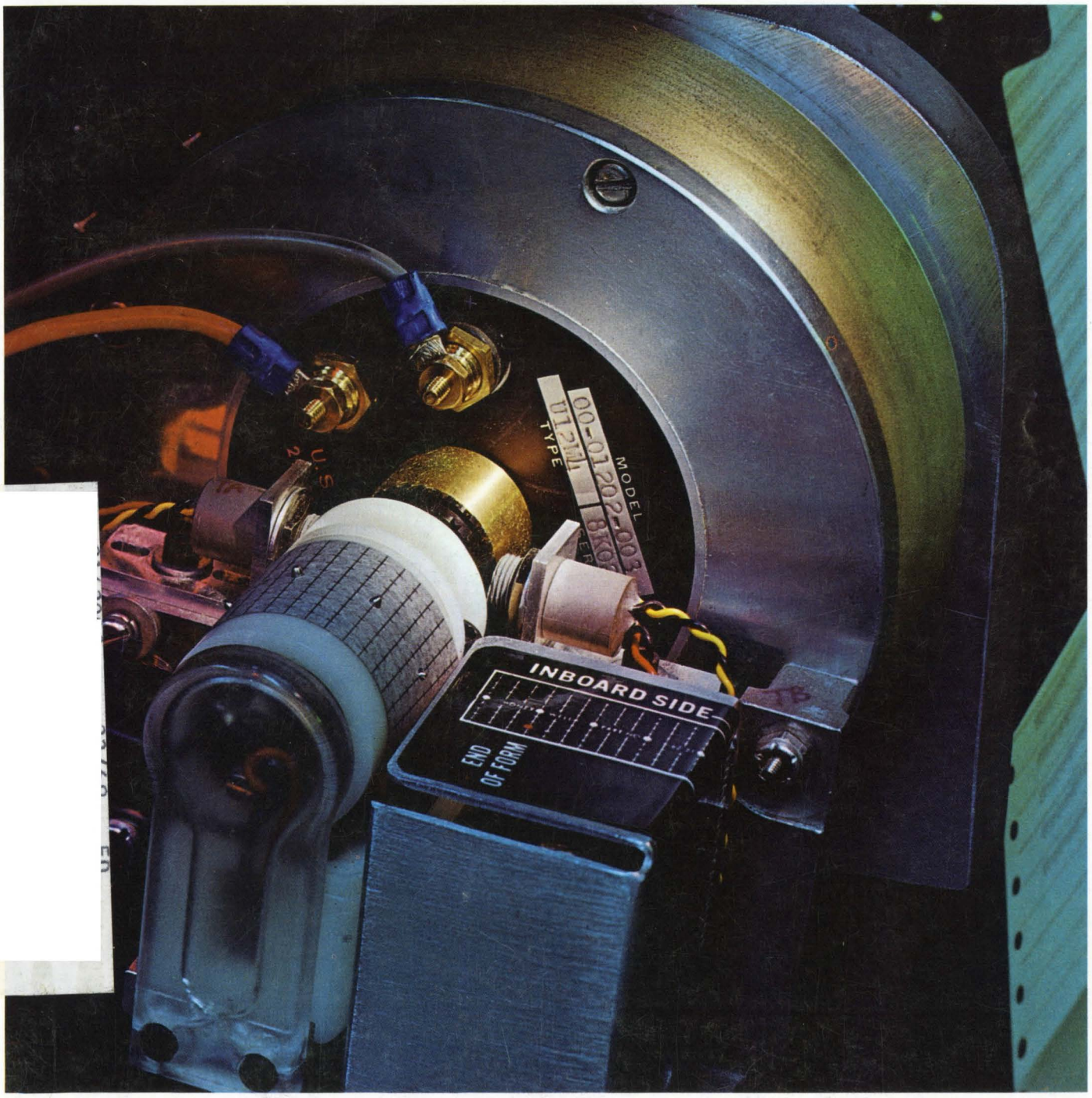
VOL. 17 NO.

Electronic Design 21

FOR ENGINEERS AND ENGINEERING MANAGERS

OCT. 11, 1969

Hall effect devices mushroom, spurred by thin-film technology, lower costs, improved reliability and reduced temperature effects. Latest applications range from solid-state computer controls to gyro pickoffs on the Boeing 747 superjet. But a new, magnetically sensitive transistor promises to give competition. See page 38.



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Newest DVM idea: double noise barrier boosts accuracy!

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- Spectrum analyzers
- Digital panel meters
- Microwave signal generators
- Laboratory magnets
- Data acquisition systems
- Microwave test sets

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Cover Photo: Two Hall devices pick up impulses from toothed magnetic wheels in a Honeywell computer printer.

ELECTRONIC DESIGN is published biweekly by Hayden Publishing Company, Inc., 850 Third Avenue, New York, N.Y. 10022. James S. Mulholland, Jr., President. Printed at Brown Printing Co., Inc., Waseca, Minn. Controlled circulation postage paid at Waseca, Minn., and New York, N.Y. 78,111 copies this issue.

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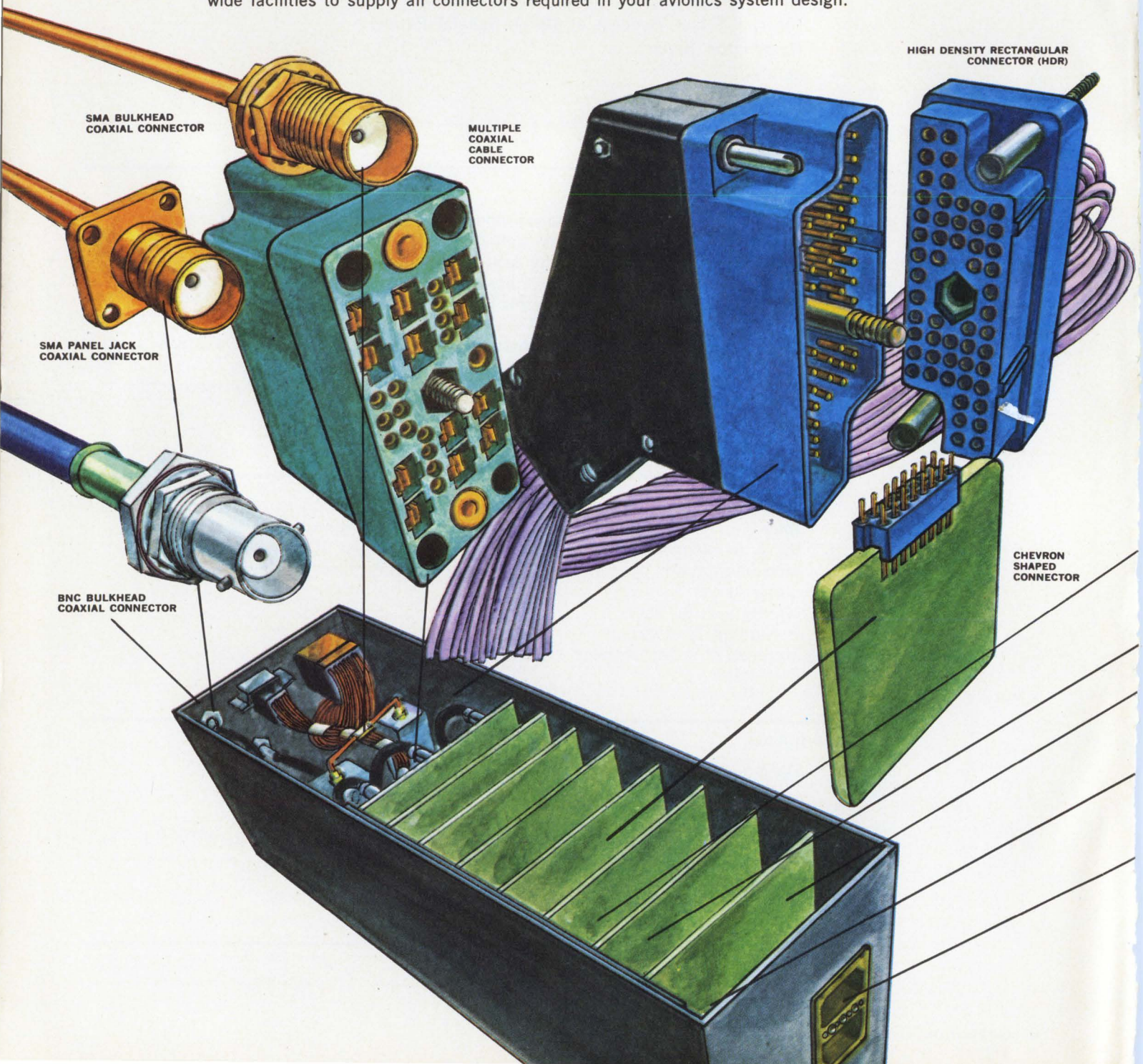

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Type TF. Sensitive.
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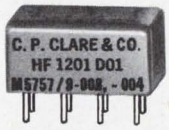
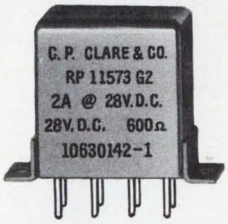
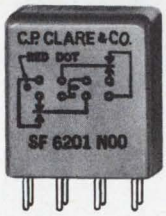


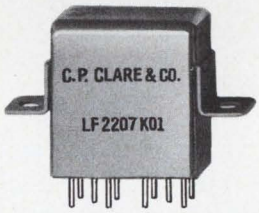
Type HF & HFW.
Low profile; low-level to 2 amp.



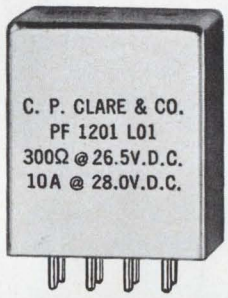
Type F & FW.
Full size; low-level to 3 amp.



Type SF.
40 mw sensitivity; low-level to 2 amp.



Type LF & LFW.
Magnetic latching; low-level to 2 amp.



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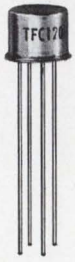
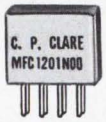
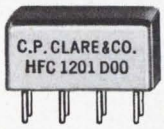


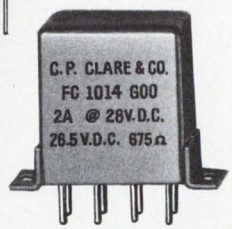
Type TFC.
TO-5 transistor size; low-level to 1 amp.



Type MFC.
One-sixth size; low-level to 0.5 amp.



Type HFC.
Rugged *"metal"* cover; low-level to 2 amp.



