANY
Pickens, South Carolina

EC66-3

Circle 219 on reader service card

New Components



rectly from the rotor, at an input of only 1.5 w. It will operate efficiently with an input as low as 0.2 w.

A phase-shift capacitor is used for single-phase operation, and rotation may be reversed by changing one connection. For two-phase operation, no capacitor is required.

Four standard gearing systems are available, providing torque up to 100 oz in. and output speeds from 300 rpm to one revolution per day. Nominal ratings are 115 or 230 v, 60 hz, but special models are readily available for variations in voltage, frequency, speed, torque and power input.

A.W. Haydon Co., 232 North Elm St., Waterbury, Conn., 06720. **[357]**

Thermoelectric module cools components

A thermoelectric module has been announced for temperature control and cooling of transistors, diodes, infrared detectors and other small components. Model H9-65 module has a maximum loaded heat pump capacity of 3.9 watts, an unloaded

New Components

temperature differential of 65°C and requires 9 amps maximum current.

Printed-circuit techniques have been applied to metalized ceramic end caps allowing electrically insulated module surfaces with higher breakdown voltage, improved cooling capability and more rapid response. The H9-65 is 3/16 in. thick and 9/16 in. square with facility for direct attachment to the component. Smaller custom units are available for placing directly into a diode or transistor case and attachment directly to the semiconductor chip.

Price is $24 for a single unit. Availability is from stock.

EG&G, Inc., 160 Brookline Ave., Boston, Mass., 02215. [358]

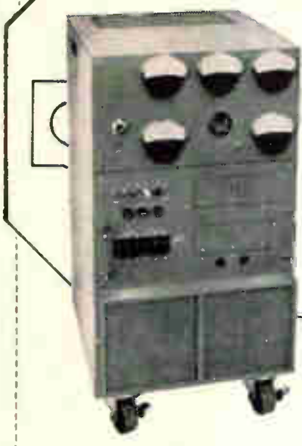
Galvanometer relays with direct switching

A line of plug-in, modular galvanometer relays is being manufactured with a new switch design. The microsensitive relays now feature direct switching with 5-watt capacity up to 125 v a-c or d-c. The switches are electrically isolated from the coil assemblies. Switch life is one million operations with resistive load. The pull-in dropout resolution is within 1.5% of coil deflection.

The new switch design allows direct control of the highest powered scr's or multicontact external relays. Sensitivities as low as 2 μa or 1.5 mv are available, eliminating the need for external electronic amplifiers.

Sensitak Instrument Corp., 531 Front St., Manchester, N.H. [359]

DRAMATIC REDUCTION



formerly 77"h. x 33"w. x 33"d.

now only

29"h X 17"w X 17"d

(5 KW Audio Power Amplifier)

All other models similarly reduced . . . (but in size only!) For instance, 10 KW Model, formerly 78" h. x 78" w. x 36" d., now only 48" h. x 34" w. x 24" d. CML Audio Power Amplifiers produce tremendous power in the smallest packages. Wide frequency range. Low distortion. Ideal for CW and pulsed operation, acoustic testing, vibration testing, plasma tubes, ion propulsion engines. Perfect for marine installations. All units with wide range of output impedance taps. Air-cooled and vapor-cooled units. Full power available into low power factor loads. Call or write today for details.

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48

Circle 312 on reader service card

New plant site?

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SIZE DOESN'T COUNT. Of 66 electronics and electrical producers in Erie County, 45 employ under 50. Big and small benefit from ample supplies of skilled talent . . . raw material . . . cheap power . . . and easy access to both U.S. and Canadian markets. For full details write Erie County Executive Edward Rath, Erie County Hall, Dept. E-1, Buffalo, N. Y. 14201. He'll send the new book that tells why Erie County offers the best profit opportunities for your new plant.

The future is here on the Niagara Frontier

(Buffalo and Erie County)

Circle 313 on reader service card

Solid-Status Report 9/66

NF. < 12 db at 10 Kc i-f frequency. For the backward diode alone?

No...for the whole receiver.

Up to now the exploitation of the state-of-the-art noise figures of Philco's backward diodes has been held back by the problems of designing a matching amplifier at audio i-f frequencies. Not any more. We now make available the P301, a compatible low-noise amplifier, to offer you a package with over-all receiver noise figures below 12 db at X-band for an i-f frequency of 10 Kc.

The P301, designed specifically for use with the L4150/60 series of backward diodes, is available in a hybrid microcircuit configuration which permits packaging the entire amplifier within the P955 holder assembly.

Consider for a moment what this little package can do for you:

You can now use the relatively simple CW Doppler receiver configuration for applications that were previously impossible because of the high noise figures of conventional diodes.

And in addition to the low noise characteristics you get inherently greater reliability and temperature stability. Philco backward diodes are available with operating temperatures to 150°C.

If you're a designer of CW Doppler mixers, altimeters, radiometers, spectrometers, etc.—you'll want more information on this new Philco package. Call, write or wire Spring City Operation Marketing Department. Or circle the Reader Service Card. (Phone: 215-948-8400.)

Microelectronics Division
SANTA CLARA, CALIF. · LANSDALE, PA. · SPRING CITY, PA.
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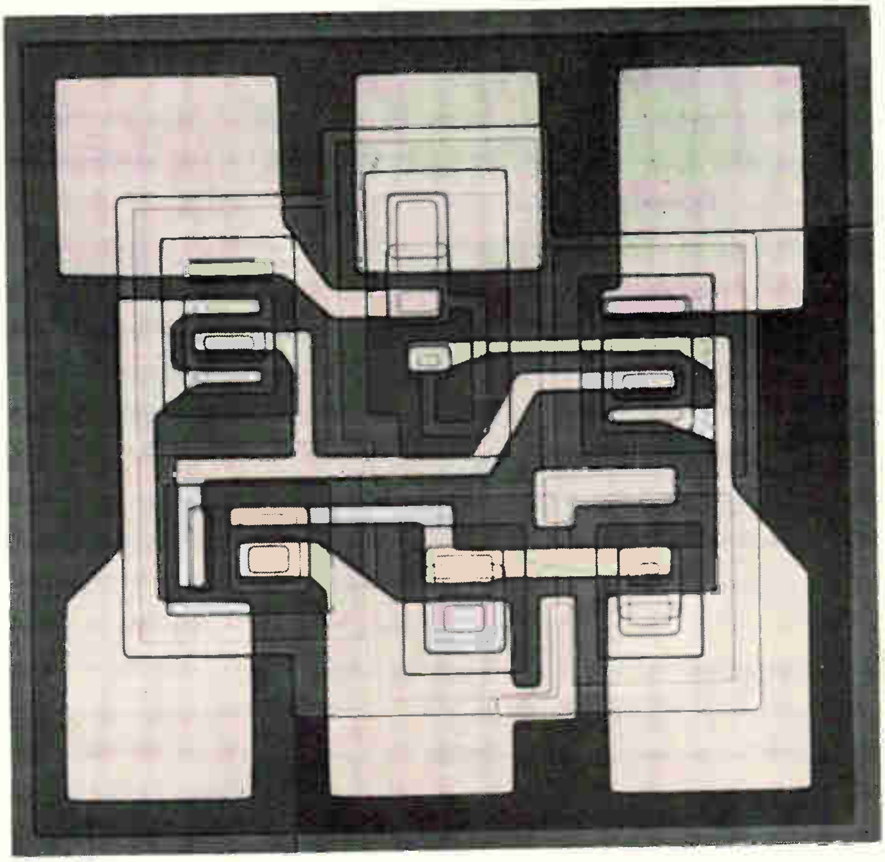
Circle 223 on reader service card

New Semiconductors

An IC amplifier for everybody



A low-cost integrated circuit amplifier that is a jack-of-all-trades has been announced by Fairchild Semiconductor, a division of Fairchild Camera & Instrument Corp. Before it is packaged, the new integrated circuit is only 20 mils square—smaller than 90% of all transistors now available, says Fairchild.

The radio-frequency/intermediate-frequency amplifier comes in three versions for three markets—military (A703), industrial (A703C), and consumer (A703E). All three versions come off the same production line, marketing manager Jack Gifford explains, but the military version is subjected to stringent testing, the industrial version undergoes somewhat less testing and the consumer version, still less testing. All three versions are packaged in sealed, 6-lead TO-5 metal cans.

The high cost of testing is reflected in the prices of the units. For quantities of 100 and more, the military model is $9.75 each; the industrial, $3.00 each. No price has been set for the consumer unit, but Gifford reports that "it will be competitive with the cost of equivalent circuitry made of discrete components." And it should be noted that Fairchild also lists television sets as a potential market for the solid state amplifier.

Fairchild gives the following applications for its silicon planar linear device:

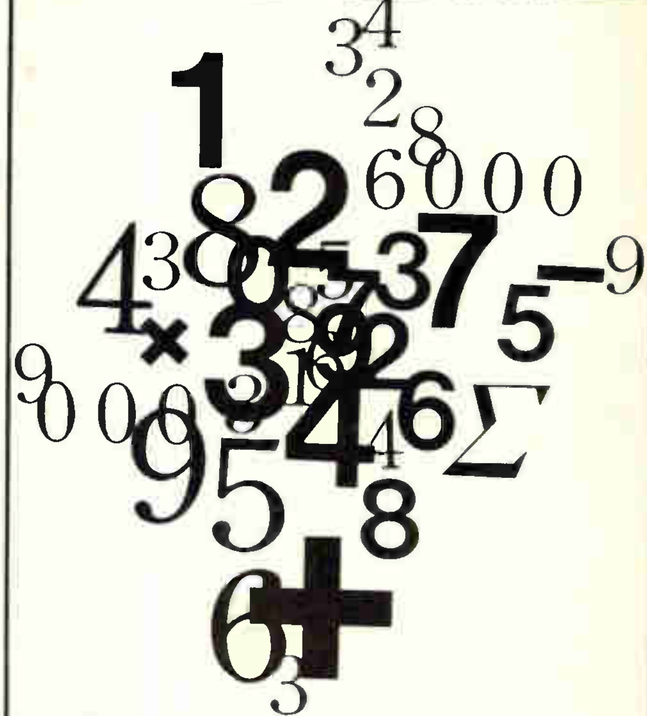
- R-f power amplifier to 150 megahertz. At 100 Mhz, the amplifier has a typical noise figure of 7 decibels and a power gain of 20 db.
- R-f, video logarithmic amplifier for radars. It limits without saturation, Fairchild says, hence it minimizes overdrive recovery problems and pulse distortion.
- Local oscillator in amplitude-modulated and frequency-modulated receivers to 150 Mhz. Input and output impedance characteristics are stable over large signal-range excursions, giving low-drift operation.
- A-m and f-m i-f amplifiers from 5 kilohertz to 100 Mhz. The self-

Great editorial is something he takes home

(What a climate for selling!)

Electronics

A McGraw-Hill *Market-Directed* Publication
330 West 42nd Street, New York, N.Y. 10036

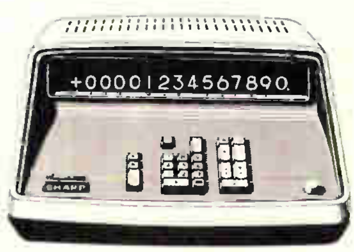


$+00001234567890_n$

$$ds^2 = \sum_{i,j=1}^{n} g_{ij}\, dx^i dx^j$$

IN CONTROL

Quietly, efficiently. When office traffic mounts up. That's when you'll be glad you invested in COMPET CS-20A ELECTRONIC DESK CALCULATOR.
And these unique features show why— a special mechanism to ensure that no two keys can be pressed simultaneously • instant calculation up to 14 digits • +, – and decimal symbols displayed automatically • no breakdowns, even when misused • and plug-in circuits for easy maintenance. COMPET ELECTRONIC DESK CALCULATOR CS-20A ... used in modern offices the world over.



COMPET Model CS-20A

Sharp **SHARP**

...to the point of perfection

HAYAKAWA ELECTRIC CO., LTD.
Osaka, Japan
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178 Commerce Road Carlstadt, New Jersey

biased device has a reverse gain of 0.002 milliohms providing good isolation between stages. Parasitic capacitance is at a minimum.

- Voltage-controlled oscillator in phase lock loop receivers.

The specifications listed below are for the military version. Some of these parameters are relaxed in the industrial and commercial versions. For example, the military operating temperature range is −55°C to 125°C; the industrial and commercial, 0°C to 70°C. Listed by military, industrial and commercial versions, the typical input conductance at 5 Mhz is 0.20, 0.35 and 0.33 millimhos; the typical output capacitance is 2.0, 2.0 and 2.6 picofarads and the maximum output conductance is 0.04, 0.05 and 0.1 mmho.

Specifications

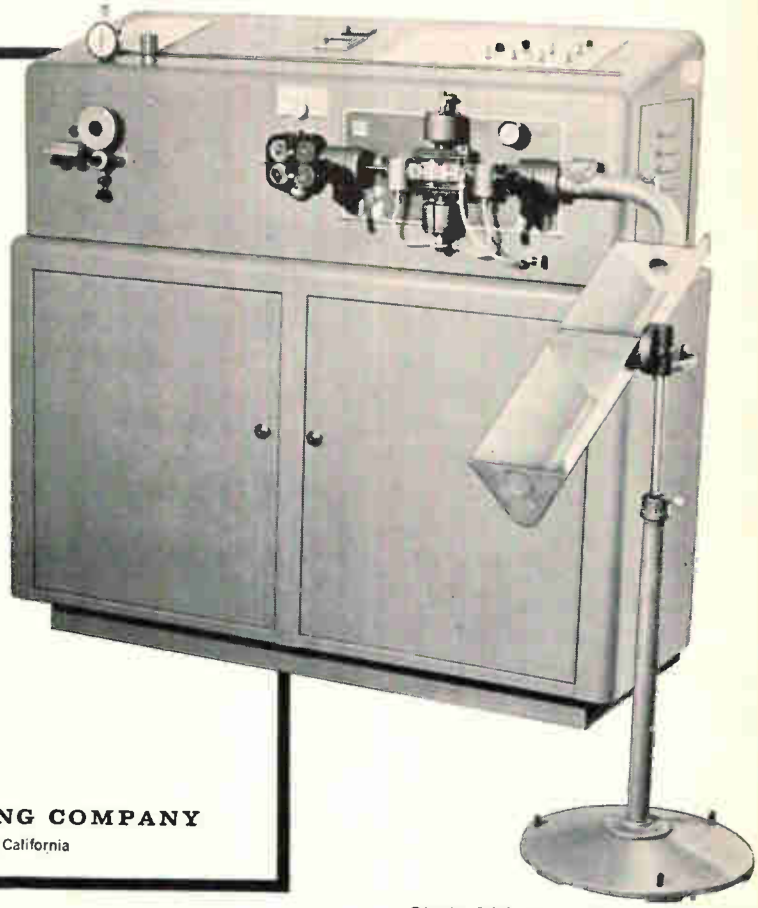
Supply voltage	20v, max.
Output collector voltage	24v, max.
Voltage between input terminals	±5.0v max.
Internal power dissipation	200 mw, max.
Peak-to-peak output (input = 400 mv oms)	3.2 mamp min.
Output saturation voltage	1.7 v, max.
Input capacitance	9.0 pf

Fairchild Semiconductor Division, Fairchild Camera and Instrument Corp., Mountain View, Calif. [361]

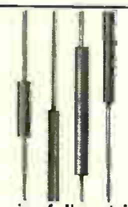
Industrial DTL IC's in molded packages

Digital integrated circuits in the 930-series DTL configuration are available in a molded plastic package. The package was announced

For solderless wrapped connections, a new automatic wire stripper



The Model 841 Solderless-Wrap Wire Stripper offers high speed preparation of 20-30 AWG solid conductor wire for insertion in a wrapping tool. It cuts wire to lengths of 1" to 50' and fully strips 1/8" to 1 9/16" from each end without nicking or scraping, whether the insulation be PVC or something as tough as Mil-Ene, Teflon or Kynar. With optional assemblies, you can also use it for shorter stripping of 10-32 AWG stranded wire. Write for information on this and other Eubanks wire strippers.



Wire is fully stripped, ready for wrapping tool.

Remaining insulation can be short as ½".

Eubanks ENGINEERING COMPANY
225 West Duarte Road • Monrovia, California

Circle 314 on reader service card

What's NEW in laminated plastics?

Synthane FR-16!

It's a lower-cost flame-retardant, glass epoxy laminate

Designed specifically for printed circuits used in computers

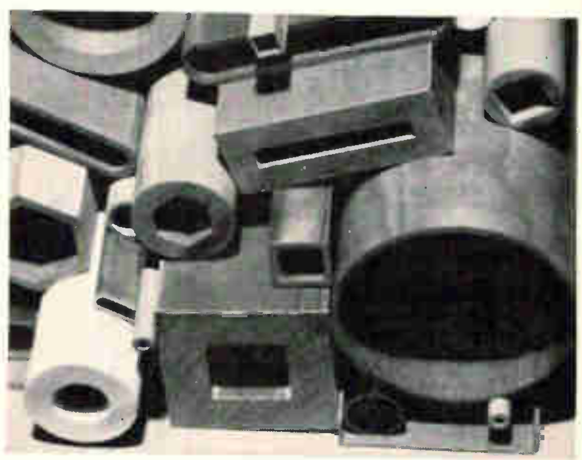
Write for FR-16 Engineering Bulletin to Synthane Corporation 36 River Road, Oaks, Pa. 19456.

SYNTHANE

Laminated Plastic Sheets, Rods, Tubes and Fabricated Parts

Circle 315 on reader service card

Does a laminated plastic tube always have to be round?



Not on your life. Synthane laminated plastic tubing may be round, square, oval, rectangular, round inside and hexagonal outside or vice versa. "U"-shapes, "L"-shapes, and multi-shapes. You name it and we have it in stock or can make it for you. Many grades, sizes. In standard round tubes—the widest ranges of sizes in the industry. Round tubes 3/32" ID to 26¼" OD, in lengths of 36" to 96". Synthane Corporation 36 River Road, Oaks, Pa.

Laminated Plastic Sheets, Rods, Tubes and Fabricated Parts

SYNTHANE CORPORATION OAKS, PENNA.

Circle 227 on reader service card

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Reprint order form

For listing of reprints available see the Reader Service Card.

Communications Satellites Part I

Send me . . . . reprints of Key no R-89 at 75¢ each.

For reprints of previous special reports fill in below:

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(For prices, see Reader Service Card)

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in March for the manufacturer's series 74TTL integrated circuits.

The 930-DTL family, designed for operation in the industrial temperature range (0°C to 75°C), has been designated series 15830N. The complete family of 11 DTL circuits is molded packaged, including dual, triple, and quadruple gates, buffers, expanders, binary elements and a one-shot.

The transfer-molded plastic unit features 14 plug-in pins on 100-mil centers for fast, economical flow-soldering and wire wrap techniques. The two rows of pins are 300 mils apart, providing sufficient space to run ground and power-supply strips directly under the body of the package. The rigid plug-in pins are adaptable to high-speed automatic or manual insertion.

The solid molded construction provides maximum protection against shock and vibration. Excellent heat dissipation (70°C/watt in free air) results from full contact of the molding compound around the silicon bar. The package meets or exceeds MIL-STD-202C, Method 106B for moisture protection.

Typical gate propagation delay for series 15830N is 25 nsec; power dissipation, 5 mw; fan-out, 3; d-c noise margin, 750 mv; and supply voltage, 4.5 to 5.5 v. Integrated circuits in the 930-DTL configuration are also available in the standard TO-84 14-pin flatpack for operation over the full military temperature range of —55° to +125°C.

Series 15830N circuits are priced an average of 25% less than previous packages.

Texas Instruments Incorporated, 13500 North Central Expressway, Dallas, Texas. **[362]**

Variable attenuators made of monolithic IC's

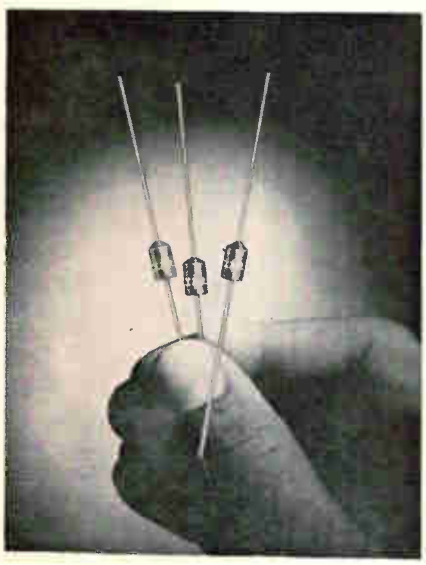
Variable electronic attenuators consist entirely of tiny monolithic integrated circuits. The controllable-loss circuits were designed for use in automatic gain control circuits in electronic equipment. They operate on a new principle that permits control of the gain of an amplifier without changing its operating parameters. This greatly diminishes the chance of distortion or of phase shifts in amplifiers.

Type ULX-0101 and ULX-0102 agc blocks can attenuate signals by up to 60 db at frequencies as high as 65 Mhz. The circuits are insensitive to power supply variations. In automatic gain control, there is virtually no distortion for a constant output of 1 mv rms over a 60-db attenuation of the input signal. The maximum input voltage is 1 volt of signal.

The ULX-0101 requires only 2 mw of control power and has a rated circuit dissipation of 110 mw, while the ULX-0102 integrated circuit attenuator has a circuit dissipation of 65 mw but requires 36 mw control power.

The units are being offered in both hermetically-sealed TO-5 style transistor cases and in flatpacks.
Sprague Electric Co., North Adams, Mass. **[363]**

Zener diodes serve as voltage regulators



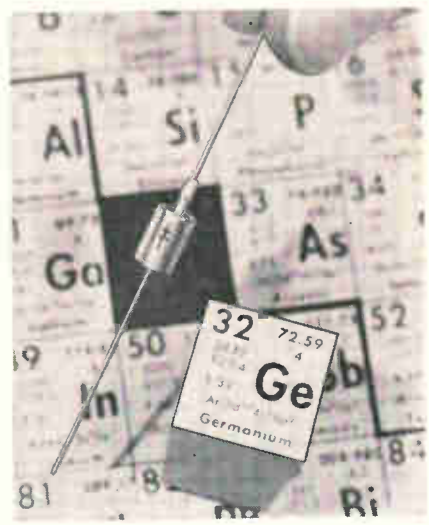
A line of zener voltage regulators, the molded LZM series, offers a low cost, insulated package claiming excellent resistance to moisture, thermal shock and vibration in the standard DO-27 outline. Voltage ratings are from 3.3 to 15 v with maximum current ratings from 300 ma to 60 ma.

The molded 1-watt zener diodes

are designed as regulators and protection devices for control, regulating and monitoring functions. Industrial applications include process control, instrumentation, switching, measurement, modulation, energy conversion, energy generation and energy transmission.

Price range is from 60 cents to $1.10 in lots of 100 to 999.
International Rectifier, 233 Kansas St., El Segundo, Calif., 90245. [364]

Germanium rectifiers minimize power losses



Extremely low forward voltage drop (0.45 v for low power loss) plus high rectification efficiency (75% at 100 khz) are exhibited by a series of germanium rectifiers. Both performance characteristics of the 1N91-93, 1-ampere device series are claimed to be 50% better than comparable low-current silicon rectifiers and are improvements over the ratings of a previously available, limited-source, Jedec-registered, 1-ampere germanium type.

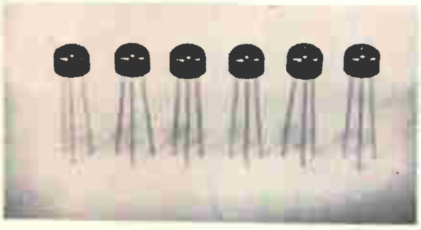
At ambient temperature of 75°C, output current of 0.1 amp, the rectifiers will block 80% of their 100-, 200- or 300-v peak-inverse voltage ratings. Up to 55°C, output current to 1 amp, 100% reverse blocking is sustained.

Applications can be found in low-power circuits where voltage losses must be minimized, such as low-current battery-charging and amplifier/voltage-biasing circuits.

The 1N91-93 series is packaged in the DO-13 flangeless case.

Motorola Semiconductor Products Inc., P.O. Box 955, Phoenix, Ariz. [365]

Epoxy-encapsulated silicon transistors



Low-cost, epoxy-encapsulated silicon transistors have been announced for large-volume consumer (radio-tv), computer and industrial applications. They are priced as low as 15 cents per unit in large production quantities.

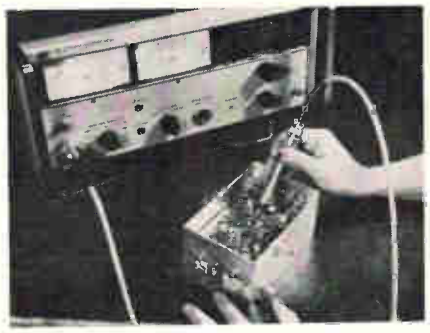
The new line covers the entire frequency spectrum from d-c to uhf and includes six medium power amplifier/switching devices registered with the EIA, for applications in computers and industrial instruments. The full line also includes other device families for small-signal audio amplifier, high speed switching, low-noise/low-level, r-f/i-f amplifier and medium-power general-purpose applications.

The manufacturer's registered EIA devices include: 2N4140 and 2N4141 (npn), which are electrical equivalents of the industry-standard 2N2221 and 2N2222; the 2N4142 and 2N4143 (pnp) which are electrical equivalents to the 2N2906 and 2N2907; and 2N4227 and 2N4228, which are npn and pnp complementary devices featuring tighter gain specifications (75 to 150 at 150 ma) than the other four types mentioned.

The devices are packaged in an epoxy-encapsulated ceramic case, with the three leads in a 100-mil circular configuration equivalent to the conventional JEDEC TO-18. This facilitates direct mechanical plug-in replacement of metal-can units in sockets or p-c boards already tooled to accept TO-18 transistors.

General Instrument Corp., Semiconductor Group, 600 W. John St., Hicksville, N.Y., 11802. [366]

Instrument measures impedance and phase



R-f vector impedance meter model 4815A measures the complex impedance of any circuit element or component in a single test by a single probe. Over the frequency range 500 khz to 108 Mhz, the instrument presents impedance directly in ohms on one front-panel meter, phase angle directly in degrees on another. A single, thin probe excites the test element and simultaneously measures its impedance and its phase angle. No supplementary equipment is required.

An internal oscillator supplies a low-level exciting signal through a 5-ft cable to the probe; a unique sampling, automatic gain control loop maintains the current constant at 4 μa. At the same time, the voltage response of the tested element is sensed and converted by a second sampling channel, located within the same probe, to read out directly in impedance. A phase detector monitors the difference between voltage and current channels to yield the phase angle of the impedance vector.

The built-in continuous-tuning oscillator, the frequency of which is displayed clearly alongside the readout, requires no balancing or data interpretations; it has controls only for band and frequency.

The impedance-reading range of the 4815A is 10 ohms to 100,000 ohms; phase angle range is 0 to 360° in 2 ranges, 0 ± 90°, and 180° ± 90°. Resolution is better than 2°.

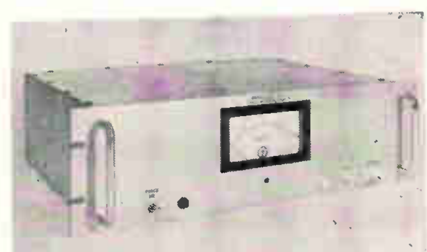
Accuracy of the instrument is fully specified. Frequency accuracy is within ±2% of reading. For impedance, accuracy is within ±4% of full scale $\pm\left(\frac{F}{30\text{ Mhz}} + \frac{Z}{25{,}000\text{ ohms}}\right)\%$ of reading, where F is the frequency in Mhz and Z is in ohms; the reading includes probe residual impedance. Accuracy for phase angle measurements is within $\pm\left(3 + \frac{F}{30\text{ Mhz}} + \frac{Z}{50{,}000\text{ ohms}}\right)^\circ$.

The manufacturer says model 4815A applications can determine the self-resonance point of capacitors, the series and parallel resonance points of crystals or the characteristics of high-frequency transformers and transducers.

Model 4815A is priced at $2,650. Delivery estimates are expected to be 30 to 60 days.

Hewlett-Packard Co., 1501 Page Mill Rd., Palo Alto, Calif., 94304. **[371]**

Phase meter/computer is highly accurate



This phase meter/computer measures a-c signal bursts as short as 700 μsec to 0.1% accuracy. Sample and hold circuitry maintains readings as long as 1 minute.

Phase angle is displayed on a 5- x 2½-in. rectangular mirrored scale D'Arsonval meter calibrated from 0° to 360° full scale. A phase reversal switch allows 0° to be at midscale on the meter, eliminating ambiguous readings for lead-lag measurement. An analog output from 0 to 3.6 v d-c provides a capability for driving chart recorders or digital voltmeters.

Phase comparison between the two a-c input channels is made by a very high speed flip-flop comparing the output of two Schmitt triggers. Zero crossing detectors substantially eliminate input signal distortion.

Sample and hold circuitry includes a chopper-stabilized operational amplifier bounded by diode networks driving into a precision polystyrene capacitor with extremely low dielectric hysteresis. Selected field-effect semiconductor devices are used to eliminate the need for relays to perform the sample and hold and reset functions, allowing very rapid rise times and very narrow sampling apertures.

The unit operates on 115 v a-c line, 50 to 60 hz and includes all necessary regulated power supplies and all silicon transistors. Size is 5¼ in. high x 17 in. wide x 13¼ in. deep for rack mounting. Weight is 18 lbs. Price is $1,895; delivery, 8 to 10 weeks.

Systems Electronics, Inc., 6132 State Road, Cleveland, Ohio, 44134. [372]

Tiny accelerometer with titanium housing

A miniature accelerometer, model 4336, features a titanium housing for low mass with high strength. It weighs 2 grams yet has a nominal sensitivity of 4 mv/g or 1.2 picocoulombs/g and a capacity of 300 pf with standard 4-ft connecting cable.

The unit can be used at temperatures up to 250° C and is completely waterproof in construction. It is said to be ideal for vibration measurements on small, low mass structures, for shock testing where minimum waveform distortion is essential and for very high frequency vibration measurements.