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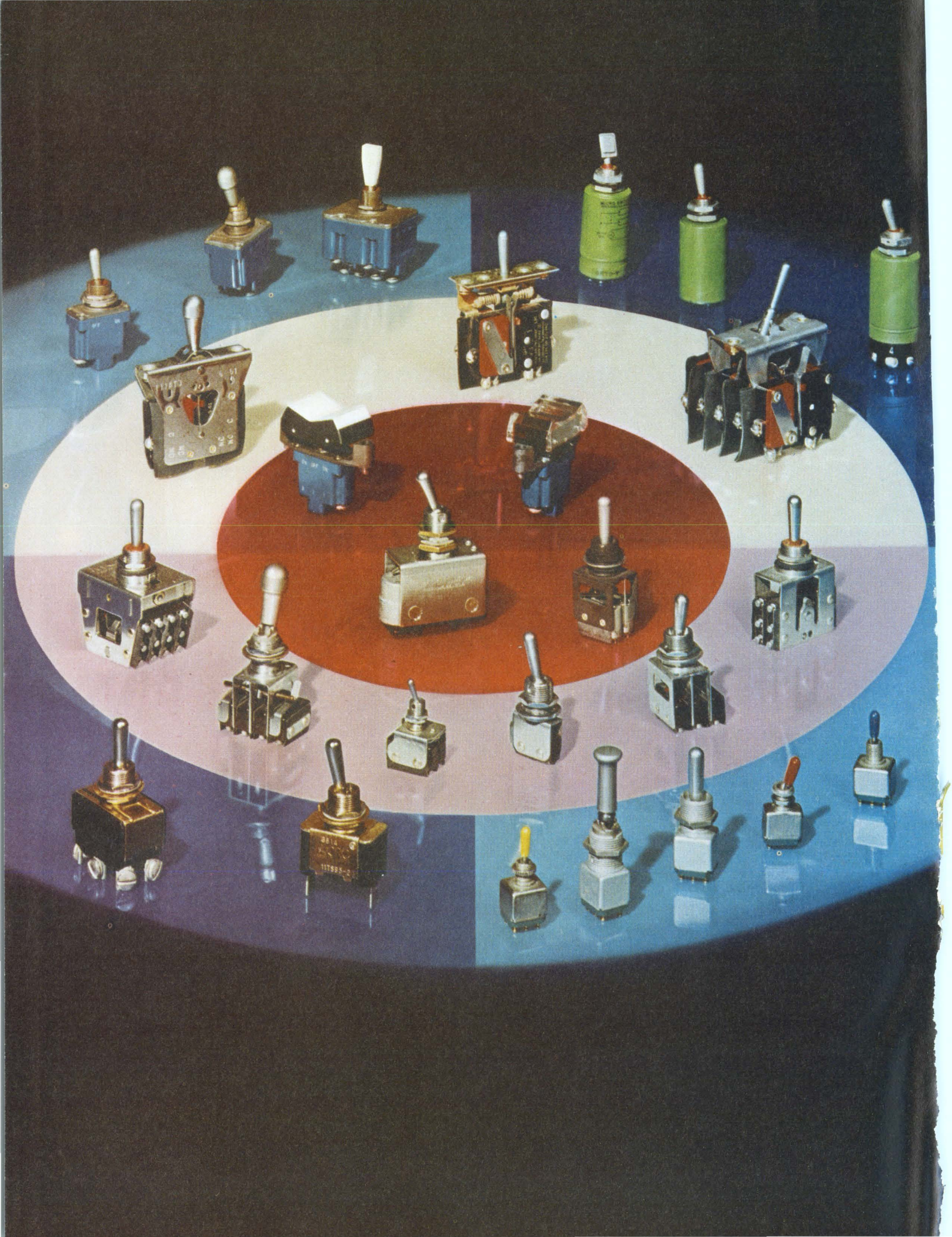

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1. Miniature toggle switches, Type TW—Weight and space savers (extend only 5/8" behind panel), yet they provide good operating feel and 35° toggle travel. Molded-in terminals. Lever seal and optional panel seal. Versatility, too: 1/4 or 15/32 inch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

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

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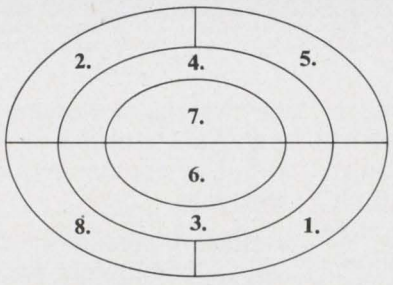
5. Magnetically-held toggle switches, Type ET—Two or three position levers, magnetically maintained, manual or remote electrical release. Environment-proof construction. MIL-S-3950 (immersion-proof). MIL-S-5272 (explosion-proof). SPDT or DPDT. Turret, screw or leadwire terminals. Standard, flat tab,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



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

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

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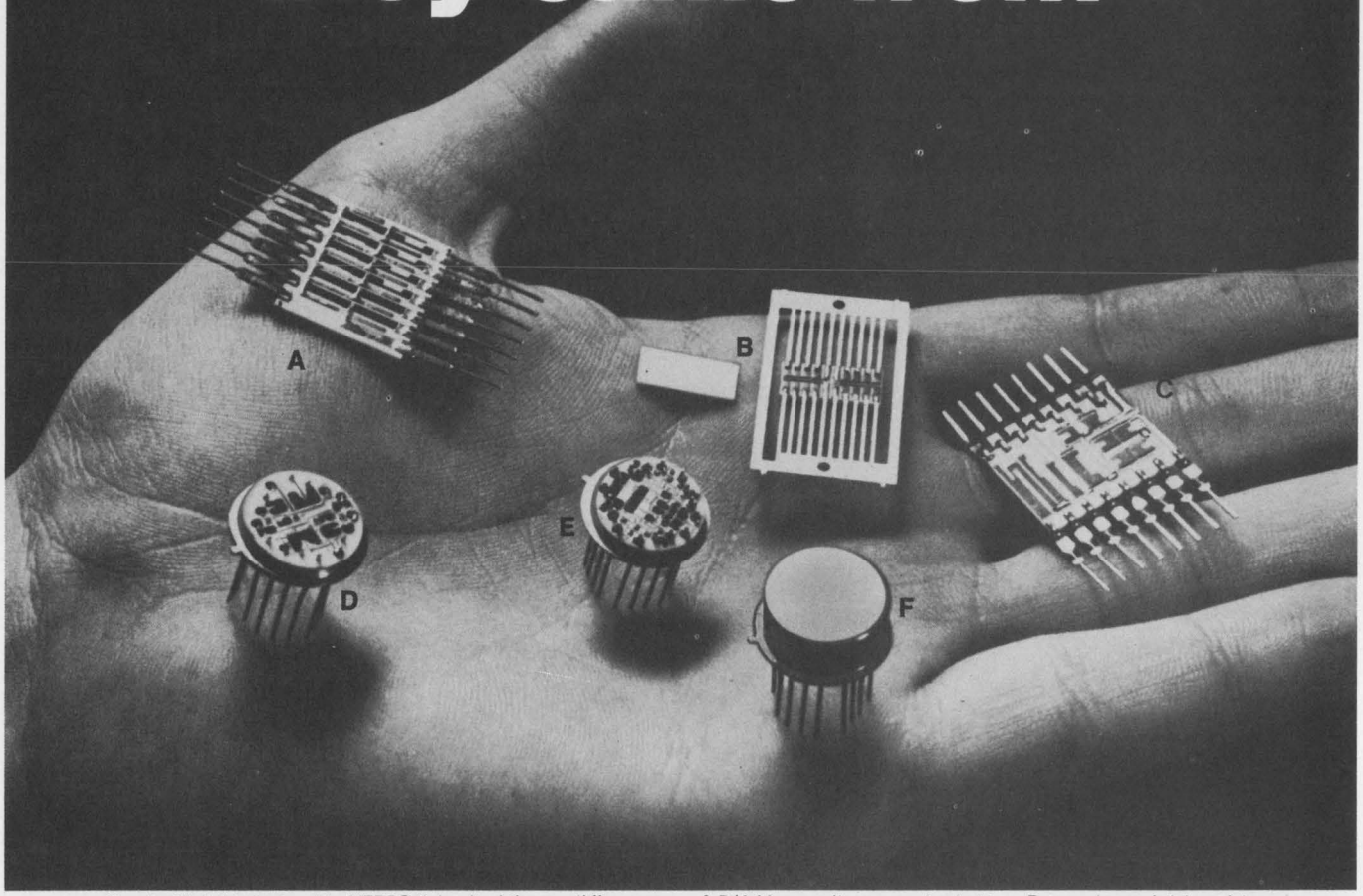

Standard hybrids featured in MEPCO "circuit of the month" program: **A** D/A binary voltage summing ladder; **B** ceramic sandwich resistor flatpack; **C** D/A binary current summing ladder; **D** DTL to MOS level shifter; **E** precision high speed ladder switch; **F** relay, lamp, core driver.

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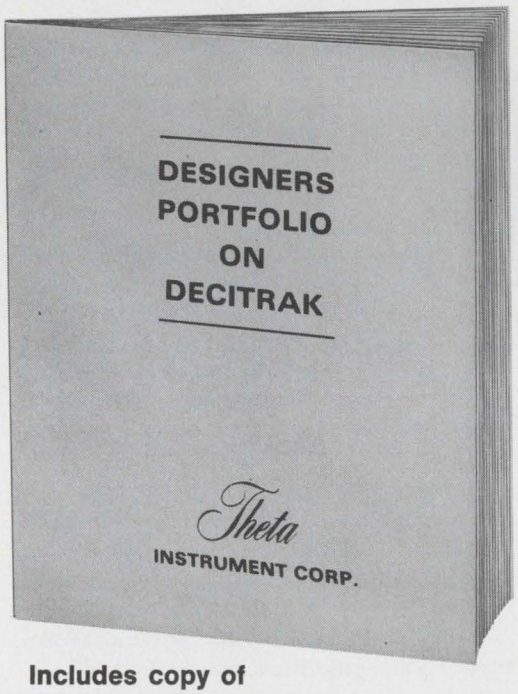

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Sun	Mon	Tue	Wed	Thu	Fri	Sat
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23	24	25	26	27	28	29
30						

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Oct. 21-23
Thermionic Energy Conversion Conference (Carmel, Calif.) Sponsor: IEEE, W. E. Harbaugh, RCA, Electronic Components, Lancaster, Pa. 17604

CIRCLE NO. 432

Oct. 26-30
Mathematical and Computer Aids to Design Conference (Anaheim, Calif.) Sponsor: IEEE, ACM, SIAM, J. F. Traub, Computing Science Research Center, Bell Telephone Laboratories, Murray Hill, N. J. 07974

CIRCLE NO. 433

Oct. 27-29
Southeastern EMC Symposium (Atlanta, Ga.) Sponsor: IEEE, D. Vrooman, P.O. Box 331, Smyrna, Ga. 30080

CIRCLE NO. 434

Oct. 27-29
Electronic & Aerospace Systems Convention (EASCON) (Washington, D.C.) Sponsor: IEEE, H. P. Gates, Jr., Sect. of Army for Southeast Asia Matters, The Pentagon, Washington, D.C. 20310

CIRCLE NO. 435

Nov. 5-7
Northeast Electronics Research and Engineering Meeting (NEREM) (Boston) Sponsor: IEEE, C. J. Peters, Sylvania Electric Products, 40 Sylvan Road, Waltham, Mass. 02154

CIRCLE NO. 436

Nov. 18-20
Fall Joint Computer Conference (Las Vegas) Sponsor: E. Grabbe, TRW Systems Inc., Bldg R3, Room 2070, One Space Park, Redondo Beach, Calif. 90278

CIRCLE NO. 437

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INFORMATION RETRIEVAL NUMBER 248 ►