Compatible with most accelerometer signal conditioners and mounting methods, the 4336 satisfies most general-purpose applications requiring the use of a miniature low mass vibration transducer.

The 4336 is available as a single unit with low-noise cable and comprehensive calibration data at $105 or as a "five-pack" at $475 (model 4356). It is also available with mounting accessories in a fitted mahogany case at $135 (model 4316).

B&K Instruments, Inc., 5111 W. 164th St., Cleveland, Ohio, 44142. [373]

Rapid and accurate low-resistance tester

A quality control device has been developed that allows rapid testing of resistances in a 0.001 to 0.2-ohm range to determine if a prespecified limit is exceeded. The VT-1160 is designed to provide inexpensive yet accurate production line tests of such things as connectors, spot welds, printed circuitry, semiconductor rectifiers, etc. These tests can be performed at rates of one per second.

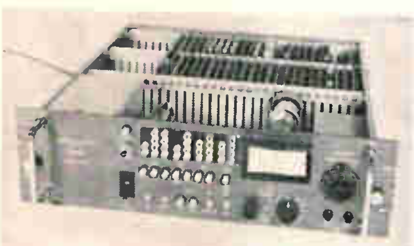
Semiautomatic in operation, the device simply requires the successive positions of two probes on the parts being tested, signaling reject parts by means of an audible alarm. The tester automatically switches on a self-contained test current after the probes have been positioned on a part, but only after proper contact has been made, eliminating any arcing with subsequent probe damage or arc marks on the part under test.

When proper contact is made, the operator immediately hears a low tone. If the tone stops, the resistance is acceptable; but if the tone changes to a distinctly higher pitch, the resistance of the reject part has exceeded the preset maximum.

Calibration of the instrument for the test limit is done by first dialing the desired test current on an ammeter (5 to 25-amp range), then setting the maximum allowable voltage drop (and thus the maximum allowable resistance) on a digital dial, which is graduated in millivolts over a zero to 1.0-v range. The ammeter reading is accurate to ±2%, and the maximum voltage setting is accurate to ±0.3% or 2 mv, whichever is greater.

The VT-1160 operates on standard current and requires 300 watts. It is available from stock at $600. The Vari-Tech Co., 546 Leonard St., NW, Grand Rapids, Mich., 49504. [374]

Frequency standard generates time code



Model 19000 is a frequency standard and time code generator designed for applications where frequency stabilities as great as 1 part in 10^9 per day and a power consumption of as low as 7 watts are required. In addition, the system can provide 115-v, 60-hz frequency-regulated power at levels of 10, 100, or 1,000 v-a.

The standard system generates the time code and calibration programs required by short-period and long-period seismographs, and the Vela Uniform code for use in magnetic tape recording applications. Alternatively, the system can be modified to generate other time programs such as those adopted by IRIG and NASA.

The system can be furnished with either a binary-coded decimal or decimal in-line readout of time in days, hours, minutes and seconds. Other outputs supplied are frequency-regulated square wave trains at 100 khz, 10 khz, 100 hz, 60 hz, and 1 hz.

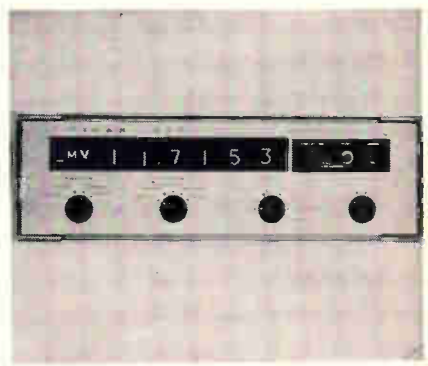
Precision frequency standards of 1 part in 10^7 or 1 part in 10^9 per day are available. To expedite setting up the frequency standard, a low-level signal at the internal standard frequency is available for heterodyning with a radio-derived standard frequency.

A time comparator employing a built-in oscilloscope is optional.

Model 19000 is available as a rack-mounted unit on a standard 5¼ x 19-in. panel or as a suitcase-sized portable unit. Prices range from $4,250 to $6,500, depending on options. Delivery is 90 days after receipt of order.

Teledyne Industries, Geotech division, 3401 Shiloh Road, Garland, Texas. [375]

Integrating dvm measures to 1,000 v



An integrating digital voltmeter, model 520, measures low-level transducer outputs from strain gages, load cells and thermocouples directly without additional amplification. The 10-mv full-scale range provides readings with 0.001% (0.1-μv) resolution. Other ranges measure full-scale signals to 1,000 v.

Guarded input and active integration provide 150-db common mode noise rejection at all frequencies, with infinite rejection of power-line frequencies and multiples. Automatic overranging is provided on all ranges except the 1,000-v range and automatic selection of the correct input range is available with a plug-in autoranging accessory.

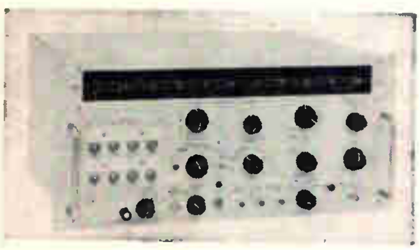
Usable as a bench or rack-mounted test instrument, the 520 is also suited for data acquisition systems where multiple inputs are scanned and output is read out by a high-speed printer, tape punch, or by similar devices. Output is 8421 BCD for reading, decimal location, polarity and function. Complete remote programing through contact closures provides maximum flexibility for data-logging or production-measurement applications.

Model 520 is also a frequency counter, offering two operating modes: direct counting of frequencies from 10 hz to 2 Mhz; and period measurements (1, 10 and 100-period averages) for high-accuracy measurement of frequencies from 10 hz to 25 khz.

The unit measures 5¼ x 16¾ x 22 in. and weighs 45 lbs. Power requirement is 115/230 v, 50/400 hz; approximately 110 w.

Vidar Corp., 77 Ortega Ave., Mountain View, Calif., 99041. [376]

Sweep generator spans 100 khz to 100 Mhz

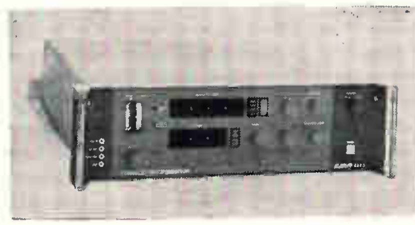


Sweep generator model 610 covers the frequency band from 100 khz to 100 Mhz. Its frequency stability, minimum harmonics and spurious signals and minimum incidental f-m set it apart from all other broadband sweepers in this range, the manufacturer says.

This generator has accurately set power level, calibrated attenuation and a variety of modulation capabilities. Another feature of the model 610 is its ability to independently set the start and stop frequency rather than to sweep around a center frequency. This feature previously has been avail-

able only on microwave sweepers in the frequency range above 1 Ghz but has not been available on sweepers below this range, according to the manufacturer. Price is $1,975.
Wiltron Co., 930 East Meadow Drive, Palo Alto, Calif., 94303 [377]

Tunable discriminator for 100 hz to 1.5 Mhz



A tunable f-m discriminator now available is capable of being controlled manually or by computer. Model 4140 is intended for f-m telemetry instrumentation systems where it can be used for system checkout, on-line, and backup applications. It provides ±1% center-frequency accuracy, 0.1% linearity and has an internal tape-speed-compensation delay network. It can be rack mounted or supplied as a portable unit.

The 4140 accommodates all telemetry subcarriers from 100 hz to 1.5 Mhz. Center frequencies are selected by thumbwheel switches or by remote signal. A rotary switch controls the choice of deviation ratio—±7.5%, ±15%, ±30%, or ±40%. When it is used in an automatic data reduction system, all operational parameters can be controlled remotely by digital program control or computer.

Output filter cutoff frequency is selected by a switch, the 3-db point being adjustable from 1 hz to 300 khz. The roll-off characteristics available are 42, 36, or 18 db/octave. The filter is switchable from a constant-amplitude (Butterworth) to a constant-delay (Bessel) characteristic.

The tape-speed compensation improvement of wow and flutter for the 4140 is in excess of 26 db.
Electro-Mechanical Research, Inc., Box 3041, Sarasota, Fla., 33578. [378]

Communications terminal plus computer

A communications terminal with two bonuses—some computational ability and a basic pricetag of $9,600—is now available from a new company, Business Information Technology, Inc.

The basic 480 Processor has one read-write channel and includes a teletypewriter with its own paper tape punch and reader. The 8-microsecond, random-access, magnetic-core memory contains 1,024 eight-bit bytes. One additional bit in each byte permits parity checking for error detection and another bit serves as a word mark, for identifying the division between variable-length words.

As a communications terminal, the 480 can be connected to a wide variety of devices, such as card punches and readers, magnetic discs, drum and tape storage, analog-to-digital converters, digital-to-analog converters, and so forth. The manufacturer also sells printed-circuit boards for designing interfaces to other company's peripheral equipment.

As a small computer, the machine can execute a stored program of arithmetic and logical operations on either data from the communications link or from the local peripheral devices. The arithmetic can be either binary or decimal. The operations are performed through an accumulator that can be varied in length to fit the specific problem.

A total of six devices, including the teletypewriter, may be connected to the read-write channel, but in most applications, only one can address the computer at a time. An exception would be in phototypesetting applications, where the computer could work fast enough to justify and hyphenate the output from six teletypewriters operating simultaneously. Up to three additional channels can be added at a cost of about $2,000 each. The channels can be addressed simultaneously with computation, for a total of five independent operations simultaneously. A priority interrupt feature is available as an option.

The memory can also be expanded incrementally to a total of 65,538 bytes. A faster cycle time—2 microseconds—is also available.

One possible application for the

New Subassemblies

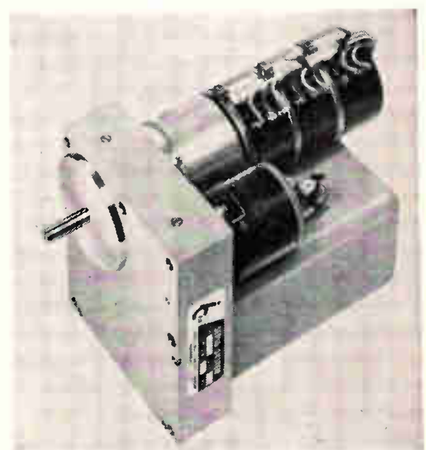
basic processor is in schools to teach the fundamentals of digital computers. When the students weren't using the machine, it could perform various accounting and programing tasks.

Other applications are in industrial process control, either directly or by relaying the process data to another computer for analysis and control. The processor can be used in engineering and scientific laboratories for small-scale computation. Business applications include replacing a tabulating installation or as peripheral equipment for a larger computer.

Delivery is 75 days.

Business Information Technology, Inc., 3 Erie Drive, Natick, Mass. 01760 [381]

Servos convert voltage into shaft rotations



The 900 series pot repeaters are unitized, precision servoassemblies that convert an input command voltage into a shaft rotation. The compact packages include servomotor, gear train, feedback pot, servoamplifier and power supply. Operation is directly from the 117-v line, and the servos are completely self-contained, requiring no additional components.

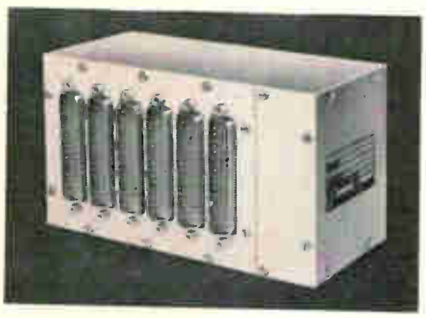
This versatile line includes 48 standard models, with customer options on: 60 or 400 hz line power; d-c, 60 or 400 hz command voltage; single, three or 10 turn feedback potentiometers; and four motor to pot gear ratios. In addition, the customer may specify any extra computing pot sections required.

With the output shaft provided, the servo can drive a digitizer, synchro, counter, chart table, or dial. With additional pot sections it performs as a servomultiplier or function generator. The small package size permits up to four servos across a 19-in. rack panel. These standard units cut development time and cost when incorporated into a larger system, and are built to MIL-E-6400.

Price is approximately $920, and normal delivery is six weeks.

Industrial Control Co., Central Ave. at Pinelawn, Farmingdale, L.I., N.Y., 11735. [382]

Data multiplexer features stepper drive



A Step/Scan data multiplexer now available uses an aerospace-proven sampling switch with stepper-motor drive for more reliable contact closure, simplified synchronization and easy programing. The unit lowers cost per-channel in process data scanning, data logging, computer time sharing, plant-wide monitoring and similar applications.

Stepper drive improves contacting reliability because wipers move quickly from segment to segment, then remain stationary during data-sampling period. Wipers have multiple redundant contact surfaces to further enhance reliability.

Phase and speed synchronization of several physically separated multiplexers requires only a simple master clock and a reference pulse generated once each frame. Dependence on motor speed controls is eliminated.

Programed scanning is equally simple. The stepper motor can be programed to drive quickly past undesired data points, or to dwell longer on points of special interest. Both functions are accomplished

New Subassemblies

with simple digital logic circuitry.

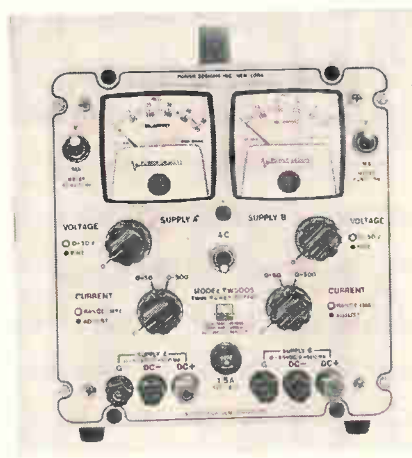
One standard Step/Scan multiplexer can contain up to six independent contact rings, each with up to 90 contact segments—providing a total of 540 input data channels. As many as 10 multiplexers can be combined into a coordinated system that provides fully synchronized scanning of 5,400 data channels. Standard scanning rate is 100 channels/sec.

Contacts are rated at 10 ma, 10 v d-c. Contact resistance is less than 1 ohm. With maintenance every 2,500 hours, a life of 10,000 hours is guaranteed.

The standard package meets aircraft instrumentation standards and weighs under 24 oz. for 540-channel capacity. Flexible printed wiring connects commutator segments to circuit-card jacks on the outside of the case. Other connector and packaging configurations are available.

Fifth Dimension Inc., Route 206 Center, Princeton, N.J., 08540. **[383]**

Dual power supply in a single package



Model TW5005 power supply features current ranges with automatic current-limit and meter-scale transfer. This all-silicon semiconductor unit provides two independent sources of 50 v, 500 ma in a single package. Each supply may be operated as a constant-voltage source with adjustable current limiting, or as a constant-current source with adjustable voltage compliance.

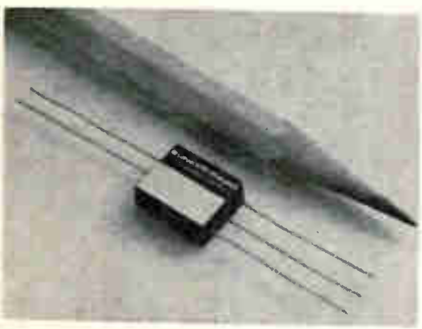
Each source has a regulation better than 0.005% plus 1 mv at both front and rear output terminals, a peak-to-peak ripple less than 1 mv, a temperature coefficient better than 0.02%/°C and a stability better than 0.02% plus 10 mv per 24-hour period after warm-up. Provisions are incorporated for external voltage or current programing.