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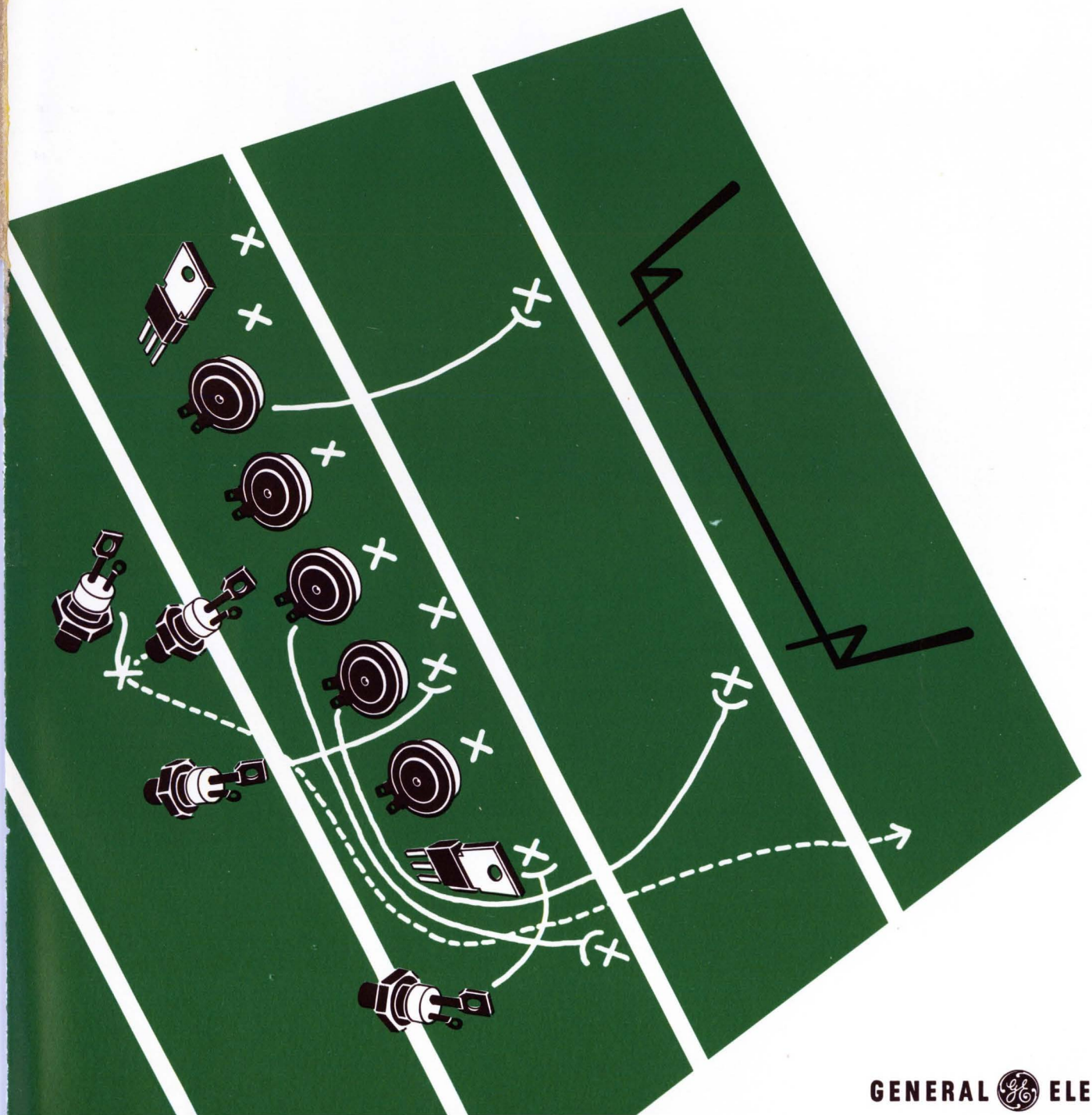
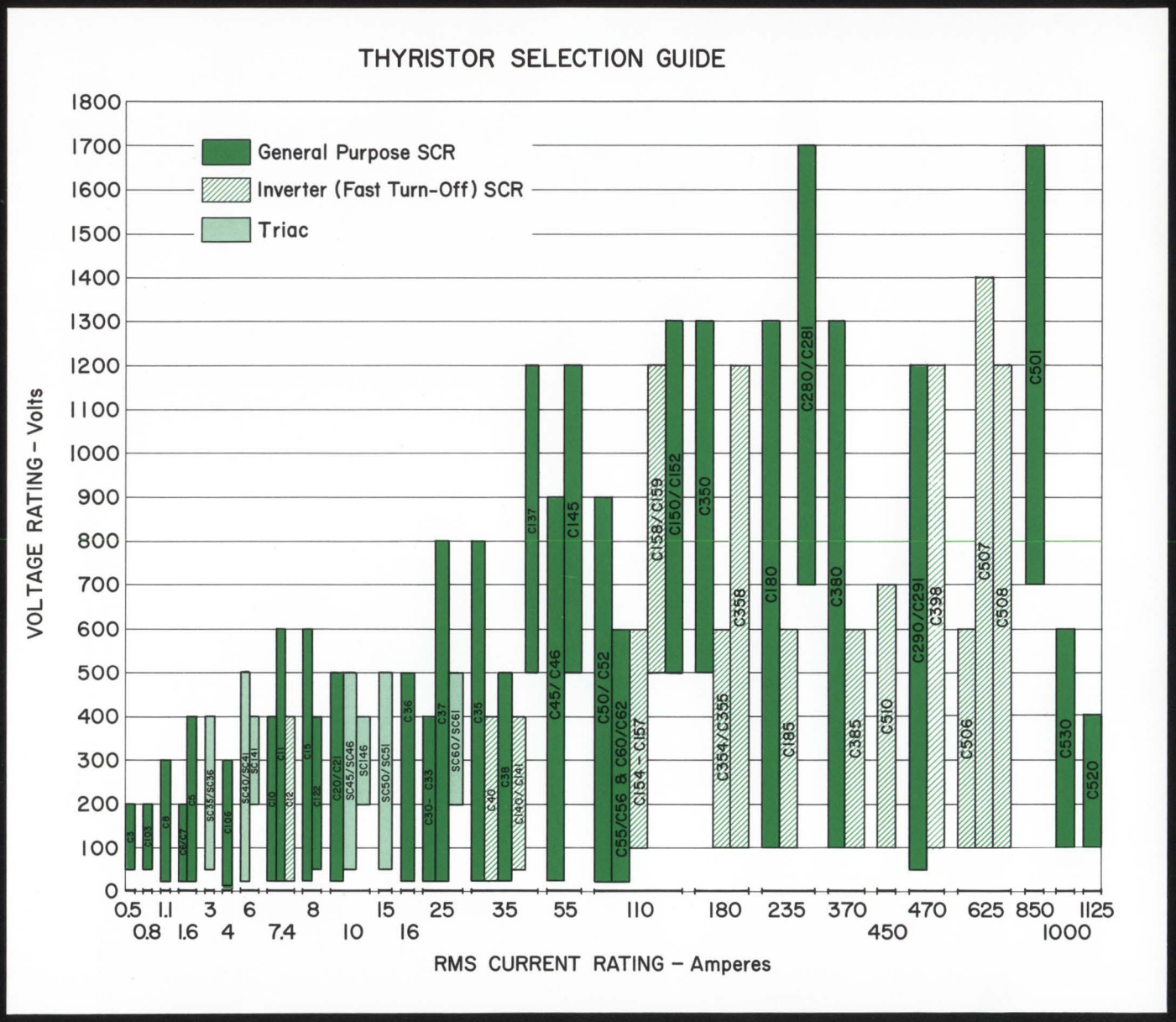


GENERAL ELECTRIC

GE's complete line of triacs and SCR's matches your price and performance needs



LOW CURRENT SCR'S

Current Rating Amps. RMS Max.	Peak Voltage Range	Product Types		Package*	Significant Product Features	Temperature—°C		For Further Information Refer to Applicable Specification Sheet
		GE	JEDEC			Junction T_J	Storage T_{STG}	
0.50	30 thru 200	C3	2N877-2N881	TO-18(1)	Small size, high sensitivity.	−65 to +150	−65 to +150	Pub. #150.5
			2N884-2N889					
0.80		C103	None	TO-18 size(2)	Lead mounted, small size, low cost, high sensitivity.	−65 to +125	−65 to +150	Pub. #150.7
1.10	25 thru 300	C8	2N1929-2N1935	See Pub. #150.12(2)	Lead mounted, double ended, 30 ampere surge.	−65 to +125	−65 to +150	Pub. #150.12
1.60	25 thru 200	C6	None	TO-5(3)	Lead mounted, medium sensitivity.	−40 to +125	−40 to +150	Pub. #150.8
		C7	2N2344-2N2348		Lead mounted, very high sensitivity.	−65 to +125	−65 to +150	Pub. #150.11
	25 thru 400	C5	2N2322-2N2329		Lead mounted, high sensitivity. Meets MIL-S-19500/276.			Pub. #150.10
			2N2322A-2N2329A					
	50 thru 400	None	2N1595-2N1599		Lead mounted, low sensitivity.	−65 to +150		Pub. #150.15
4.00	15 thru 200	C106	None	Flat Pack(4)	Tab and/or lead mounted; high sensitivity, low cost.	−40 to +110	−40 to +150	Pub. #150.9

*Number in parentheses corresponds to outline drawing.

MEDIUM CURRENT SCR'S

Current Rating Amps. RMS Max.	Peak Voltage Range	Product Types GE	Product Types JEDEC	Package*	Significant Product Features	Temperature—°C Junction T_J	Temperature—°C Storage T_{STG}	For Further Information Refer to Applicable Specification Sheet
7.40	25 thru 400	C10	2N1770A-2N1777A	TO-64(5)	Medium current, high temperature. Meets MIL-S-19500/108.	−65 to +150	−65 to +150	Pub. #150.20
	25 thru 600	C11	2N1770-2N1778		Medium current, general purpose.	−65 to +125		Pub. #150.21
			2N2619					
	25 thru 400	C12	None		Same as C11, except with 12 μsec. turn off (max).			Pub. #150.25
8.00	25 thru 600	C15			Limited temperature range, general purpose.	−65 to +105		Pub. #150.22
	50 thru 400	C122		Power Pac(6)	Plastic package, round leads, glass-sealed junctions.	−40 to +100	−40 to +125	Pub. #150.35
10.0	25 thru 500	C20†		Stud (¼-28) (7)	Limited temperature range, general purpose.	−40 to +100	−40 to +100	Pub. #150.30
		C22†		Press Fit(8)				
16.0	25 thru 500	C36	2N1842-2N1850	TO-48(9)			−40 to +125	Pub. #160.19
25.0	25 thru 400	C30†	None	Stud (¼-28) (7)			−40 to +100	Pub. #160.27
		C32†		Press Fit(8)				
		C31†		Stud (¼-28) (7)	Same as C30 and C32, except has 9.0 mA, I_{GT} (max).			
		C33†		Press Fit(8)				
	25 thru 800	C37†		TO-48(9)	Limited temperature range, general purpose.	−40 to +105	−40 to +105	Pub. #160.23
		None	2N681-2N692		Medium current, general purpose.	−65 to +125	−65 to +150	Pub. #160.22
		C35	None		Similar to 2N681-92 series with specified dv/dt, di/dt, t_{off} and I_H. Meets MIL-S-19500/108.			Pub. #160.20
35.0	25 thru 400	C40			Similar to C35, except has 12 μsec. turn off (max).			Pub. #160.25
	25 thru 500	C38			Similar to C35, except has high temperature.	−65 to +150		Pub. #160.30
	50 thru 400	C140	2N3649-2N3653		High speed for applications to 25k Hz., 15 μsec. turn off.	−40 to +120		Pub. #160.35
		C141	2N3654-2N3658		Same as C140, except has 10 μsec. turn off.			
	500 thru 1200	C137	None		High voltage, 100V/μsec., 150A/μsec., 360 amp. surge. 40 mAdc trigger I @ T_C= 25°C, 75 μsec. turn off.	−40 to +125	−40 to +150	Pub. #160.45
	600 thru 1200	None	2N5204-2N5207		Similar to C137—For general purpose phase control applications—100A/μsec. di/dt—300A surge.			Pub. #160.46