The sources present an impedance less than 0.1 ohm in the constant-voltage mode and more than 200,000 ohms in the constant-current mode. Resolution is better than 1 mv and 0.25 ma, and the recovery time is less than 50 μsec for a step-change in rated load (1 μsec rise time) from 10 to 100% or from 100 to 10%.

The model TW5005 operates from a 105- to 125-v, 57- to 440-hz input. It weighs 17 lbs. Price is $297.50; delivery, 3 to 4 weeks after receipt of order.

Power Designs Inc., 1700 Shames Drive, Westbury, N. Y. [384]

Voltage regulator is suited for aerospace



A lightweight, microminiature, solid-state voltage regulator is especially adaptable to aerospace applications. Model BR-801 has a regulated d-c output range of from 10 to 25 v and is extremely stable; the output varies only 15 mv with a 10-v input variation.

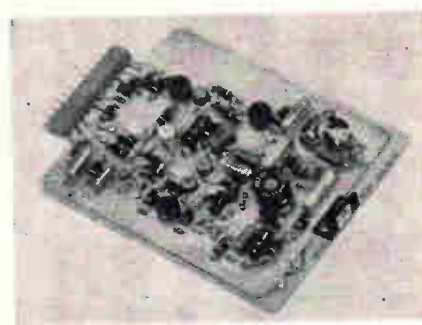
The regulator compares the output voltage to a temperature-compensated zener reference voltage and provides regulating current to a series-regulated transistor at a rate greater than 10 μa per millivolt of error. It can be used to provide up to 75 ma of load current with a single power transistor. Using a Darlington pair, load currents over 1.5 amps can be achieved.

The regulator is 0.5 in. long, 0.4

in. high, and 0.19 in. wide. Its weight is 2 grams. Absolute maximum ratings are: storage temperature, —65°C to +200°C; operating temperature, —55°C to +85°C; input d-c voltage, 40 v. The BR-801 is priced in quantities of 1 to 9 at $65 each, 10 to 24 at $59.50 each; 25 to 99 at $53.10 each; and 100 to 499 at $35.10 each.

The Bunker-Ramo Corp., 8433 Fallbrook Ave., Canoga Park, Calif. **[385]**

Video amplifier works in crt systems



Model VA548 is a d-c coupled, 10 Mhz, all-silicon, solid-state amplifier featuring plug-in convenience and low cost. It is designed for application in any cathode-ray tube or storage-tube display system where up to 40 volts of grid drive is required.

The unit is a feedback amplifier to provide optimum linearity and gain stability, and may be directly coupled to the crt grid or a-c coupled to a d-c restoring level. The amplifier is fully compatible with all other modular display system components manufactured by the company.

Availability is three weeks after receipt of order.

Beta Instrument Corp., 377 Elliott St., Newton Upper Falls, Mass. **[386]**

H-v power supply for lab and industry

A line of d-c power supplies has been introduced to provide low-cost high power for laboratory and industrial applications. It includes units with voltages up to 100 kv.

Pictured is the model BF20-300,

whose output is continuously variable from 0 to 20 kv d-c with currents from 0 to 300 ma at either positive or negative polarities. Over-voltage and over-current protection are provided by the use of sensitive, fast-acting meter relays. The unit contains complete controls and safety features.

Priced at approximately $3,000, the BF20-300 can be delivered within 30 to 60 days.

Cober Electronics, Inc., 7 Gleason Ave., Stamford, Conn., 06902. **[387]**

Miniature delay line computer memory

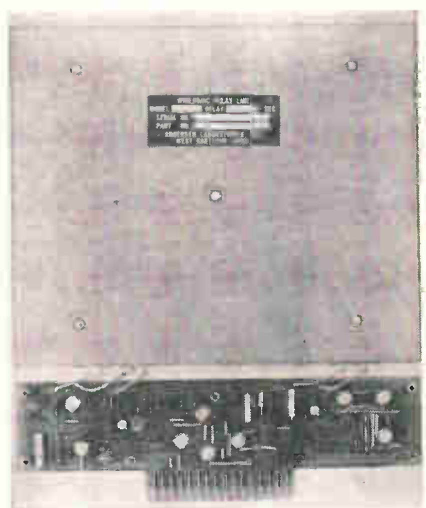
A series of miniature delay line computer memory modules has been developed. Called Delcoms, they are designed to be conveniently assembled into a multichannel memory stack. The MA2064 memory illustrated consists of eight MS2064 Delcom channels, each capable of storing up to 2,000 bits of data in a 3.5 x 6.37 x 4 in. package.

Each MS2064 Delcom contains a magnetostrictive delay line and microelectronic read, write and logic circuitry. They are supplied with delays of up to 1,000 μsec and for use at bit rates of up to 1 Mhz in the return-to-zero, and 2 Mhz in the non-return-to-zero modes.

Inputs and outputs are designed to match into Fairchild Micrologic flip-flops (913) and each module consumes less than 0.3 w of power. Individual MS2064's are easily mounted to p-c boards. Their size is 3.5 x 6.37 x 0.5 in., and weight is 11 oz.

Price of the MS2064 is $350 in small quantities, and delivery is 4 to 5 weeks after receipt of order.
Computer Devices Corp., 6 W. 18 St., Huntington Station, N.Y. [388]

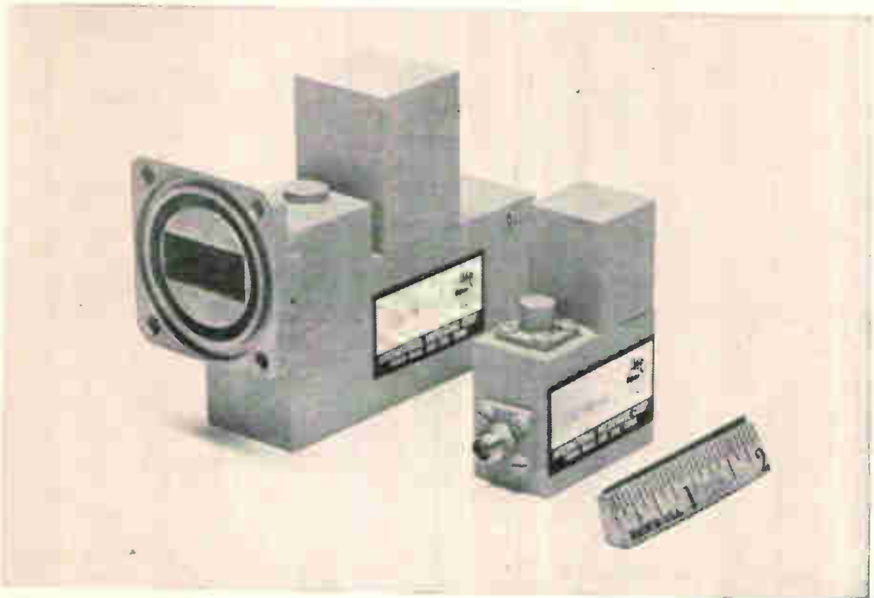
L-f serial memory can store 20,000 bits



A series of low-frequency serial memories has been introduced for use as buffer memory systems between high-speed computer and low-speed periphery equipment, in typewriter systems programed to type statistical information for storage in computers and in video-screen display.

The device offers storage capacity of up to 20,000 bits and data rates up to 2 Mhz. Logic levels are available from 3 to 12 v (±3 v to ±12 v) of either polarity. The system also offers both micrologic and fully transistorized circuitry.
Anderson Laboratories, Inc., 501 New Park Ave., West Hartford, Conn., 06110. [389]

Stable noise source via satellite



Developmental work on a space satellite amplifier has resulted in a small, stable tunnel diode noise source, believed to be the first on the market. It is only a few inches in each dimension, has an output relatively independent of temperature and can operate for over 250 hours from a single flashlight battery. The manufacturer, the International Microwave Corp., Cos Cob, Conn., a subsidiary of Microwave Associates, Inc., says the device can supply incoherent, white noise over any 20% bandwidth in the frequency range from 2 to 12 gigahertz.

Although not a direct replacement for highly temperature stable devices, such as the argon noise lamp, the tunnel diode source can be used where low power and small size are more important than overall accuracy. Norman Chasek, president of International Microwave, says the source is small enough to build into test equipment for monitoring the receiver noise figure of long-range radars, troposcatter systems and satellite ground terminals. The gain of negative resistance devices such as parametric amplifiers will not be changed whether the unit is on or off because the voltage standing wave ratio is the same in either state; consequently noise measurements are simplified. Chasek says the device is also suitable for portable test units since it is light and does not generate high spurious signals that need shielding.

The units supply noise powers 15 decibels above that developed by a resistor at room temperature—the basis for noise comparison. If the unit's temperature is stabilized by a small oven, the noise power will be stable to ±0.5 db over an ambient temperature range from −55° to 85°C. Without an oven, noise power variations can be held to ±1 db over a temperature range from −20° to 50°C.

Other combinations of power, bandwidth and temperature stability can be supplied. In general reducing the noise power requirements allows the units to operate over an extended temperature range for a given bandwidth.

The primary source of noise in the unit is the shot noise developed by electrons crossing the junction of a tunnel diode. Shot noise is independent of the diode's junction temperature. Chasek says there is a temperature-dependent noise source within the diode, but that it only accounts for 10% of the power output.

Since the noise power developed across the tunnel diode's junction is only about 4 db above that developed by a resistor, it is necessary to amplify the noise to obtain the 15 db outputs. This is where a stable tunnel diode amplifier is valuable. Developed for a satellite system the company was bidding on, the amplifier has extremely good gain stability with temperature. As a result the amplifier produces only a minor degradation in the temperature stability of the noise, while resulting in higher noise power outputs.

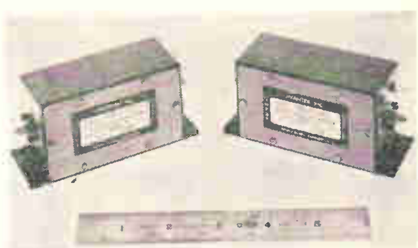
The waveguide unit at the left in the photograph on page 247 is designed for operation at 8.5 to 10 Ghz, while the coaxial unit on the right is for 5.9 to 7.0 Ghz.

Specifications

Unit	Tunnel diode noise source
Bandwidth	20%
Frequency range	2 to 12 Ghz
Excess noise level (referenced to resistor's noise at room temperature)	15 db
Gain stability	
With oven	±0.5 db from —55° to 85°C
Without oven	±1.0 db from —20° to 50°C
Voltage standing wave ratio	less than 1.2:1
Price	$1,500
Delivery	60-75 days after receipt of order

International Microwave Corp., a subsidiary of Microwave Associates Inc., River Road, Cos Cob, Conn. [391]

Telemetry preamps cover L and S bands



Telemetry preamplifiers, models AM-1435 and AM-2200 cover 1.435 to 1.550 Ghz and 2.2 to 2.3 Ghz respectively. They are designed for the new microwave receivers now on the market. Noise figures are 5 and 6 db respectively. Both models feature all solid state components, rugged military construction, miniature size and low power input.

Minimum gain is 25 db; power output at 1 db gain compression point, 0 dbm; power input, —15 v d-c at 25 ma. Size is 4 x 1.4 x 2 in.; weight, 10 oz.

Because of "almost infinite" shelf life, the ability to provide extremely close gain matching, a mean-time-between-failure of 200,000 hours and no fine grain noise variations, the units are said to offer substantial advantages over twt amplifiers.

The accompanying illustration shows, on the left, the full octave wide AM-1000, a companion to the telemetry series. It covers 1 to 2 Ghz, with 6-db noise figure and 25-db gain, and is designed for electronic warfare, radar and communications systems.

Avantek Inc., 3001 Copper Road, Santa Clara, Calif. [392]

Traveling-wave tube delivers 30 watts

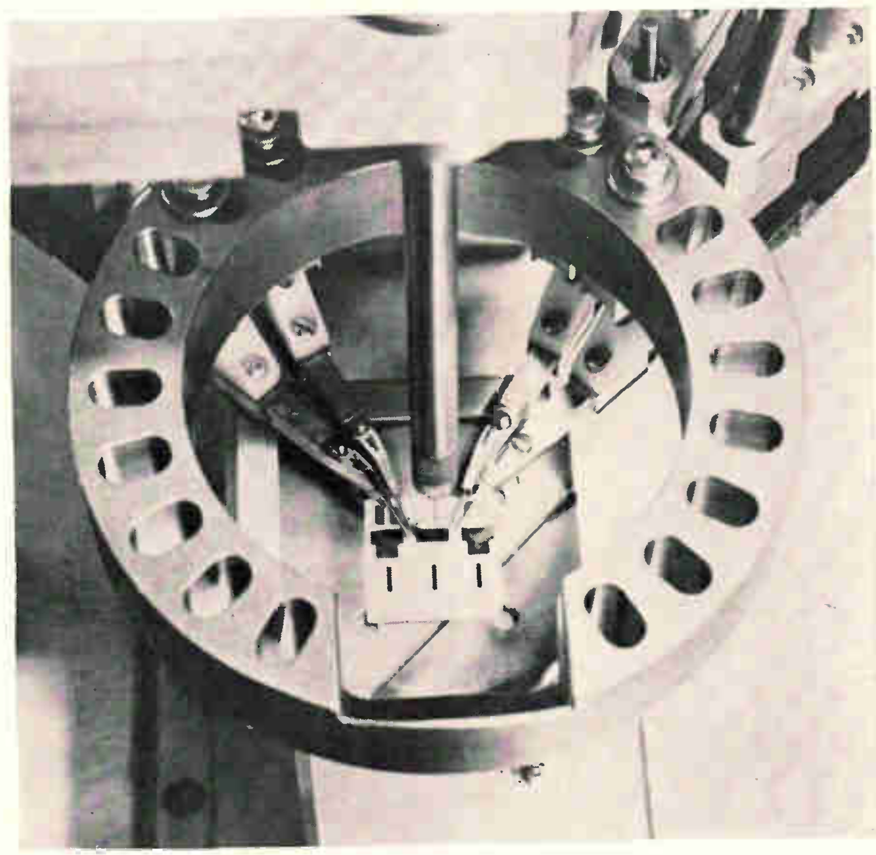
A traveling-wave tube is available with 30-w output in the 3.6-to-4.2-Ghz band. The W7/5G tube was designed for 1,800-channel microwave links.

With a typical gain of 43 db at a working output of 20 w, saturated output is 30 w. In an existing system, the W7/5G can be substituted for a 40-db-gain tube with an output of 10 w and, using the same drive power, the W7/5G will produce twice the previously obtained output.

The W7/5G operates in a rugged, periodic-permanent-magnet mount, type WM110A. Incorporated in the mount are: r-f input and output waveguide connections (a choice of WG12A or WR229 is offered); mechanical alignment; deflection and matching adjustments; tube ejection control at either end of the mount; a convection cooler, and facilities for easy field replacement of tubes.