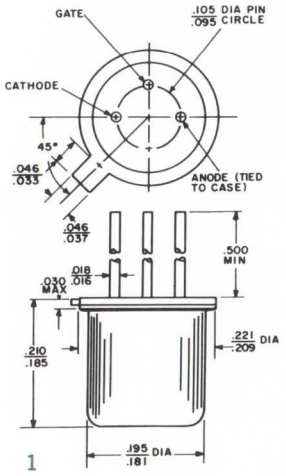
HIGH CURRENT SCR'S

Current Rating Amps. RMS Max.	Peak Voltage Range	Product Types GE	Product Types JEDEC	Package*	Significant Product Features	Temperature °C Junction T_J	Temperature °C Storage T_{STG}	For Further Information Refer to Applicable Specification Sheet
55.0	25 thru 900	C46	None	TO-49(10)	General purpose.	−40 to +125	−40 to +150	Pub. #170.17
		C45		Flag Terminal(11)				
	500 thru 1200	C145		TO-103(12)	Compact size, high voltage, high dv/dt.		−40 to +125	Pub. #170.18
110.0	25 thru 900	C50	2N1909-2N1916	TO-49(10)	General purpose, high power.		−40 to +150	Pub. #170.20
		C52	2N1792-2N1798	Flag Terminal(11)				
	25 thru 600	C55	None	TO-49(10)	Same as C50 and C52, except with 20 μsec. turn off (max.).			Pub. #170.21
		C56		Flag Terminal(11)				
		C60	2N2023-2N2030	TO-49(10)	Same as C50 and C52, except has 150°C junction temperature (max.)	−65 to +150	−65 to +150	Pub. #170.26
		C62	None	Flag Terminal(11)				
	100 thru 600	C154		TO-49(10)	High dv/dt, 10 μsec. turn off for inverter applications.	−40 to +125	−40 to +125	Pub. #170.35
		C156		Flag Terminal(11)				
		C155		TO-49(10)	Same as C154 and C156, except has 20 μsec. turn off.			
		C157		Flag Terminal(11)				
	500 thru 1200	C158		TO-49(10)	Amplifying gate, very high di/dt, soft firing, 30 μsec. turn off time for high frequency applications.			Pub. #170.36
		C159		Flag Terminal(11)				

* Number in parentheses corresponds to outline drawing.
† Isolated-case versions available.

GENERAL ELECTRIC

OUTLINE DRAWINGS



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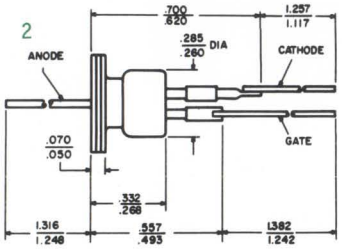

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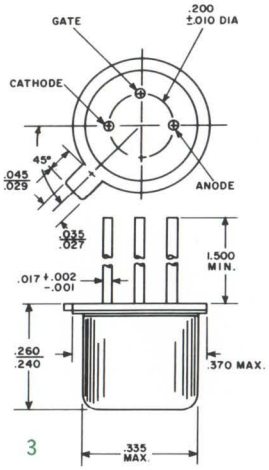

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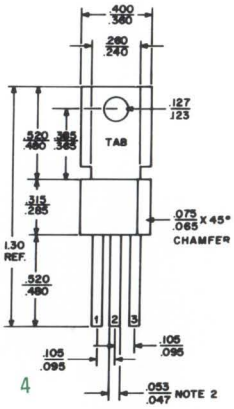

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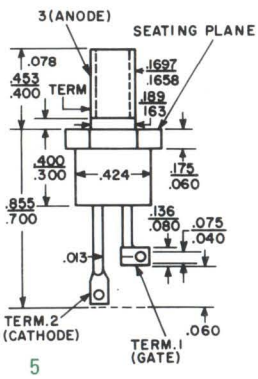

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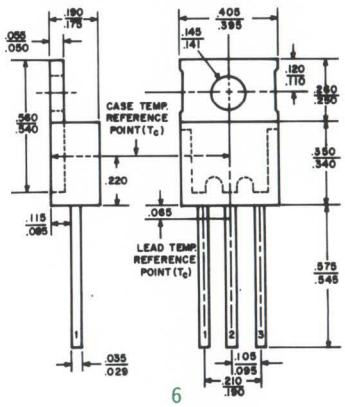

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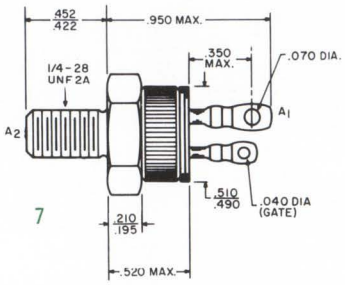

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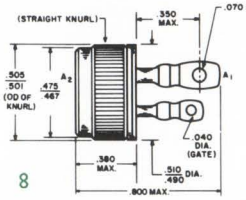

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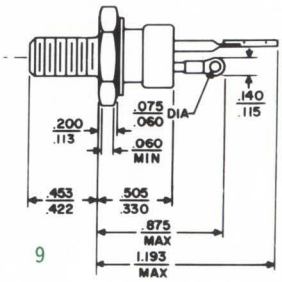

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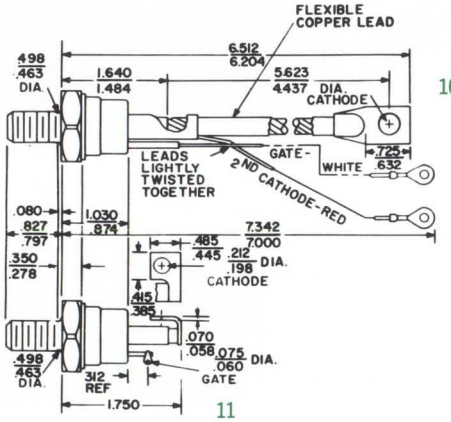

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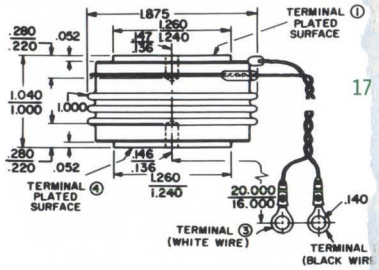

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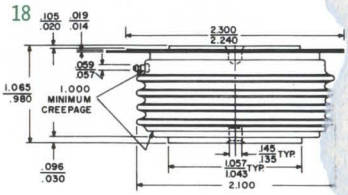

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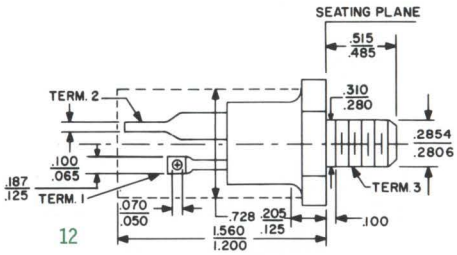

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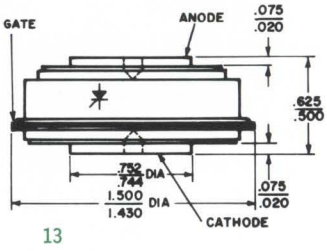

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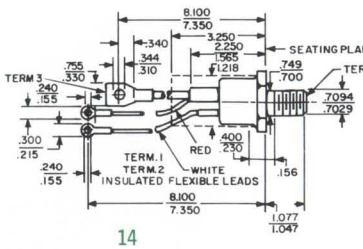

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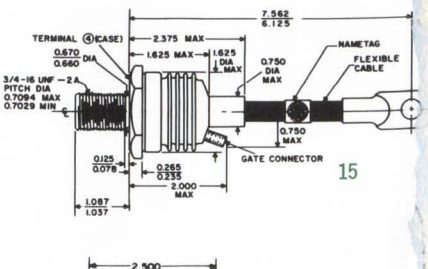

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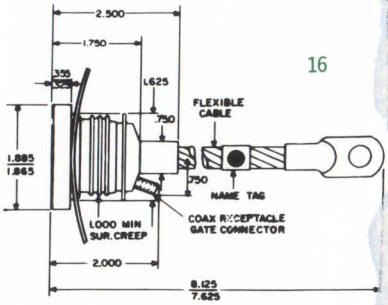

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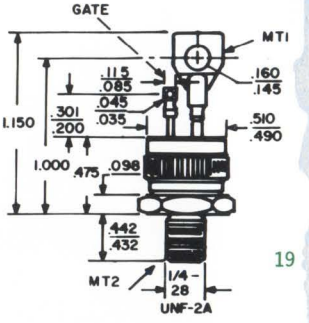

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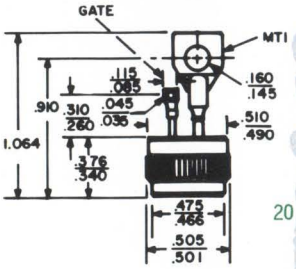

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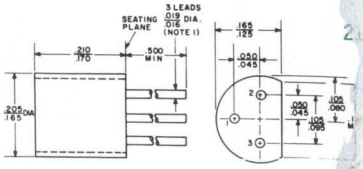

2

GENERAL ELECTRIC

TRIACS

Current Rating Amps. RMS Max.	Peak Voltage Range	Product Types GE	Product Types JEDEC	Package*	Significant Product Features	Temperature °C Junction T_J	Temperature °C Storage T_{STG}	For Further Information Refer to Applicable Specification Sheet
3.00	50 thru 400	SC35‡	None	Stud (¼-28) (7)	Designed for 60 Hz. AC switching and control applications, such as lamp dimming, motor speed and temperature controlling, and static switching.	−40 to +100	−40 to +125	Pub. #175.19
		SC36‡		Press Fit(8)				
6.00	50 thru 500	SC40‡		Stud (¼-28) (7)				Pub. #175.20
		SC41‡		Press Fit(6)				
	200 thru 400	SC141		Power Pac(6)	Plastic package, round leads, glass-sealed junctions.			Pub. #175.15
10.0	50 thru 500	SC45‡		Stud (¼-28) (7)	Same as SC40 & SC41.			Pub. #175.20
		SC46‡		Press Fit(8)				
	200 thru 400	SC146		Power Pac(6)	Same as SC141.			Pub. #175.15
15.0	50 thru 500	SC50‡		Stud (¼-28) (7)	Same as SC35, 36, 40 & 41.	−40 to +115		Pub. #175.20
		SC51‡		Press Fit(8)				
25.0	200 thru 500	SC60‡		Stud (¼-28) (19)	Similar to SC40 & SC50 series, except with higher current rating. High dv/dt, handles 6 kW at 240 V.	−40 to +115		Pub. #175.21
		SC61‡		Press Fit(20)				

* Number in parentheses corresponds to outilne drawing.
‡ Isolated-case and 400 Hz versions available.

SILICON CONTROLLED RECTIFIERS

Voltages from 15 to 1700 volts

Current ratings from ½ to 1125 amps

Lead mounts, plastic power pacs, stud mounts, press fits, press paks

TRIACS

Voltages from 50 to 500 volts

Current ratings from 3 to 25 amps

Stud mounts, press fits, plastic power pacs

General Electric also offers a complete line of switch and trigger devices to be used with these triacs and SCR's. For more information about UJT's, programmable unijunctions, silicon switches and diacs, ask for the line folder on triggers on the reply card below.

GENERAL ELECTRIC

Want more information on a specific triac or SCR?
Would you like a salesman to call?
Fill out this postage-paid reply card and mail today!

☐ Please send complete spec sheets on the following SCR's: _____

☐ Please send complete spec sheets on the following triacs: _____

☐ Please send line folder (pub. no. 60.01) on trigger devices.

☐ Please have a salesman call.

MY GE DISTRIBUTOR IS: _____

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CITY _____ STATE _____ ZIP _____

HIGH CURRENT SCR'S, CONT.

Current Rating Amps. RMS Max.	Peak Voltage Range	Product Types GE	Product Types JEDEC	Package*	Significant Product Features	Temperature—°C Junction T_J	Temperature—°C Storage T_{STG}	For Further Information Refer to Applicable Specification Sheet
110.0	500 thru 1300	C150	None	TO-49(10)	High voltage, high dv/dt, all-diffused.	−40 to +125	−40 to +125	Pub. #170.23
		C152		Flag Terminal(11)				
180.0	500 thru 1300	C350		Press Pak(13)	Electrically similar to C150 with increased current capability. Pressure mounted.			Pub. #170.54
	100 thru 600	C354			High dv/dt, 10μsec. turn off for inverter applications.			Pub. #170.37
		C355			Same as C354, except has 20 μsec. turn off			
	100 thru 1200	C358			Amplifying gate, similar to C158 with increased current capability.			Pub. #170.38
235.0	100 thru 1300	C180		TO-93(14)	High voltage, high dv/dt, all-diffused.		−40 to +150	Pub. #170.52
	100 thru 600	C185			Similar to C180, except with 20 μsec. turn off (max.)			Pub. #170.53
	700 thru 1700	C280		Stud (¾-16) (15)	Very high-voltage.		−40 to +125	Pub. #170.58
		C281		Flat Base(16)				
370.0	100 thru 1300	C380		Press Pak(13)	Electrically similar to C180 with increased current capability. Pressure mounted.			Pub. #170.56
	100 thru 600	C385			High dv/dt, 20 μsec. turn off for inverter applications.			Pub. #170.57
450.0	100 thru 700	C510		Press Pak(17)	High dv/dt, 15 μsec. turn off time. Very high di/dt for inverter and chopper applications.**			Pub. #170.80
470.0	50 thru 1200	C290		Stud (¾-16) (15)	High voltage, high current.			Pub. #170.60
		C291		Flat Base(16)				
	100 thru 1200	C398		Press Pak (18)	Amplifying gate, very high di/dt, soft firing, 30 μsec. turn off time, pressure mounted.			Pub. #170.45
625.0	100 thru 600	C506		Press Pak (17)	High dv/dt, 35 μsec. turn off time for inverter applications.**			Pub. #170.76
	100 thru 1400	C507			Same as C506, except with 100 μsec. turn off time.**			Pub. #170.77
	100 thru 1200	C508			Same as C506, except with 60 μsec. turn off time.**			Pub. #170.78
850.0	700 thru 1700	C501			Very high voltage, high dv/dt for general purpose use.**			Pub. #170.70
1000.0	100 thru 600	C530			Electrically similar to C501.**			Pub. #170.82
1125.0	100 thru 400	C520			Electrically similar to C501, except has 150°C T_J max.**	−40 to +150	−40 to +150	Pub. #170.81

*Number in parentheses corresponds to outline drawing.
**Available separately, or in factory-assembled air- and water-cooled heat exchangers.

NOTE: For definitions of symbols and terminology used, refer to Chapter 2, 4th Edition of GE's SCR Manual (Pub. #ETR 3875 is the SCR's 10th Anniversary Issue).

HAPPENINGS IN ELECTRONICS

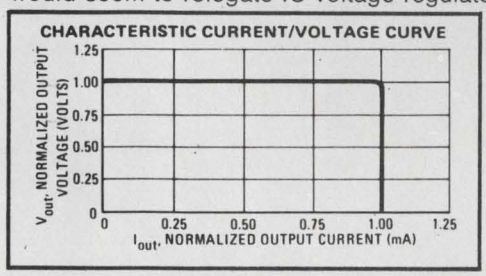
October, 1969

Schweber makes history with Allen-Bradley!

Allen-Bradley has selected Schweber Electronics as their first distributor of electronic components. This marks the first such appointment in the sixty years of Allen-Bradley's history. Schweber prices will be the same as the factory in specified quantities. Among the components Schweber is now privileged to sell from stock are fixed composition resistors that meet or exceed all applicable military specifications including the new Established Reliability specification MIL-R-39008A at the highest level—the S level. Other stocking items will be the A-B types J and G potentiometers to MIL-R-94C, carbon trimming potentiometers, and ceramic feed-thru capacitors. For a complete brochure on all Allen-Bradley electronic components, circle #241.

Motorola Voltage Regulator Circuit joins LIC hit parade.

Linear integrated circuit technology takes its second great leap forward with the Voltage Regulator circuit. (The Op Amp circuit was the first.) It would seem that the microscopic size of monolithic devices offers insurmountable barriers to the creation of effective voltage regulators on a single chip. The limitations imposed on voltage and current by size would seem to relegate IC voltage regulators to marginal applications. But Motorola has changed this picture by introducing a monolithic voltage/current regulator circuit that "floats" on top of the output voltage of the power supply and thus is not subject to voltage limitation! Actually, the only restriction on the range of voltages that can be regulated is the breakdown voltage rating of the external pass transistor, and this maximum of several hundred volts can be adjusted all the way down to zero volts. Designated MC1566L (commercial version MC1466L), this exciting new circuit is immediately available from Schweber stock. The commercial version sells for 12.75 each in 1 to 24 pc. quantities, the military for 36.75 each in similar quantities. For technical literature circle #242.



Fairchild trains big guns on Op Amps.

In the meanwhile, the monolithic Op Amp continues to proliferate in all directions. Of the last seventeen LICs to come off the drawing boards at Fairchild, ten are Op Amps: High Speed 715; Instrumentation 725; Micropower 735; Dual Low-Noise High-Gain 739; Frequency-Compensated 741; Radiation-Resistant 744; Dual Internally Compensated 747; High Performance 748; and last but not least, the plain Jane of the Op Amps, the Dual 749. But in spite of its plain name, the Dual Op Amp749 has some unusual features. The output stage is a class A common emitter PNP circuit with collectors uncommitted, features which are not usually found in OP Amps. This permits ORing of the dual outputs and makes possible such applications as a Dual Level Comparator circuit, Strobing with independently strobed outputs, and Peak Voltage Detection without external diodes. All ten devices are stocked at Schweber. To receive all ten data sheets, circle #243.

μA749

Dual Op Amp

92 dB Voltage Gain
±11V Common Mode Range
20 MHz Bandwidth
No Latch-up
Output Short Circuit Protected

U6A7749393		
1-24	25-99	100+
5.95	4.75	3.49
U6A7749312		
17.95	14.35	11.95

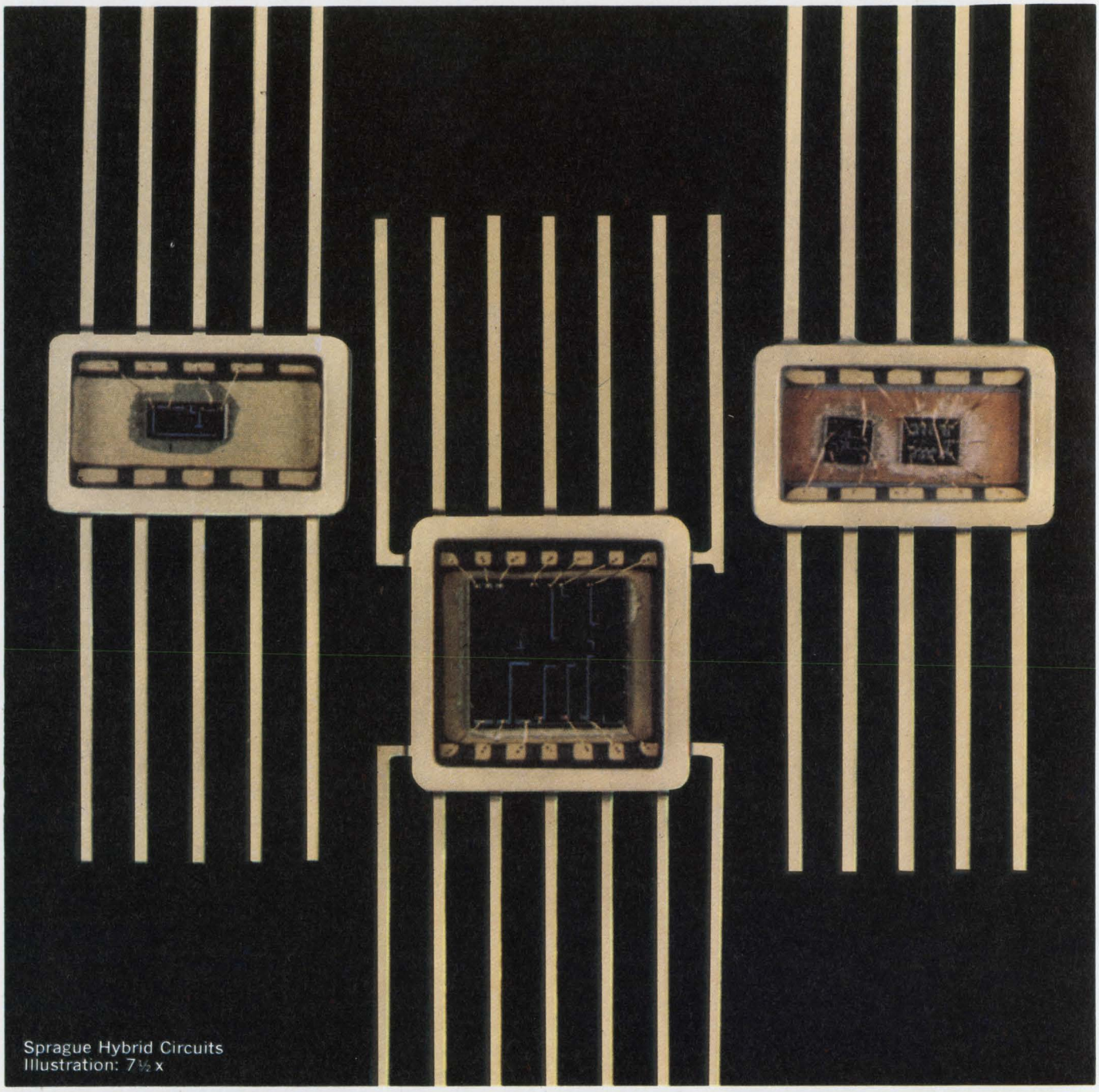
Review of new catalogs:

1. RCA's Solid State Product Guide is now available just off the press. This 48-page catalog has a unique arrangement of characteristics by type number. Thirty-four pages of charts list parameters ranked in order of a significant rating or characteristic. The charts are grouped under three major categories (AF, RF, Switching & Pulse) which in turn are further sub-divided. Thus, this product guide serves a two-fold function:—it provides data on a specific type and provides types for a specific application. Circle #244.