ITT Electron Tube division of International Telephone and Telegraph Corp., Box 100, Easton, Pa., 18043. [393]

Quick trims, either thick or thin



Sandblasting—the popular but inexact term for abrasive trimming of thin- or thick-film resistors for hybrid integrated circuits—can now be done with an off-the-shelf automated system. In the past, users of the Airbrasive equipment made by S.S. White Co. had to prepare custom setups to trim at high production rates.

Up to 1,000 resistors an hour are trimmed by the new system, demonstrated last month at Wescon. Instrumentation added to the basic equipment allows it to adjust a resistor's value in 1 to 3 seconds, depending on the size of the resistor and the amount of material to be removed. Removing some of the film narrows the resistive path or lengthens a U-shaped resistor, raising the resistance value. The finished tolerance can be less than 1%.

The first model, AT-701, trims one resistor at a time. Future models will trim several resistors simultaneously.

The resistor is positioned under tungsten-carbide probes, held by an adjustable, 18-position mounting ring. The initial value is measured by a precision, four-wire resistance-limit bridge. If the resistance is within an acceptable initial range, the resistor is automatically trimmed until a preset stop value is reached. Trimming is done by a jet of fine alumina powder propelled by gas through a tiny nozzle. The nozzle is moved by a slide mechanism started by a trim command and stopped by a stop command from the instrumentation. After a time delay, the resistance is again checked and the resistor is accepted if the value is within the programed tolerance.

If the initial value is outside the specified range for trimming, the machine does one of two things. It immediately tests the resistor for acceptance or rejection if the resistor value is above the trimming range. Or, it rejects the resistor if the value is too low for trimming.

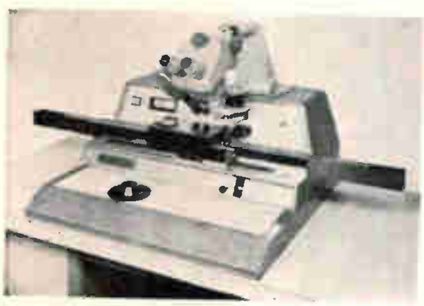
Four trimming ranges from 0 to 10 kilohms through 0 to 10 megohms can be selected. The tolerance range is 0 to ±11% with a resolution of 0.1%. Stop value is programed as a negative percentage of final value, from 0 to 11.1% with a resolution of 0.01%. The position and travel limit of the nozzle-slide mechanism can be set electronically; motion is accurate to within 95 microinches per inch of travel at 68°F.

Trimming stages are displayed on the control panel. The operator can manually override the programed trimming cycle, adjust the time delay before final test and take manual readings of the final value.

Price of the system will vary with tooling for holding and positioning the resistor substrates, but the basic price is $17,000. The company expects to begin deliveries in January.

Industrial Division, S.S. White Co., 201 East 42 St., New York, N.Y. 10017 [395]

Nailhead bonder produces IC's fast



High-speed production of flatpack and TO-can integrated circuits is achieved by the model 1136 thermocompression nailhead bonder. The unit has a production rate of 125 finished IC's per hour with 24 bonds per circuit (3000 bonds per hour).

All flatpack or can headers are automatically handled from storage rack through heater station and returned to a storage rack for further processing. Model 1136 utilizes a stacking system for the rack and carries 10 strip carriers in a storage rack. The elevator system presents each carrier as it is required instantly, precisely and ready for passage through the automatic transfer system with the heat column on command of the operator.

The preheat time is relatively

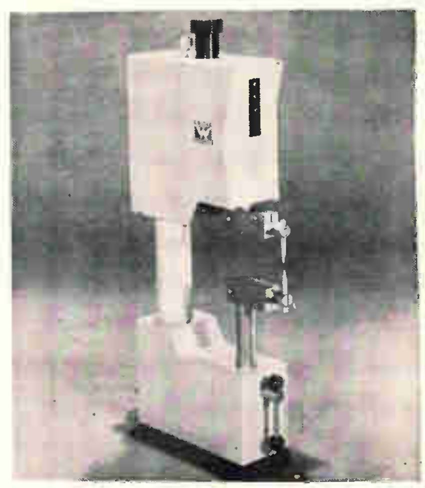
slow on the new bonder, thus assuring minimum glass seal failures. The racks are hard stainless steel with a heat insulating shield to prevent heat from affecting both performance of the operator and of machinery.

The bonder is provided with a new trouble-free wire handling system as well as a time-saving pigtail puller. After bonding, pigtails are automatically removed during the flame-off cycle. Heads can be changed rapidly.

Temperature of the headers in the heat tunnel is controlled within ±2°C up to a maximum temperature of 400°C. While 117 v, 60 hz operation is standard for the bonder, the unit can be furnished for 220 v, 50 hz operation on special order.

Micro Tech Mfg. Inc., 703 Plantation St., Worcester, Mass., 01605. **[396]**

Heavy-duty weld head still has precision



A lean profile, vertical weld head assembly is designed for heavy-duty, precision resistance welding operations that require larger weld configurations. Model 2-129-01 is said to offer the largest electrode clearance and throat depth currently available in addition to a total flexibility of adjustment for both electrodes and the weld head. This design can accommodate outsized or complex configurations. To increase production versatility, the head is detachable from the base, permitting fixturing capability.

Force settings are direct readouts on the front-mounted scale to enable close process control. Force range is adjustable from 8 oz. to 100 lbs. Maximum energy rating is 500 watt seconds.

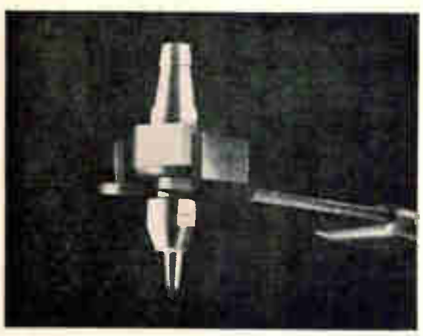
A force sensor in the weld head discharges energy from the power supply the instant that preset electrode force is applied to the weld piece. Electrode arms travel on a newly designed raceway that assures a lower minimum force setting, while also increasing sensitivity and improving follow-up characteristics. Rotation or misalignment at high force settings which could cause "wiping" or "skidding" weld characteristics is eliminated. Electrode indexing is also featured.

The lean profile not only makes the head more flexible as a unit, but also increases flexibility for clustering many weld heads for special production requirements.

Electrode stroke is 1 in., and throat depth on the assembled unit is $7\frac{1}{4}$ in. Maximum vertical work opening is $5\frac{3}{8}$ in. The unit measures $20\frac{3}{4}$ in. high x $3\frac{3}{16}$ in. wide x 10 in. deep.

Weldmatic Division/Unitek, 950 Royal Oaks Drive, Monrovia, Calif., [397]

Bonding capillaries made of heated glass



Heated glass capillaries achieve fast, effective thermocompression bonding of microcircuits and interconnects. Designed for standard tapered magnetic holders without modification or adaptation of existing equipment or fixtures, the manufacturer says the new heated glass tips provide significant operational savings. Initial cost is said to be 30% to 55% less than for metal capillaries.

A number of other operating ad-

vantages are also offered, many exclusive with glass. Glass is naturally smooth; there are no burrs, machine marks, or other roughness as with metal. This inherent smoothness and the "stepless" taper of the bore assures continuous, unbroken wire feed. The result is less down time and higher production rates.

Another advantage of glass is its transparency. Clogging dirt can be quickly spotted before it causes troublesome galling and binding. In addition, transparency permits visual threading.

When not in use, the capillary lies horizontally. The tip does not contact the work surface.

Tip bores can be as small as 0.0005 in. in diameter and are accurate to ±0.0001 in. Tip outside diameters are held ±0.0005 in.

Specialty Glass Products, Inc., 2557 Wyandotte Road, Willow Grove, Pa., 19090. **[398]**

Hot melt dispenser for wax potting

A piece of semiautomatic machinery has been designed for potting electrical components in wax. The temperature of the wax is automatically maintained at up to

300°F by thermostatic control in an electrically heated, stainless steel 6-gallon hopper; rotating stainless steel agitator blades keep the molten wax in motion to assure uniformity of flow.

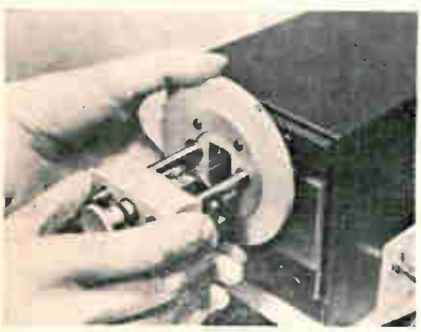
Operation consists of inserting an electrical/electronic assembly into a heated fixture and mechanically clamping it in position. A remote foot switch actuates the machine; however, the assembly is automatically preheated for a preset time to assure full potting of the cavity. A pneumatic lift mechanism raises the jig into the dispensing position and the component is accurately potted under pressure with a uniform volume of wax.

Pottings may be accomplished at rates of 180 per hour with shot volumes of 21 grams. Shot volume is easily adjusted by setting a calibrated dial and may be varied between 5 grams and 150 grams.

Approximate price, less fixture tooling, is $4,900.

G. Diehl Mateer Co., 776 W. Lincoln Highway, Wayne, Pa., 19087. **[399]**

Machine straightens component leads



A lead-straightener, model 1110, for transistors, integrated circuits and other components features a rapid-action lead positioner that expedites the routine production handling of components. Components are dropped into a carrier and two combs advance to segregate the leads at the component base. The operator combs the leads apart for their total length, advances the ends into the Delrin receiving insert of the motor-driven lead straightener, retracts the combs, and advances the component leads into and out of the lead straightener. The component is then dropped into the receiving tray and the tool is ready for reloading.

The component leads touch no metal but are gently flexed between one orbital and two stationary Delrin inserts. A variety of inserts can be installed to accommodate the leads of various components such as 8-lead TO-5, 4-lead TO-18, and 10-lead TO-5 semiconductor packages. Standard combs available on current production models of the lead positioner are for 8-lead TO-5 devices, but special combs for other configurations will be developed as required.

Model 1110 component lead straightener, including the new lead positioner, is priced at $850.
Macronetics, Inc., 220 California Ave., Palo Alto, Calif. [400]

Microsoldering system uses projection optics

Full color, direct viewing of the entire soldering operation is featured in a microsoldering system. The 20-power, direct viewing screen eliminates the eye fatigue associated with binocular microscopes and permits close supervision and quality control of the entire production process, according to the manufacturer.

With microheating capability ranging from thin-film soldering to high-temperature silver soldering, this system offers complete production capability in a single integrated unit. Also included in the system is an automatic electrode hold-down control that prevents the operator from lifting the electrodes during the solder cooling phase. Rapid positioning and angular alignment are maintained with an X-Y workblock system.

The completely automatic soldering cycle is controlled with an actuator switch located on the positioning workblock, eliminating the problem of foot and hand coordination and allowing the operator to position the work and cycle the unit by hand.

Price is $1,990, with four week delivery available.
Browne Engineering Co., 2003 State St. Santa Barbara, Calif. [401]

Wire stripper operates thermally

A thermal wire stripper, model TWC-1 Stripall, is supplied complete with a solid-state temperature control unit. Temperatures of the insulation-stripping blades are adjustable from 100° to above 1,700°F, adapting this Stripall model to a wide range of insulation materials, including Teflon and other high-temperature wire coverings. Blades heat to full temperature in less than two seconds. The unit is valuable in manufacturing military and NASA standards, where thermal wire stripping is required.

The temperature-control unit of the TWC-1 plugs directly into an electrical outlet, eliminating workbench clutter. Otherwise, the unit is completely self-contained, using no remote transformers or power supplies.

The entire stripping function, including removal of the wire covering, is accomplished in one quick continuous motion. A gage stop, adjustable to the size of the wire in process, prevents the Stripall's blades from exerting any pressure on the conductor. This eliminates nicks or wire damage. Furthermore, the stripper does not heat the wire and thus protects the remaining insulation.

Stripped wire is entirely oxide-free and ready for soldering. No insulation melts into wire strands. The blades themselves are high-strength alloy to provide long service.

The TWC-1 is priced at $79.95.
Kinetics Corp., 410 S. Cedros Ave., Solona Beach, Calif. [402]

High-temperature ceramic coating

Ceramacast 505, a high-temperature casting ceramic, is being used as a spray or brush coated insulation coating for metals such as stainless steel and aluminum to offer thermal insulation and improved oxidization resistance to temperatures as high as 3,000°F.

It is a high alumina coating material that is applied by mixing with water and then brushing or spraying on the metal to be coated. In a typical production procedure for coating aluminum, the metal is preheated to 500°F, and the Ceramacast is sprayed on the heated base metal. The Ceramacast gels immediately and forms a hard coating on the base metal with no further curing required.

In addition to applications as thermal and oxidization resistant coatings for high-temperature work, the Ceramacast offers some possible use as a dielectric base for thick-film circuits.

Aremco Products, Inc., P.O. Box 145, Briarcliff Manor, N.Y., 10510. [406]

Foamable polyethylene insulates co-ax cable

An expandable compound, MPE27, consists of a patented combination of ingredients based on low-density polyethylene. As the pellets are extruded, gas inside the compound uniformly expands the polymer into a structure of small, closed cells.

Foamable polyethylene is used to insulate coaxial cables found in community antenna television systems and radar installations. Since the gas cells afford excellent electrical insulation, only about half as much foam compound is needed in comparison with conventional polyethylenes.

MPE27 is said to be substantially less sensitive to changes in extruder operation with improved diameter control. Its quality performance over a wider range of extrusion conditions also cuts scrap loss, the company says.

Monsanto Co., 800 N. Lindbergh Blvd., St. Louis, Mo., 63166. [407]

Protective coating adheres to all metals

Development of a protective coating has eliminated harmful corrosion to all metals exposed to nitrogen tetroxide, a rocket fuel oxidizer. HumiSeal type 332 provides complete protection against the fumes of, or immersion into, the oxidizing agent. The material is a multiple polymer resin said to have outstanding adhesive characteristics to all metals and most plastics. Its chemical and moisture resistance indicates excellent protection for printed circuit board assemblies against chemical corrosion and high humidity environment.

Type 332, because of good flexibility and adhesion to polyurethane, is being used for sealing the surfaces of foam. The one-can system can be applied by dip, brush or spray and is completely cured at room temperature. The cured coating is transparent and has excellent light stability.

HumiSeal type 332 has an alcohol solvent that will not affect plastic-encased electrical components, Mylar film and printing inks.

Price is $18 per gallon and delivery is from stock.

Columbia Technical Corp., 24-30 Brooklyn-Queens Expressway, West, Woodside, N.Y., 11377. [408]

Conductive paint needs no formulating

An electrically conductive polymer alloy, Dynaloy 350, is a silver filled paint that adheres readily to conventional solder, metals, plastic, glass, rubber and ceramic surfaces.

Anticipated usages include coatings for tantalum anodes, electrostatic shielding and component grounding—to name a few. Maximum volume resistivity is reported at 0.001 ohm-cm.

Prior to its introduction, commercially available solderable conductive paints were, according to the manufacturer, characterized by low temperature resistance, poor adhesion and inconsistent solderability.

Dynaloy 350 requires no formulating and can be applied directly from the container by dip, brush, or roller coating, in addition to silk screening.