2. A Master Selection Guide to Motorola semiconductor devices and a price list for an appendix is available from Schweber. The guide lists all of Motorola's many device categories including Zener diodes, Rectifiers, Thyristors, Bipolar & FET transistors, Opto-electronics, Varactors, Digital & Linear ICs. The tables include only basic specifications to permit quick comparison and preselection of semiconductors that are most suitable. Circle #245.

SCHWEBER ELECTRONICS

Latest news on new products and prices from Schweber Electronics, Westbury, N.Y. 11590 (516) 334-7474 . . . Edited by Sam Kass



Sprague Hybrid Circuits
Illustration: 7½ x

Look. Look into a 10-bit D-to-A with 2.8 MHz count rate.

Get 10-bit accuracy with only eight packages. You get ladder networks, ladder switches, and buffers. Just add a PC board and the fastest Op Amp you can find.

Only 240 mW total power dissipation. There's no speed/power trade-offs with these new Sprague Hybrids. And you save space, too. The circuits are in ¼″ x ¼″ and ⅛″ x ¼″ ceramic flatpacks, for operation −55 to +100° C.

Other D-to-A hybrids from 4 bits...

can be made from our standard line of packaged ladders, switches and buffers. Get the high accuracy tantalum resistor ladder alone, or a complete kit for up to 12 bits. Start your conversion to Sprague hybrids now.

4SS-9116

Call Sprague Info-Central (617) 853-5000 extension 1969.

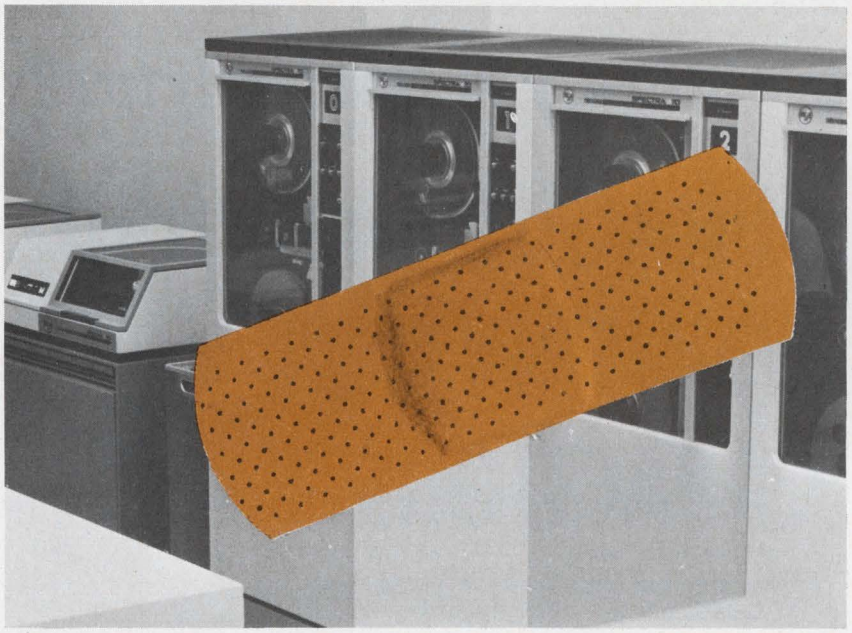
Or call your Sprague industrial distributor. He has the 10-bit 2.8 MHz circuits on the shelf. For complete specification data, circle the reader service number below.

SPRAGUE®
THE MARK OF RELIABILITY

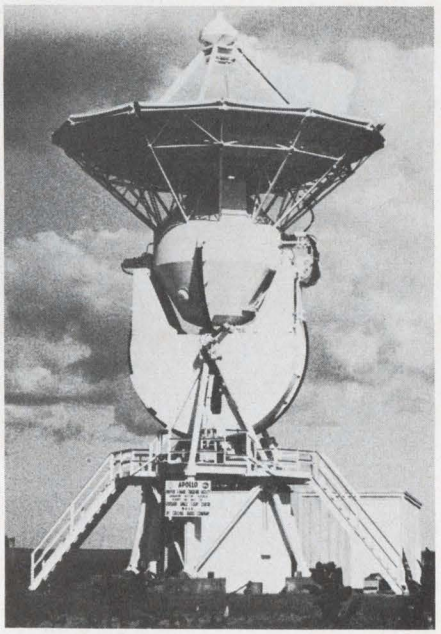
INFORMATION RETRIEVAL NUMBER 14

News

The venerable Hall-effect device is finding ever wider use in a variety of industrial and aerospace applications. Here, a Hall current-measuring system monitors up to 50,000 amperes dc, used in refining bauxite ore for aluminum production. p. 38.



A computer that can spot its own failures and then repair itself is a necessity for long space voyages. JPL has designed a prototype. p. 32.



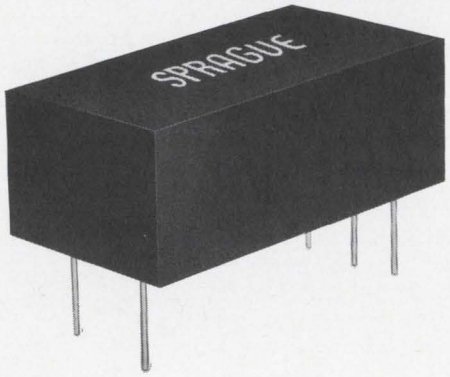
Telemetry manufacturers see end of two-year slack period. p. 25.

Also in this section:

IR device said to improve cancer detection. p. 28.
LSI computer to cut time-sharing costs. p. 52.
News Scope, p. 21 . . . **Washington Report,** p. 47 . . . **Editorial,** p. 71.

For bandpass signal control without inductors...

Select SERIES JF33-2000 ACTIVE FILTERS



Developed for a variety of bandpass signal control applications. Combine both high performance and small size. Offer circuit designers a ±7.5% bandwidth, 20 db gain, and center frequencies from 400 Hz to 14.5 kHz. Precise capacitor and resistor components plus integrated amplifiers provide extremely stable performance at temperatures from −25 C to +75 C. Available in encapsulated construction. Meet vibration, shock, moisture resistance, thermal shock, and immersion cycling requirements of MIL-F-18327.

INFORMATION RETRIEVAL NUMBER 821

4SF-9163

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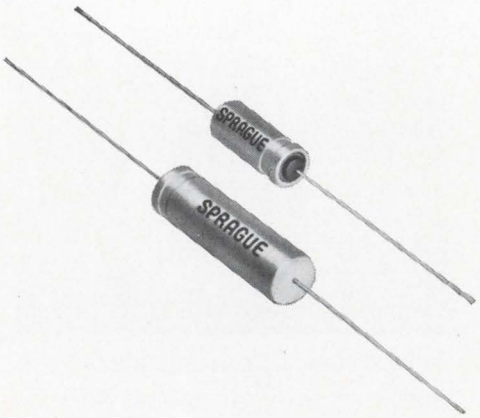

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News Scope

Nixon approval of SST welcomed by industry

The decision by President Nixon to proceed with development of a U.S. supersonic transport is sparking high interest in the electronics industry. A number of vital onboard systems and major ground systems will have to be developed, and the market for operational systems is, as one industry source put it, "very respectable."

In addition to conventional electronics, the SST will require a myriad of warning systems, complex navigation and landing systems, advanced cockpit instruments, long-range radar, and malfunction detection and alarm equipment. At a price tag of up to $45-million each and potential world sales of up to 1200 aircraft, avionics suppliers have an important market for exploitation.

The SST program must still be approved by Congress, but if it is (and a tough fight is expected), electronic needs for the plane are expected to fall somewhere between 10 to 15 per cent of the total cost. The Boeing Co. is prime contractor for the aircraft, and General Electric is the engine developer. Electronics supplies will be selected by Boeing over the next several years.

The Nixon Administration will seek an appropriation of $96-million for fiscal 1970 and the release of some $90-million in carry-over funds. This falls short of the $212-million Boeing officials had sought to keep the program on a 1972 flight schedule.

The cost of building and developing two prototypes is estimated at $1.6-billion, in all. Expenditures to date by U.S. industry and the federal government are estimated at nearly $550-million.

Because of its 1800-mph speed and 70,000-ft. altitude flight design, the SST will require highly sophisticated electronics. The Air Line Pilots Association has urged a number of system requirements to assure aircraft and passenger safety. For example, it has recommended satellite relay of VHF voice communications and a continuous data link for updating air traffic, navigation and weather information.

It proposes inertial guidance as the primary navigational subsystem, but urges a backup system, such as improved Loran or a satellite navigational system, to cross-check inertial accuracy. It also urges improved pictorial displays with pre-programmed flight direction—for example, computer-driven moving map displays.

The pilots' association proposes that all major flight systems be tri-redundant, so that a malfunction in one element can in no way cause intersystem failure.

Also, because of the operational characteristics of the craft and the unique flight environment, the pilots see a need for many warning systems. These include a positive collision-avoidance system, meteorological sensors for weather prediction, forward-looking weather radar out to 300 nautical miles, radiation detectors, equipment-malfunction monitors with a central warning system, and a means for detecting clear-air turbulence.

Navy will switch to solid-state relays

The Navy plans to replace most of its electromechanical relays in airborne systems with solid-state devices by the mid-1970s.

Its program was outlined at a recent "think-in" seminar on relays, sponsored by the Ohmite Corp. in New York. Leonard Wendling, program manager of the Engineering Support Group, Avionics Div., Naval Air Systems Command, Washington, D. C., explained that the work was being planned by Project Sostel (solid-state electric logic), which he manages.

Until recently, one problem in using solid-state relays has been their inability to switch currents of more than 1 ampere. But recent developments have made available solid-state relays that can switch up to 10 amperes.

Wendling said that 90 per cent of all avionic systems presently use 3 amperes or less in switching by electromechanical means.

Airlines demonstrate anti-collision system

The pilots in two planes—the one a Martin 404 jetliner, the other a Fan Jet Falcon—flew at each other on a collision course. Suddenly alarms beeped and a panel indicator flashed the instruction "Dive" to one pilot and "Climb" to the other. The two planes passed each other safely.

It was a test flight to demonstrate to the public the airlines' progress in developing a 13-year-old concept: a cooperative type of collision-avoidance system. The demonstration, put on by Martin-Marietta from its airfield in Middle River, Md., was sponsored by the Air Transport Association as part of a program that has cost some $2-million and required about 300 hours of flight time so far.

The collision-avoidance system is being developed by Bendix Avionics, Fort Lauderdale, Fla., McDonald Douglas, St. Louis, and a team from Wilcox Electric, Kansas City, Mo., and Sierra Research, Buffalo, N.Y.