Air drying accomplishes the cure, however, optimum adhesion and conductivity is assured by forced air drying (10 minutes at 125°C or 30 minutes at 105°C).

Trial quantities of Dynaloy 350 are available at $10 for a 3-oz. can. Commercial quantities, including pints, quarts and gallons are available.

Henry Mann Co., Box 104, Cornwells Heights, Pa., 19020. **[409]**

Photoresist offers coating latitude

An improved photoresist, KPR type 3, offers increased coating and processing latitude. It is designed primarily for use in the production of printed circuits and chemical milling of parts from copper and high copper alloys such as brass and bronze. It provides excellent adhesion to substrates and coating uniformity with dipping, whirling, spraying or roller coating.

This photoresist is slightly faster than KPR, and about the same speed as KPR2. KPR3 has long tank life and great development latitude in a trichlorethylene vapor degreaser.

Type 3 is available in quarts, 40-lb. cans (4½ gallons) and 450-lb. drums (50 gallons).

Eastman Kodak Co., Rochester, N.Y., 14650. **[410]**

New Books

Radio engineering

Non-Linear Transformations of Stochastic Processes
Edited by P.I. Kuzentsov, R.L. Stratonich and V.I. Tiknov
Pergamon Press, 498 pp., $20

It is rare that a book has a logical sequence when it is compiled from a series of independent papers. But here the 39 papers on nonlinear transformations of stochastic processes, originally published in Soviet technical journals between 1953 and 1961, not only stand alone but, frequently and surprisingly, two or three papers provide a broad look at a subject area.

In addition, the book presents original solutions which complement but do not duplicate Western literature. Apparently some of the early work of American and British mathematicians such as Wiener, Rice, Middleton and Woodward was known, but the Soviet work doesn't reflect their methods. In some cases, the authors report on areas that have not been covered in the West as yet.

Although the applications discussed are in radio and communications engineering, people in other disciplines who use statistical analysis can profit from the book. The techniques are adequate for any technical problems that can be represented by similar mathematics. A strong background in probability theory and stochastic processes and some knowledge of the mathematical description of linear and nonlinear radio devices are necessary.

Most of the papers in the first section investigate the parameters that describe random functions when transformed by various nonlinear systems, such as higher-order moment functions, semi-invariants and quasi-moment functions. Formulas are developed to convert one set of descriptive functions to another. The parameters describing the nonlinear transformation can be determined by a corresponding linear transformation of the quasi-moment functions.

Other work includes the investigation of Markov processes and a generalization of the Focker-Planck equation that can be applied to random functions with short correlation time intervals. The results are important in determining the effect of a delay or memory on a nonlinear transformation. The effects of linear transformations on random functions are also discussed but in rather standard fashion and in only two papers.

Two chapters apply the theory to noise effects, spectral representations of narrow-band random processes and almost-harmonic fluctuations. The effects of noise on detectors and the effect of random fluctuations in oscillators are explored in some depth.

Investigations of the zero-crossing problem, the distribution function of the interval between the random functions' successive zeros and transformations on the expected number of crossings are reported. The last chapter introduces the problem of optimum filtering and prediction in both linear and non-linear systems.

Other techniques developed include:

- Methods to make a linear approximation of a nonlinear transformation, permitting application of correlation theory.
- A quasi-static approximation to reduce a nonlinear transformation with memory to one without memory. (A transformation without memory is independent of past and future values of the random variable.)
- An analysis of random functions constructed from random points that are correlated in time and space.

Sidney J. Korn
Airborne Instruments Laboratory
Deer Park, N.Y.

Oscilloscopes

Oscilloscope Measuring Technique
J. Czech
Philips Technical Library, Springer-Verlag New York Inc., 620 pp., $15.80

A definite advantage of this book is that a simple oscilloscope and auxiliary equipment will suffice to perform most of the measurements described and an expensive high-grade laboratory scope is not needed. However, the reader seeking to learn the latest advances in oscilloscope measuring techniques will be disappointed and will have to turn to scope manufacturers' technical literature.

The book is recommended as a thorough introduction to the general applications of oscilloscopes. About two-thirds of the book is devoted to oscilloscope measuring techniques and practical applications, covering radio, television and even mechanical measurement problems. Helpful photographs of scope traces are included.

A few of the practical examples, however, suffer from obsolescence. One unfortunate omission is time-domain reflectometry for testing transmission lines and impedance matching. This is a powerful new tool that has great advantages over swept frequency measurements and impulse testing—the older methods discussed by the author. A concluding section on waveform photography and projection of oscilloscope images on large screens for audience viewing is well done.

Readers who purchase the book by title alone will be surprised to find fully one-third of the text devoted to instrument design, most of which is obsolete. For example, the circuits described are almost exclusively vacuum tube circuits. This section must therefore be viewed not as a design guide, but rather a statement of design problems.

The book is a revised and expanded version of an earlier German edition. The translation is smooth with only a few annoying European terms.

Robert Kolar
Hewlett-Packard Co.
Colorado Springs, Colo.

Microcircuits

Integrated Circuit Engineering:
Basic Technology
Engineering Staff of Integrated Circuit Engineering Corp.,
Boston Technical Publishers, Inc.,
408 pp., $22.50

The economic impact of integrated circuits, their materials, processing, design packaging, assembly, reliability and testing are among the

New Books

topics included in this handbook. Other areas covered are: mathematics of IC design, digital and linear IC's and future capabilities of IC techniques.

Charts, graphs, cross sections of IC's and schematics are abundant. The book is intended to keep the working engineer, purchasing agent and company president informed on this fast moving technology.

Although this is the fourth edition of the book, it is the first to appear in hard cover. It was originally prepared as part of a $250 course on IC's. Previous editions, in a loose-leaf binder, were available only to those attending the course.

Recently published

Electronics, Roy H. Mattson, John Wiley & Sons, Inc., 620 pp., $12.95

Alternating Current Circuits and Measurements: A Self-Instructional Programed Manuel, C.J. Anderson, A. Santanelli and F.R. Kulis, Prentice-Hall, Inc., 367 pp., $12

Digital Computer Fundamentals, second edition, Thomas C. Bartee, McGraw-Hill Book Co., 402 pp., $6.95

Approximate Analysis of Randomly Excited Nonlinear Controls, Harold W. Smith, The M.I.T. Press, Research Monograph 34, 138 pp., $7.50

Introduction to Electronics, Theodore Korneff, Academic Press, 545 pp., $11.75

Engineers' Relay Handbook, sponsored by the National Association of Relay Manufacturers, Hayden Book Co., 300 pp., $11.95

A Fortran Introduction to Programming and Computers: Including Fortran IV, Marvin L. Stein and William D. Munro, Academic Press, 122 pp., $3.95

Electron Tubes, Royce Gerald Kloeffier, John Wiley & Sons Co., 262 pp., $5.95

Radio Astronomy, John D. Kraus, McGraw-Hill Book Co., 481 pp., $13.75

Electromechanical Power Conversion, Enrico Levi and Marvin Panzer, McGraw-Hill Book Co., 499 pp., $12.75

Handbook of Stroboscopy, Frederick Van Veen, General Radio Co., West Concord, Mass., 116 pp., $1

Handbook of Relay Switching Technique, J.Th. Appels and B.H. Green, Philips Technical Library, Springer-Verlag New York Inc., 321 pp., $10.80

Proceedings of the Fifth Annual Symposium on Nondestructive Evaluation of Aerospace and Weapons Systems Components and Materials, Southwest Research Institute, San Antonio, Texas, 364 pp., $10

RCA Linear Integrated Circuit Fundamentals, Technical Series IC-40, Radio Corp. of America, Electronic Components and Devices, Harrison, N.J., 240 pp., $2

Technical Abstracts

Ferroelectric memory

Ferroelectric ceramic logic
and NDRO memory devices
D.C. Schueler, Sandia Laboratory,
Albuquerque, N.M.

Ferroelectric elements are looking better and better for applications where simple, small-capacity memories are needed for compatibility in size with semiconductor integrated circuitry.

Interest in them has increased for several reasons:

- Ferroelectric ceramics have been developed that can be used over a wide temperature range.
- Material coefficients can be determined as precise functions of the ceramic composition.
- New hot pressing techniques allow improved control of material homogeneity and density.

Capitalizing on these improvements Sandia Laboratory built a seven-bit ferroelectric memory of lead zirconate-titanate that can fit into a quarter-inch square integrated circuit flatpack. The memory itself is in the shape of a disk, 150 mils in diameter and 3 mils thick. A circular or dot electrode at the center of the disk is surrounded by seven pie-shaped segments—the bits of the memory.

The dot electrode is used to excite the piezoelectric vibrational mode. Its polarization is constant at saturation remanence. (Like ferromagnetic materials, the ferroelectrics have a square-shaped hysteresis loop when polarization is plotted versus electric field.) The back surface of the disk is a single electrode.

Sandia fabricated the memory from bulk ceramic material that has been precisely ground into cylinders having the finished diameter. The cylinder is then sliced into disks, lapped and polished to the desired thickness. Each is ultrasonically cleaned and heat-treated at 750°C. Thin aluminum or chromium-gold electrodes 3,000 to 5,000 angstroms thick are vacuum-deposited on the major surfaces; the pattern is defined by metal shadow masks.

Gold wire leads 1 mil in diameter are then nailhead bonded to each cured in a microcircuit flatpack with a 25-mil layer of RTV Silastic. The electrode leads are wedge-bonded to the package lands.

For storing binary information, the phase relationship of the dot and segment voltages is the only polarization-sensitive parameter. The segment voltage changes phase by 180° when the direction of the remanent polarization is reversed. Nondestructive readout is readily obtained by detecting the phase of the segment voltage relative to a reference voltage. Disk drive levels can be adjusted so that a segment can drive a logic gate directly at about 3 volts rms.

High-speed write in is generally not needed for applications where ferroelectric memories are useful. Write-in times range from 1 to 10 milliseconds. This allows the power source to have a higher impedance (10 to 100 kilohms per bit) and lowers the amplitude of the critical polarization voltage.

In writing, a negative pulse is first applied to the write line so that all bits are negatively polarized. A positive voltage pulse is then applied to the write line, with the input register determining which of the bits are polarized positively. Write in of a word is in parallel and takes a few milliseconds. Breakdown voltage of the transistors in the NOR gates of the write-in circuit must be as high as 150 volts, requiring this part of the circuitry to be composed of hybrid elements.

Presented at the Western Electronics Show
and Convention, Los Angeles,
August 23-26, 1966

Voltage statistics

Random sampling-a statistical
measurement approach
John T. Boatwright, Hewlett-Packard
Co., Loveland, Colo.

A voltmeter that samples input radio-frequency signals randomly, functioning somewhat like a sampling oscilloscope, is free of the limitations inherent in conventional broadband voltmeters. Incoherent sampling permits measurement of a signal from 1 kilohertz to 1 gigahertz tuning.

Conventional techniques with

synchronized samplers can recover complete information about the sampled signal so long as the signal is periodic, or almost periodic, so that coherent sampling is possible. The random or incoherent sampler loses the time information about the sampled signal but retains statistical information, even if the signal is not periodic. The sampler requires no synchronization circuitry.

A noncoherent sampler has been constructed to measure the average value of a broadband of high-frequency signals. The instrument's output is displayed on a meter and the output of the zero-order or sample-hold circuits are made available by means of a jack at the back of the instrument. Sampling is performed in the measurement probe to keep the physical lengths in the sampling-bridge element short. The samples from the probe are fed through an attenuator and amplifier before processing by the sample-hold circuits and the average detector.

The pulse generator that drives the sampler assembly is controlled by a repetition-rate modulator so that the sampler is always asynchronous with any input signal.

The signal recovered from the random sampler is basically a relatively broadband signal whose spectral energy is uniformly distributed over a specified low-pass bandwidth. This uniform distribution—unlike the harmonically related intervals of the spectral energy from the recovered signal in a synchronous sampler—does limit the instrument's sensitivity, since simple matched filter techniques can no longer be used to reduce the total noise power from the sampler or zero-order hold circuit.

The instrument's absolute average detector can be modified with appropriate circuitry to make root-mean-square or peak value measurements. But it then becomes necessary to assure that statistical reliability exists—that enough samples are taken so that the recovered signal is truly representative of the sampled signal.

Presented at the Western Electronics Show and Convention, Los Angeles, Aug. 23-26, 1966.

New Literature

Capacitor reliability. General Electric Co., Box 158, Irmo, S.C. A 26-page brochure describing a report on the reliability of tantalum-foil capacitors gives the company's definition of reliability.
Circle 420 on reader service card.

Operational amplifiers. Analog Devices, 221 Fifth St., Cambridge, Mass., 02142. A four-page short-form catalog describes 13 operational amplifier models and gives specifications covering 22 units. [421]

Trimming potentiometer. Helipot division, Beckman Instruments, Inc., 2500 Harbor Blvd., Fullerton, Calif., 92634. Data sheet 66191 covers the model 63P trimming potentiometer, a 3/8-in.-square military trimmer with Cermet resistance element. [422]

Rotary thumbwheel switches. Engineered Electronics Co., 1441 E. Chestnut, Santa Ana, Calif., 92702. The industrial Blue Cover line of economical rotary thumbwheel switches is described in a four-page brochure. [423]

Rosin core solder. Alpha Metals, Inc., 56 Water St., Jersey City, N.J., 07304. A technical bulletin describes Reliacor No. 11, a mildly activated rosin core solder designed to provide more effective soldering under type RMA of Federal Specification QQ-S-571d. [424]

Transistor test set. Baird-Atomic, Inc., 33 University Road, Cambridge, Mass., 02138. Brochure EP-2 deals with the company's latest version of its model PB-1 automatic transistor test set that performs up to 10 tests in less than 1 second in any sequence. [425]

P-c board holders. Taurus Corp., Academy Hill, Lambertville, N.J., 08530, has published an eight-page catalog on its line of printed-circuit board holders in plastic, steel and beryllium copper. [426]

Vacuum catalog. Andar Corp., 185 E. Evelyn Ave., Mountain View, Calif., 94041, has available a vacuum catalog that includes a complete price list and technical data on ion pump systems, flanges and fittings for high-vacuum applications. [427]

Teflon tapes and film. Dilectrix Corp., 69 Allen Blvd., Farmingdale, N.Y., 11736, offers a four-page illustrated fact sheet describing the manufacturing methods for fabrication of Teflon tape, sheet and film. [428]

Photoconductive cells. Epic, Inc., 150 Nassau St., New York 38, N.Y., has available descriptive literature on photoconductive cells, the sensitive material of which consists of cadmium sulphide with doping materials of cadmium combined with elements of the sixth group of the periodic system. [429]

DTL circuits. Signetics Corp., 811 E. Arques Ave., Sunnyvale, Calif. Design data and applications for 17 diode-transistor-logic circuits are featured in a brochure on the SE100J series integrated circuits. [430]

Pulse generator. E-H Research Laboratories, Inc., 163 Adeline St., Oakland, Calif., 94607. A technical data sheet covers the model 120E pulse generator, which features a fast rise time and high repetition rate. [431]

Data transmission system. Lenkurt Electric Co., Inc., 1105 County Road, San Carlos, Calif., has available a four-page brochure on the 25A data transmission system, which can be arranged for a wide variety of multichannel telegraph and intermediate-speed data applications. [432]

Stepper motors. The A.W. Haydon Co., 232 North Elm St., Waterbury, Conn., 06720. Product information sheet No. 127 provides data on high torque, general duty and miniature stepper motors. [433]

Potentiometer wire. Sigmund Cohn Corp., 12 South Columbus Ave., Mount Vernon, N.Y., 10553, offers a brochure outlining the advantages of the company's L.T.C. gold alloy potentiometer wire, its corrosion resistance, high tensile strength, low-noise level and length of life. [434]

Tuning forks. Riverbank Laboratories, P.O. Box 65, Geneva, Ill., 60134. A 20-page catalog, No. 966, covers many lines of precision audio-frequency standards. [435]

Reed switch. Solid State Electronics Corp., 15321 Rayen St., Sepulveda, Calif., 91343, has published a bulletin on the model 7001 spdt Microreed relay. [436]

Microminiature connectors. Continental Connector Corp., 34-63 56th St., Woodside, N.Y., 11377. An eight-page catalog covers the series MM-22 microminiature plug and socket connectors. [437]

Capacitors for transistorized tv. Nucleonic Products Co., Inc., 3133 E. 12th St., Los Angeles, Calif., 90023, has published a four-page application note titled "Metallized Lacquer Film Capacitors in the Horizontal Deflection Circuit of Transistorized T.V.". [438]

Miniature recorders. Thomas A. Edison Industries, McGraw-Edison Co., West Orange, N.J., 07051. A six-page illustrated bulletin, No. 3091, describes miniature circular chart recorders available in D'Arsonval or moving iron move-

New Literature

ments for current, voltage, or temperature recording. [439]

IC logic modules. Wyle Laboratories, Products division, 133 Center St., El Segundo, Calif. The series M line of integrated-circuit logic modules is described in a set of detailed specification sheets. [440]

Hermetically sealed relays. Guardian Electric Manufacturing Co., 1550 W. Carroll Ave., Chicago, Ill., 60607, has released a 16-page bulletin giving complete information on hermetically sealed relays, contactors and control switches that meet or exceed military specifications. [441]

Static frequency converters. The Louis Allis Co., 427 E. Stewart St., Milwaukee, Wisc., 53201. Bulletin 7050 presents information on a line of static frequency converters, the company's advanced solid state complete power package for precise, adjustable speed control of single or multiple a-c motors. [442]

Pressure transducers. American-Standard, Advanced Technology division, 1401 South Shamrock Ave., Monrovia, Calif., offers a four-page, short-form catalog on its complete line of bonded, strain gage pressure transducers. [443]

Differential operational amplifier. Analog Devices, 221 Fifth St., Cambridge, Mass., 02142. An application sheet covers basic principles, uses and technical specifications for model 301 varactor bridge differential operational amplifier. [444]

Induction heating. Lepel High Frequency Laboratories, Inc., Woodside, N.Y. Volume II No. 1 of the Review contains articles entitled "Induction Heating and Solid State Technology" and "Induction Heating In Heat Transfer Research". [445]

Test sockets for TO devices. Barnes Development Co., Lansdowne, Pa., 19050. Data sheet 178B shows a line of Quik/Sert sockets for test, aging and breadboarding of 3 to 14 lead transistors and integrated circuits packaged in TO housings. [446]

Coaxial and waveguide switches. E&M Laboratories, 7419 Greenbush Ave., North Hollywood, Calif. A four-page bulletin describes coaxial and waveguide switches that cover the frequency range of d-c through 26.5 Ghz.[447]

Carriers and contactors. Barnes Development Co., Lansdowne, Pa., 19050, has issued a data sheet on the series 029 carriers and contactors, which provide convenience, speed and protection for handling and test of 14-lead flatpack integrated circuits. [448]

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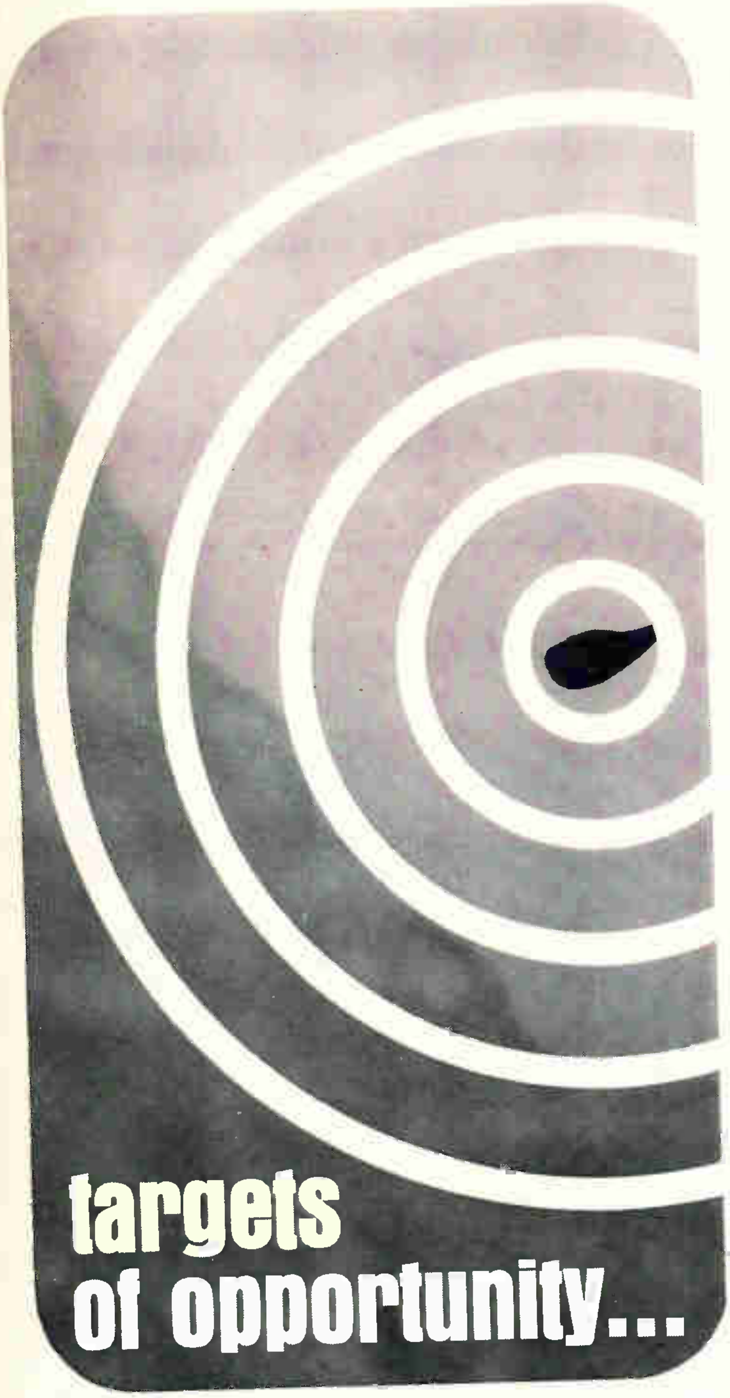

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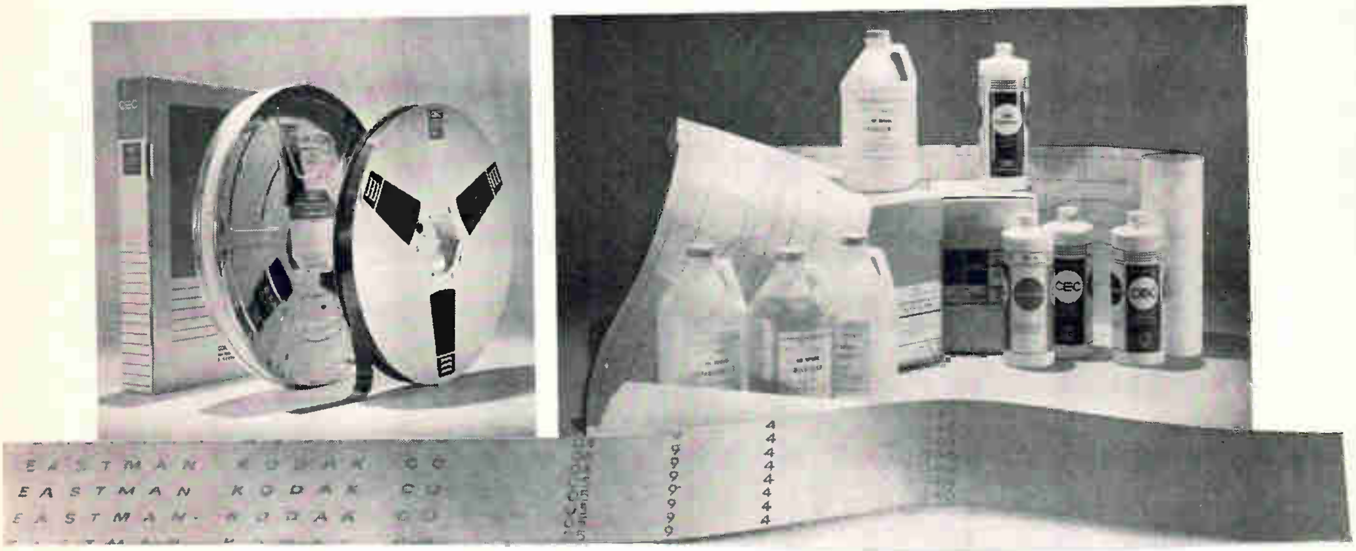

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September 19, 1966

Electronics Abroad

Volume 39
Number 19

Soviet Union

Computer show

Soviet leaders stoutly maintain they'll soon have a network of supercomputers running the country's industries and solving its economic problems. But judging from the Interorgtechnica Automation Show held in Moscow earlier this month, the engineers who have to design and build the supercomputers aren't faring too well at the game of follow the leaders.

Far from supercomputers, the few new Soviet machines unveiled at the show were small, easy-to-use models. And the most elaborate demonstrations in the Soviet pavilion—largest at the 18-nation exhibition—featured the two-year-old Minsk 22 computer [Electronics, July 26, 1965, p. 133].

To be sure, the Soviets keep their advanced computer technology very much unto themselves. So Western showgoers who had hoped for a glimpse of the BESM 6, reportedly the largest and best Russian digital computer, found only a small ancestor on display, the BESM 4. It's known, however, that the first nonmilitary BESM 6 went into service last month at the meteorological center in Moscow. But even after discounting Soviet secrecy, Western observers remain convinced that the emphasis in production clearly centers on small machines.

Industrywide. In the drive to put whole industries under computer control, Russian data-processing experts apparently haven't waited for the advent of supercomputers. One display at the Soviet pavilion indicated the Russians are trying to control their entire fertilizer industry with a system built around the Minsk 22.

According to the Interorgtechnica display, the Minsk 22 system handles data processing for the production of 28 different kinds of fertilizer and its supply to 20 customers—Soviet republics and export agencies—across the country. A Soviet computer specialist at the show said that about 100 such systems currently are in operation in the USSR, controlling everything from material flow to bookkeeping. At the Lvov television works in the Ukraine, for example, a Minsk 22 system schedules work flow throughout the plant on the basis of inputs from several dozen counters and some 30 teletypewriters.

Transistorized. The best transistorized machine in sight at the Soviet pavilion was the KBM 1, kingpin element for an industrial management and control system the Russians call COY 1. The system consists of modular units and can perform up to 100,000 operations a second from a repertoire of 256 different operations. It has compilers for two computer languages plus a supervisory program that allocates priorities for multiprograming among as many as 80 asynchronous requests. The fast-access memory has a capacity of 4,096 words.

Another fully transistorized computer shown was a hybrid—a combination of a Dnieper digital control computer and up to three MN-10 analog machines. The combination works especially well for continuous process control, the Soviets say.

Slow and easy. The Soviets at Interorgtechnica also displayed a pair of small, slow, easy-to-operate machines that were designed, seemingly, to cope with a lack of trained computer personnel.

One, the Vilnius, accepts only keyboard inputs. Its basic computing elements are relays, diodes and electromechanical counters, limiting its speed to 300 operations a minute. It adds, subtracts, multiplies and divides automatically but is only semiautomatic when it comes to taking square roots or raising to a power.

About in the same class is the MIR family of machines for solving engineering problems, developed by the Kiev Institute for Cybernetics. This computer has a battery of 200 programs and the user simply types out the problem to feed it into the computer for solution.

East Germany

Cut to fit

Driving to boost the output of the state-run electronics industry despite a labor shortage, East German economic planners are turning increasingly to automatic production techniques. So determined are the planners to step up productivity, for example, that they've converted an aircraft factory in Dresden to develop automatic production equipment solely for plants that turn out electronic and electrical components.

The effort seems to be paying off. The new plant, called VEB Elektromat, now is producing automatic stator-winding machines, fuse assemblers, resistor-grinding machines and wire-harness makers.

Elektromat officials make con-

Punched paper tape programs East German machine that forms harnesses automatically.

siderable ado about a 66-foot long automatic resistor production line they developed in just 15 months. And they have high hopes for some of their machines in Western markets. Already they've sold resistor-grinding equipment to British and French manufacturers. They also expect to turn up Western customers for their automatic wire-harness forming machine. With both these machines Elektromat maintains it has come up with equipment no one else yet produces.

Best seller. Elektromat's best export seller so far is its $25,000 automatic resistor-grinder that cuts spirals on film resistors to adjust their resistance to a tolerance of ±0.3%. A small computing network in the grinder varies the pitch of the cut so that the spiral takes up at least 70% of the active length of the film.

The grinder can handle film resistors with values as low as 10 ohms and as high as 10 megohms. All the operator has to do is dial in the nominal unground value, the desired value and the tolerance. After that, the machine takes over.

Unground resistors are fed automatically from a vibrating hopper to a spindle that rotates the resistor as the cutting tool advances along it to produce a spiral. When the spindle grips a resistor, it's initial value is accurately measured. Based on this measurement, the computing network sets the speed of the cutting tool feed. Then the resistor is switched into a bridge circuit; the cutting operation continues until the bridge is balanced. If the desired value can't be obtained with a cut between 70% and 100% of the active film length, the machine rejects it. If 10 resistors in a row are rejected, the machine shuts down and flashes a warning light indicating that the operator should recheck his settings.

Harnessed. Elektromat thinks it may have another export winner in its automatic wire-harness machine. The machine lays out wires for harnesses according to a paper-tape input. It can handle layouts up to 21 inches wide and 48 inches long involving up to 20 different size of wire.

Harnesses are laid out on a drum studded with pins. Wires are fed to the layout drum from a magazine of spools. They are wrapped around the pins and are cut according to the tape program as the drum rotates and shifts up and down, also under tape control. Maximum harness-forming speed is about 33 feet a minute.