The system uses atomic clocks to keep precise track of time in cooperating aircraft and at two ground stations, one at the Martin field at the Federal Aviation Administration Experimental Facility in Atlantic City, N.J.

In operation, each aircraft transmits a short burst of data in digital form, giving its altitude and other information. Only one aircraft transmits at a time, with all the others listening, until their turn comes to transmit. Computers in each plane determine relative positions and rates of closure, and

News Scope CONTINUED

also indicate to the pilots the evasive maneuvers to take.

Initial versions for the air carriers are expected to cost from $30,000 to $50,000. Estimates of the ultimate cost for a general-aviation (private flying) version range from $2,000 to $10,000.

A prime limitation of the system is that it does not detect any plane that does not have the equipment on board. To help breach this gap, much effort is being expended on low-cost proximity warning indicator systems, which only tell the pilot: "Watch out!" The main efforts here center on infra-red detection systems that are triggered by the infra-red energy of flashing Xenon lights, now in common use on all planes.

The airlines expect to complete tests on their prototype by the end of this year.

Low-cost color TV player demonstrated by RCA

Selecto Vision players that will attach to any standard color TV set and display prerecorded programs were demonstrated by RCA at its Princeton, N.J., laboratory last week. According to Dr. James Hillier, executive vice president, RCA Research and Engineering, the player is expected to be the first consumer product to employ lasers and holography. The Selecto Vision players will play one-half and full-hour recordings made on tape of clear, inexpensive material such as is used in supermarkets to wrap and display meats.

Production will commence in 1972, according to Chase Morsey, Jr., executive vice president, RCA Operations Staff, with delivery shortly thereafter. The target price for the player, he stated would be $400. A library of 100 original program albums in half- and full-hour lengths will be offered at the same time; project price for a half-hour program is set at $10, Morsey added.

Robert W. Sarnoff, RCA president, noted that this is the first time an RCA Laboratories' project has reached the demonstration stage with its own record of exhaustive market studies to define the nature and extent of the demand that can be expected.

Wall-sized displays are 100 times brighter

A Charactron tube for projecting computer-generated text, graphics and analog information on a wall-sized screen has been stepped up to emit 100 times more light than the standard Charactron tube.

Developed by Stromberg DatagraphiX, a San-Diego-based subsidiary of General Dynamics, the Charactron process produces minute characters and lines on the tube face, which are then projected onto the screen by means of a reflective optical system. Coupled with the appropriate software, the new tube displays information at computer speeds. The company plans to market the system to both industrial and military groups.

The extra brightness was achieved by improving the efficiency of the electron gun. This was done by removing, from their normal internal location, the electron beam controlling elements and mounting them on the outside of the tube. This reduces the distortions and allows a higher percentage of the emitted beam to reach the Charactron matrix and ultimately the viewing screen.

Semiconductor leaders discuss the market

When four presidents of the nation's leading semiconductor companies got together at a panel meeting sponsored by the IEEE Electron Devices Group in Sunnyvale, Calif., last month, what was the topic of conversation? Prices of course.

C. Lester Hogan of Fairchild, Robert R. Noyce of Intel, James Riley of Signetics and Charles Sporck of National Semiconductor agreed that the marketplace continues to be the prime factor in determining prices.

"In some applications," said Hogan, "it would be ridiculous to talk about selling semiconductor devices at $5 apiece because there is no market at that price . . . You have to establish your price at what the market is willing to pay and then try like hell to make a buck doing it."

Noyce agreed, pointing out that in the specific market Intel is aiming for—memories—the price is set by cores at about a penny a bit.

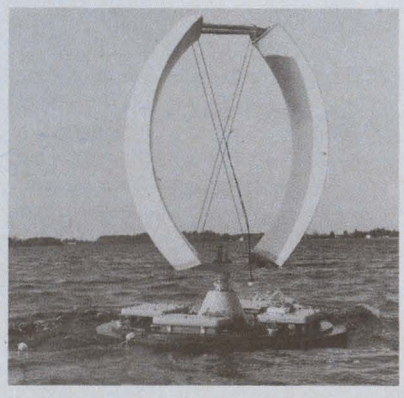
"We can't possibly meet those prices today," he said, "but we can certainly look forward to matching them and eventually to cutting them in half."

Sporck—whose company has just announced price reductions of 60% on 17 field-effect transistors—termed price-cutting practices "terrible" and blamed them on "immature management."

Noyce countered by arguing that "if you look back at history, profitability has been almost inversely related to price."

Hogan agreed, noting that "This is an era when the price of discretes has never been lower and yet that's where most of the money is being made in our industry today. In fact, if one plots the life cycle of devices, it appears you make the most money on any device after it stabilizes into a high-volume business at low prices."

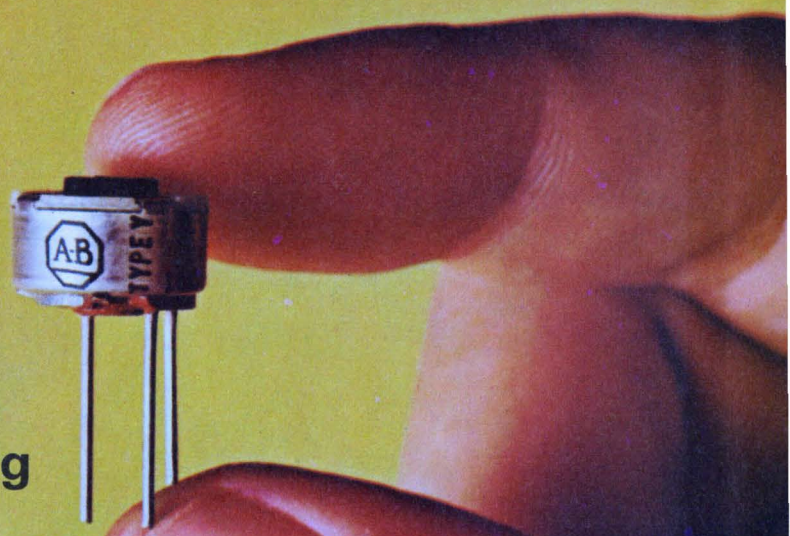
Robot sailboat



A robot sailboat developed by RCA can navigate itself unmanned by radio command to any point on the world's seas. The craft employs movable sails and rudders plus electronic navigation to proceed to a designated point. It will hold its station until commanded to move elsewhere.

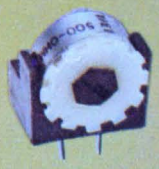
LOW PROFILE

hot-molded trimmer for close circuit board stacking



Basic Type Y unit shown actual size

With wheel for side adjustment



With attachment for horizontal mounting and wheel for side adjustment

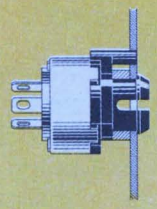
With attachment for horizontal mounting

Type Y single turn trimmer is especially designed for use on printed circuit boards. It has pin-type terminals for use on boards with a 1/10″ pattern. And the low profile easily fits within the commonly used 3/8″ space between stacked printed circuit boards.

For greater operating convenience, the Type Y can be supplied with an optional thumb wheel for side adjustment, or an optional base for horizontal mounting, or both. The Type Y enclosure is splash-proof as well as dust-tight, and the metal case is isolated to prevent accidental grounding.

While featuring a new low profile, this new Type Y trimmer retains the popular Allen-Bradley solid resistance element, which is produced by A-B's exclusive hot-molding technique. With virtually infinite resolution, adjustment is smooth at all times. Being essentially noninductive, the Type Y can be used at frequencies where wirewound units are inadequate. The Type Y is rated 1/4 watt at 70°C and is available in resistance values from 100 ohms to 5.0 megohms. Standard and special tapers are available.

For immediate delivery at factory prices, call your authorized A-B industrial electronics distributor. Or write: Marketing Dept., Electronics Div., Allen-Bradley Co., 1201 South Second Street, Milwaukee, Wis. 53204. Export Office: 1293 Broad St., Bloomfield, New Jersey, U.S.A. 07003. In Canada: Allen-Bradley Canada Ltd.



Type Y with handy snap-in panel mount, supplied with spacers for use on panels up to ⅛″ in thickness

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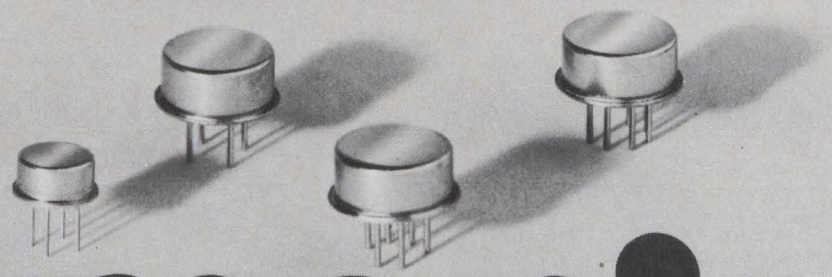

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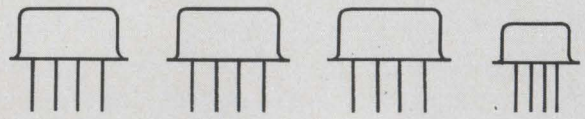


MODEL NO.	6347 MA	6347 MB	6348 MA	6348 MB
Center Frequency	10.7 MHz ± .5 KHz	10.7 MHz ± 1 KHz	21.4 MHz ± .5 KHz	21.4 MHz ± 1 KHz
Bandwidth, 3 dB	6 KHz min	15 KHz min	6 KHz min	15 KHz min
Bandwidth, 40 dB	24 KHz max	50 KHz max	24 KHz max	55 KHz max
Ripple, Max	1 dB	1 dB	1 dB	0.5 dB
Insertion Loss, Max	3 dB	2 dB	3 dB	2 dB
Spurious Returns	> 40 dB down	> 30 dB down	> 30 dB down	> 20 dB down
Terminations (Resistive)	1.5 kilohms	3.9 kilohms	0.38 kilohms	1.3 kilohms
Ultimate Atten.	55 dB	50 dB	50 dB	45 dB
Op. Temp Range	0°-60° C	0°-60° C	0°-60° C	0°-60° C
Case	TO-8	TO-8	TO-8	TO-5

DAMON

Telemetry is down, but don't count it out

Delegates to Washington conference look for new applications in military, space and business areas

John F. Mason
Military-Aerospace Editor

If there was one point on which everyone agreed at the International Telemetering Conference in Washington, D. C., it was that business is slow. "Most companies in our industry are fairly hungry," said Miller S. Redden, Jr., president of DEI Industries, Rockville, Md.

Mark Mougel, marketing director of Radix Telemetry Corp., Anaheim, Calif., agreed:

"The whole industry has been in the doldrums since Apollo and Saturn got out of the design and development stage and into operational hardware. This covers at least the past two years."