Great Britain

Computer on the rails

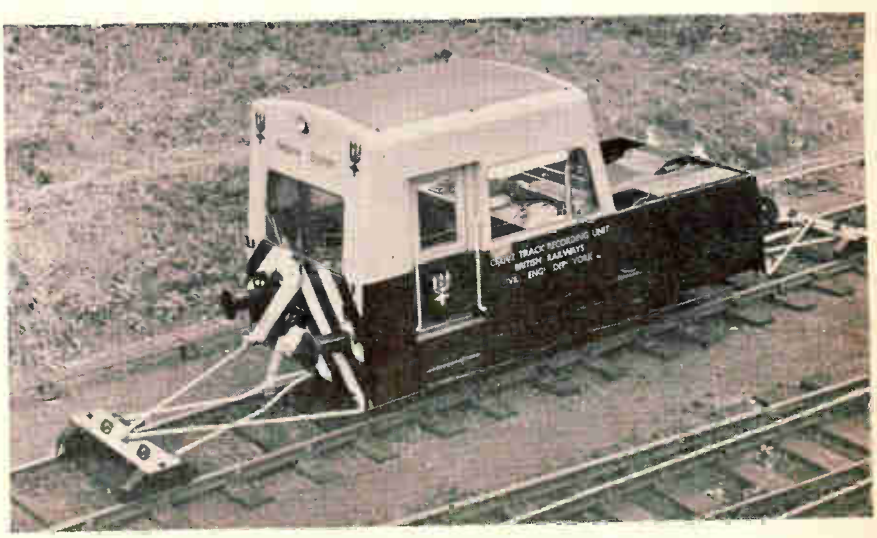
British Railways has put a computer on the rails as part of its effort to hold the line on roadbed maintenance costs, now running slightly over $75 million a year.

For more than a decade, the government-owned railroad has been checking out alignment of its 27,000 miles of tracks with recording trolleys that produce accurate —but voluminous—chart records of track conditions. The sheer volume of the charts, which require painstaking evaluation by experts to spot faults, loomed as a bottleneck in British Railways' plans to automate maintenance equipment.

To eliminate the bottleneck, British Railways and Derwent Electronics Ltd. jointly developed a system that automatically spots track faults. The equipment costs $34,400, but apparently will pay for itself many times over in maintenance savings. After running tests on a prototype, British Railways ordered an additional 11 systems and plans to have them checking track throughout the country within the next year.

Superimposed. The so-called Neptune system (for North Eastern Electronic Peak Tracing Unit and Numerical Evaluator) superimposes a fixed-program digital computer on the traditional electromechanical track-checking trolley. The trolley picks off data for five parameters—right- and left-hand top (smoothness of the rails), right- and left-hand rail curvature and cross level (difference in height between rails). The data for each parameter is fed into a separate channel in a data logger with a floating peak analyzer. Output of the data-logger channels passes to arithmetic units that analyze statistically the recorded peaks.

The peaks are stored and printed out every quarter of a mile. Cycle time of the arithmetic units is 11 microseconds and storage capacity is 70 eight-bit words. Whenever a parameter strays outside the acceptable limits, the printout shows it with a symbol alongside the out-of-limits value. In addition to the digital printout, Neptune produces a punched tape that can program automatic tamping machines. For serious deviations in cross level,



British Railways' Neptune system puts computer on track-checking trolley to spot faults quickly.

the track fault that makes railroad cars sway, the system develops an output signal that actuates a paint sprayer. It marks the track within 9 inches of the defect.

With Neptune, British Railways has carried electronic analysis of rail conditions a step beyond the system installed in early 1965 on the private car assigned to the vice-president for engineering of the New York Central Railroad. The New York Central system uses strain gages fitted between the body frame and the axle journal box to obtain a rough analysis of cross level.

But New York Central engineers can get a better idea of how smooth their passenger cars ride at high speeds over a stretch of railroad. Their system can handle speeds from 40 miles per hour all the way up to 120 mph. Neptune, by contrast, has a top speed limit of 40 mph for checking cross level. When all five track parameters are checked, top speed for the trolley is 20 mph.

Accent on avionics

The British aviation industry is beset by a big problem—too much capacity and too few airplanes to build—but the woes of the airframe makers haven't grounded the country's avionics producers.

At the bustling Farnborough Air Show this month, it was clear that much of the industry's vitality is coming from high-flying avionics manufacturers. The stress now is on aircraft control and instrumentation, but British companies remain active in communications, surveillance and testing equipment.

Avionics, in fact, accounts for a big chunk of Britain's electronic production. Of a total of $750 million last year, avionics covered almost a third—some $238 million. The proportion is even higher when it comes to exports. British sales of airborne equipment and ground navigational aids last year came to $81 million out of total electronics exports of $238 million.

Mobile. There was plenty of evidence at Farnborough that British avionics manufacturers are developing world-class equipment even though the country's aircraft production is declining. Marconi Co., for example, introduced a mobile military radar system that can handle several flight interceptions at speeds up to Mach 2. Marconi says the three-trailer system can be operating within two hours after it arrives at an unprepared site.

The Marconi system consists of three elements—a C-band height finder, plus S-band and L-band surveillance radars. The S-band radar has a moving target indicator that eliminates "blind speeds". The C-band height finder has a dual transmitter-receiver unit with scan pattern controlled by the Myriad computer that rides herd on the over-all system.

No hands. Another set of hardware that figures to boost Britain's avionics exports is a new instrument landing system developed by Standard Telephone and Cables Ltd., an affiliate of the International Telephone & Telegraph Corp. The solid state system uses a patented technique to prevent bends caused by reflections from buildings or high ground in the azimuth and guide-slope beams.

STC says it has virtually designed routine maintenance out of its new ILS system; a monitoring system handles routine checks and tests. The system carries a price tag of just over $120,000, lower than most ILS systems now in use. STC already has in hand more than $1 million worth of orders for the new system from British and Australian aviation authorities.

Well spaced. The Farnborough Air Show also provided a sampling of the space hardware British manufacturers have developed as part of their effort to keep from being grounded by the slowdown in aircraft production. Associated Electrical Industries Ltd. for instance, showed a working model of the latest British satellite-tracking radio telescope—which boasts an 82-foot dish antenna—built for the Chilbolton station of the Science Research Council.

Elliott-Automation Ltd. showed what it has proposed to the European Space Research Organization for a pair of 800-pound scientific satellites ESRO plans to launch in 1969 or 1970. For this ESRO proposal, Elliott is project leader for an international team that includes companies from France, Holland, Italy, Sweden and the U.S.

Japan

Breaking in

A solid market in England for computer peripheral equipment may be in the offing for Fujitsu Ltd., the lone Japanese computer maker that has achieved any significant success so far with exports.

Fujitsu will deliver late this year to Elliott-Automation Ltd. a trial shipment of four magnetic tape handlers and one high-speed line printer. Elliott plans to test the units on a 503 computer; if they work out, the Japanese peripherals stand to become standard equipment on Elliott's new 4100 series.

The tape handlers are Facom 603 models, which have a transfer rate of 60,000 characters per second and feature a single capstan with direct drive through a Minertia motor produced by the Yaskawa Electric Manufacturing Co. The line printer is a Facom 642, which has a maximum speed of 1,500 lines per minute with up to 136 characters per line.

Elliott, a heavyweight in the British computer industry, will be switching suppliers—rather than changing production policy—if it adopts the Fujitsu equipment as standard. For the computers it markets, Elliott produces the central processor and generally relies on United States companies like the Ampex Corp., Potter Instrument Co., the Anelex Corp. and the National Cash Register Co. for peripheral equipment. This is in line with the British government's policy to bolster the computer industry by concentrating on central processers.

The trial order was worth only $110,000 to Fujitsu but it could be the entree to substantial and steady sales in Britain over the next few years. Along with the tape handlers and high-speed line printer, Elliott also may buy magnetic disk memories, drum memories and paper tape units from Fujitsu.

Belgium

Victory at sea

Hardly a week goes by without some Japanese electronics company snapping up a contract in somebody else's backyard. But last month, a small Brussels-based firm turned the tables on the Japanese. The company, SAIT Electronics, waltzed off with an order worth more than $6 million to fit out with marine electronics gear 60 "Freedom" cargo ships that will be built in Japan by the Ishikawajima industrial group.

SAIT (an acronym for Société Anonyme Internationale de Télégraphie sans Fil) managed to underbid its Japanese competition largely because SAIT produces a standard line of bridge consoles, navigational radars, direction finders, fathometers and the like that fit Ishikawajima's bill with little modification. Along with its edge in price, SAIT clinched the deal because it could offer worldwide maintenance service for the equipment. Together with the Marconi Co. of Great Britain and the Radio Corp. of America, SAIT runs a globe-girdling service network called Radio Marine Associated Companies.

Secretive. SAIT is little known outside maritime circles and apparently likes it that way. Even the company's annual report to stockholders doesn't disclose sales figures, although SAIT admits that 80% of its business comes from marine electronics.

When it can't sell marine gear outright—as it did to Ishikawajima—SAIT often leases it. Something between 20% and 25% of its annual output of marine equipment is leased. Along with the equipment, a SAIT maintenance man often goes aboard to keep it serviced. Even SAIT's competitors admit the Belgian company has built a solid reputation among ship operators with its equipment and service.

Looking landward. Although marine equipment will be SAIT's mainstay for a long time to come, company chairman Gilbert Périer in recent years has charted a course that has landed SAIT considerable business ashore. SAIT already has supplied, for example, a flight simulator for Eurocontrol and portable microwave links for the government-run Belgian television networks. And SAIT won the contract for the high-speed data-logging equipment used in a prototype small reactor recently completed at Belgium's nuclear research center in Mol.

SAIT also expects to expand its maritime sales to Soviet-bloc countries. After about 15 years of cultivating potential East-bloc customers, a payoff has started to come. This month, the second of three freighters being built in Antwerp for Yugoslavia was launched. All three ships will carry SAIT gear.

New markets on land and at sea, Périer feels, will keep the company's sales growing steadily. Profits have climbed over the past four years from less than $400,000 in 1961 to $800,000 last year. To finance the expansion, which is backed up technically by four specialized research teams, SAIT is increasing its capital substantially. Even so, only 25% of the company's shares will be publicly owned and SAIT figures to remain closemouthed about its operations.

Gilbert Perier heads SAIT Electronics.

Italy

The plot quickens

Rome's carabinieri are famous for getting to the scene of a crime in record time. Their speed comes in large part from a continuous plot of patrol car locations that shows the duty officer at headquarters which car is closest to a trouble spot.

Now the carabinieri (roughly the equivalent of a uniformed FBI) are testing a system that will make the plot even more of an occupational hazard for criminals. Instead of keeping tabs on cruising patrol cars by position reports radioed in, the new system automatically interrogates the cars at a rate of one per second. The tests—on 10 patrol cars—will wind up this month. By the end of the year, the carabinieri expect to have the automatic plot in full operation with 40 cars. The system, developed by Selenia S.p.A., can handle up to 64 cars.

Coded. In the new system, patrol car locations are plotted automatically on a king-size wall display split up into 2,000 position sectors. Each car is interrogated in turn with a nine-bit code transmitted in the 40-magahertz band used also for police voice communications.

The patrol car transceiver responds automatically when it picks up its code signal. It transmits back a 15-bit code that shows its sector location and whether or not the car is cruising, stopped or in action. At the display, the response is decoded and fed into a memory that switches the wall display's position-indicating lamps on and off.

One method of getting the fixes on patrol car locations would be a triangulation among two fixed receiving stations and the interrogated patrol car. For the Rome system, Selenia adopted a less complex technique.

When a patrol car goes on station, the carabinieri aboard punch pushbuttons to feed the sector number into the memory of the transceiver. As the car passes from one sector to another, the new number is punched in to keep the automatic plot up to the minute.

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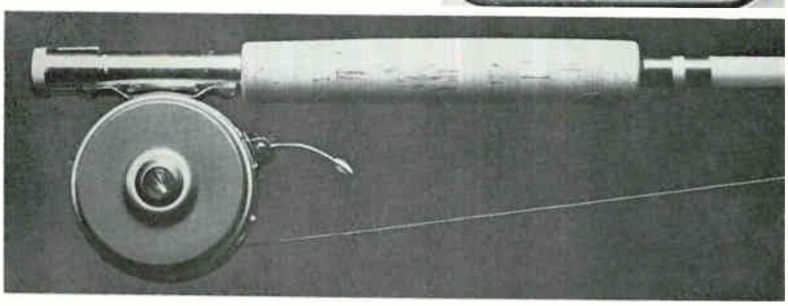

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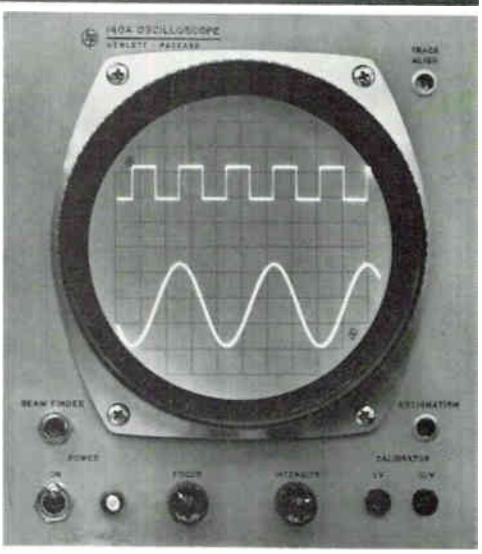

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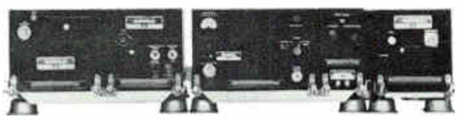

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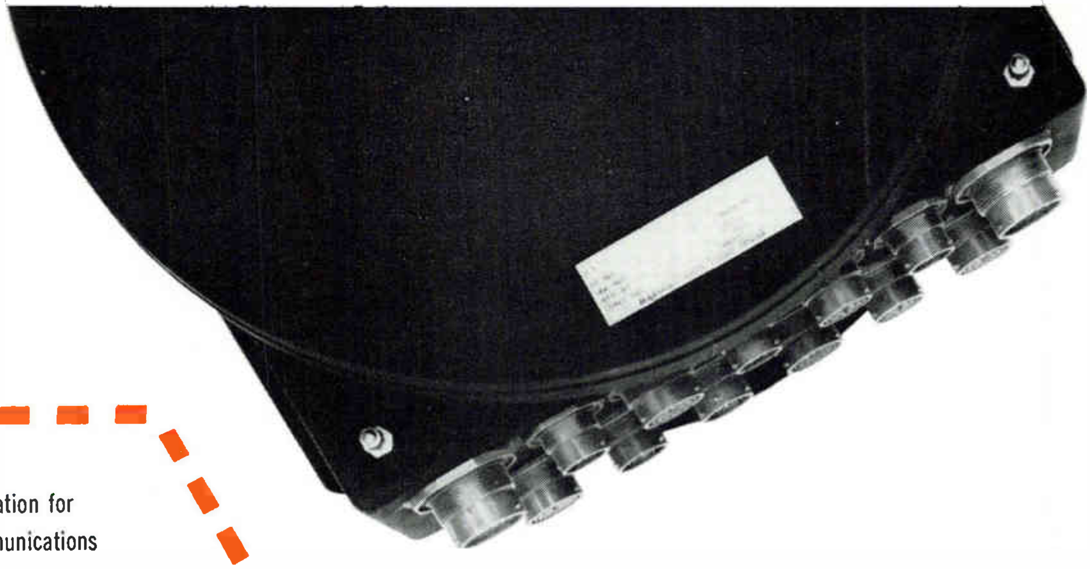

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