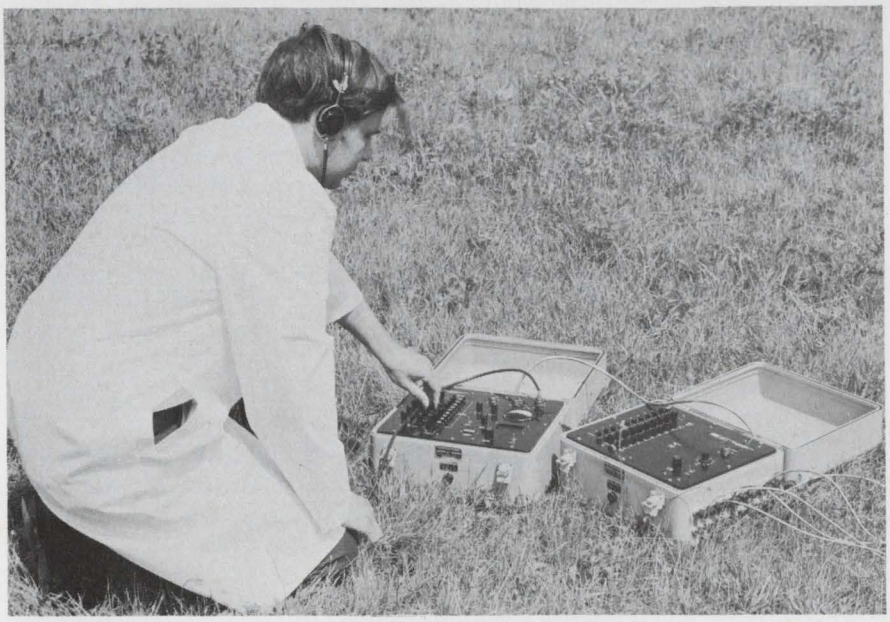
The main market that has slowed to the near-panic point is, of course, instrumentation of the nation's missile ranges. The ranges are relatively complete, except for replacement of equipment as it wears out.

But most of the 1100 delegates from the nation's telemetering equipment makers—200 companies were represented—also agreed on another point: better times are coming. When and from what source, however, depends on the company's specialty, marketing philosophy and how optimistic it is.

Pentagon business expected

What if the current mood in Congress cuts defense work severely? "It won't," was the general answer.

"Some companies refuse to believe that some of their business has dried up," warned a spokesman for a big instrument house, who asked to remain anonymous. "I know people who just can't accept the fact that the Air Force's MOL [manned orbiting laboratory] and the Navy's SAM-D [surface-to-air missile] are dead. If they don't go out and find a new market, *they're* dead!"



A 10-channel alarm system built by DEI Industries warns of intruders within a 3.6-million-square-foot area. Called AIDS-10, the system employs buried geophone sensors that are linked by wire to a multiplexer.

Radix's Mougel, an articulate young observer of the Government scene, comments on what he considers a more subtle marketing blind spot: "Many companies miss the boat by spreading themselves too thin. They go out and grab any contract they can get, finally ending up with a completely diverse line of products. Our philosophy is to settle on one area in which we know we are competent and try to get as many contracts for that family of products as we can."

Radix makes modular, pulse-code-modulation, data-acquisition devices for the Navy's Poseidon missile, the Minuteman missile, re-entry warheads and other classified missiles. These systems are, needless to say, one-shot products, some costing in the neighborhood of $10,000.

Mougel looks to a build-up in military business and explains why.

"There's been such a delay in so many Defense Dept. programs because the money's being spent in Vietnam and because of Congress' tough attitude on the military," he said, "that the state of the art has passed the military by, leaving it with obsolete equipment.

"The situation has become so bad—especially in view of how advanced Russian equipment is and the growing Chinese potential—that they've got to do something.

"They've learned a lot in Vietnam. Much of the equipment didn't operate well and has to be redesigned."

Summing up his military market forecast, Mougel said: "We're seeing, right now, a spurt of buying. I've seen more business in the last three months than I've seen in a year.

"The Defense Dept. is channeling money into areas of known practicality. We're going forward suddenly with procurement of real hardware."

Examples of the big new programs that will shoot lifeblood into the telemetering business are the Navy's F-14 carrier-based fighter,

needed to replace the F-111B that never got off the deck; the Phoenix air-to-air-missile, which will arm the F-14; the S-3A antisubmarine warfare carrier-based aircraft; classified missiles, re-entry warheads, and now, perhaps, the Advanced Strategic Manned Aircraft, to replace the aging B-52 bomber. Also expected is a new fighter for the Air Force—the F-15 to replace the F-4.

"Taking MOL from the Air Force and giving it to NASA means a loss for telemetry equipment makers," Mougel said. "NASA will use hardware it already has, whereas the Air Force would have had to develop it. And, of course, much of our business depends on the development phase of a program."

The main roadblock, Mougel said, is the exhaustive scrutiny Congress is giving all military programs. "Although this certainly isn't all bad," he conceded, "it can aggravate one problem: The Defense Dept. has always had a tendency to procrastinate in getting on with programs. This will make them worse."

Space contracts foreseen

What if the space program is drastically reduced? "It won't be," was the consensus.

This optimistic response was partly borne out the last day of the conference, Sept. 17, when the President's Space Task Group published its anxiously awaited report. Although it did not recommend a crash program for putting a man on Mars, it called for a substantial continuation of the nation's exploration of the moon and planets; the establishment of military space systems, and a big program for building stations to orbit the earth and the moon.

How much new ground equipment the ranges will buy to support this space work is debatable. Elie J. Baghdady, technical program chairman of the conference and president of Adcom, a Teledyne company in Cambridge, Mass., said that the vhf receiver market had dried up but that the uhf had not. He referred to an order to the national ranges to shift from vhf to uhf by 1970. In cases where this has not been done, translators have been installed to convert the uhf signals received from missiles and spacecraft to the old vhf receivers. Baghdady believes, however, that these vhf receivers will be replaced. If they are, DEI's Redden said, it will mean a market of approximately $4.5-million.

"But such a buy," Redden added, "would probably take place, piecemeal, over the next five years as vhf receivers wear out.

"The range market is not a closed door by any means," Redden continued. "We're selling our new TMR-74 receiver because it's better than anything they've got.

"It includes 9 rf amplifiers which determine the predetection bandwidth, which is selected by a front panel switch. The receiver also has an automatic frequency control feature that holds on to faded signals, waiting for them when they come back. The future for range receivers is the computer-controlled device.

"We're also selling a new bit synchronizer analyzer."

Some companies are still working for the range on contracts awarded before business dried up. "We're not hurting," said George A. Lynn of Symetrics Engineering Corp., Satellite Beach, Fla. "We were saved by a large contract, awarded three years ago, that has carried us through this slump. We're selling L- and S-band equipment to White Sands Missile Range, and L-, S- and P-band to the Pacific range. We're now looking forward to work on some of the ambitious programs lined up for space."

Potential in communications

Predictions for exactly how much and what kind of support will be bought for future space missions differed at the conference. One of the big hopes was that NASA would move quickly to start development of a data-relay satellite system for communication with the many satellites and spacecraft expected to be operating in the solar system in the next 10 years. According to Baghdady: "This would be a $300-million to $400-million market. It would also be the first step toward communications for an earth-orbiting laboratory."

ITT, New York City, is looking for its major telemetry business in satellite systems.

Mougel sees telemetery in a number of commercial applications of the future. "I see it in oil-well drilling rigs, in dams under construction, in reservoirs, in pipelines," he said. "And the more complex the operation you're monitoring, the more complex your equipment will have to be."

He cautioned, however: "But the potential here will be slower in coming than many people believe."

Baghdady believes this market will open up soon. Not only for the commercial uses that Mougel expects but for urban improvements as well: for control of water and air pollution and for street traffic.

DEI's Redden observes:

"Medical electronics is a growing market but it's hard for a small company to know where to invest its money. Communication between doctors and the electronics industry needs to be improved. The equipment must be extremely reliable, safe and cheap enough for hospitals to afford."

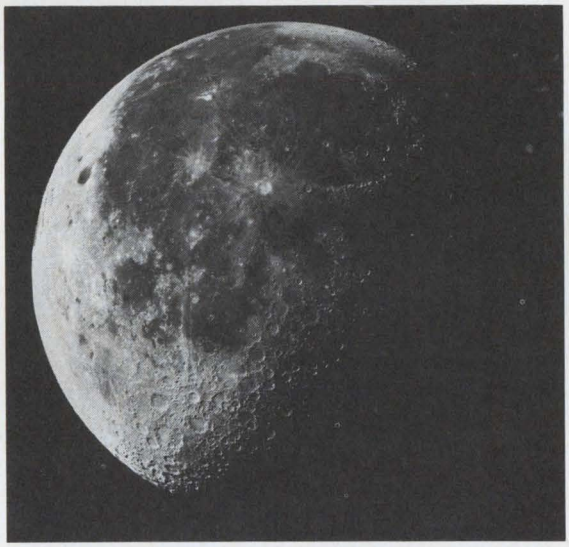
Industrial telemetry is another area manufacturers eye wistfully, but real research into the problems of unrelated businesses and how electronics can solve them is required.

ITT and DEI are both looking for a big market in personnel-intrusion detection devices to supplement closed-circuit television systems now used by banks, apartment houses, stores and factories.

DEI has built two seismic units, one big enough to monitor national borders and a smaller unit that military troops can carry and set up around a camp. ITT has developed an anti-intrusion device that is acoustic. In an industrial version, it works in conjunction with a seismic unit; for a military version it employs radar.

"A vast opportunity," Bahgdady said, "lies in two areas: automatic checkout systems for telemetry, and multifunction receivers—receivers that by modulation can receive tracking, command and communication all on one signal, or at least on signals not too far apart in the spectrum." ■■

Signetics was on the ball.



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INFORMATION RETRIEVAL NUMBER 17

IR device said to improve cancer detection

Autonetics sensor reported an order of magnitude more sensitive than other infrared instruments

Elizabeth deAtley
West Coast Editor

A new infrared temperature-sensing device developed to detect flaws in microcircuits may be sensitive enough to detect cancer up to a year and a half before the disease can be spotted by expolratory surgery.

So says Dr. E. F. Marriner, director of Life Sciences Operations at Autonetics, Anaheim, Calif., developer of the sensor. A research program being carried out at Autonetics, with the cooperation of specialists, is showing encouraging results, Dr. Marriner says, not only in the detection of early cancer but also of vascular disease, bone and joint disease, varicose veins and even early pregnancy. All these conditions affect the heat distribution pattern of the skin and can therefore be detected by a highly sensitive temperature-sensing device.

Medical infrared detection systems have been on the market for some years. But according to Dr. Marriner, the Autonetics thermographic device is more than an order of magnitude more sensitive than any of these systems. It can detect temperatures down to 0.02°F. Most of the instruments on the market today detect temperature differences of only 0.2°F.

The Autonetics detector is yielding results in early detection of breast cancer, Dr. Marriner says, that are comparable to mammography—the X-ray technique currently used for diagnosis.

According to R. Ward Jones, a member of the technical staff of Autonetics' Systems Div. and one of the designers of the instrument, it owes its extraordinary sensitivity to signal-processing techniques similar to the image enhancement done on lunar photos that are telemetered to earth from space probes. The device consists of an infrared radiometer, a minicomputer and a CRT display.

"In our system," Jones points out, "the radiometer scans the scene point by point. Each point is then converted to a digital number, which is processed by the digital computer and displayed on the CRT screen. The image is either photographed or recorded on magnetic tape."

The photos show differences in temperature as variations in shades of gray and differences in height—giving a 3D effect. Thus the cooler spots in the photo are whiter and stand above the surrounding hotter areas.

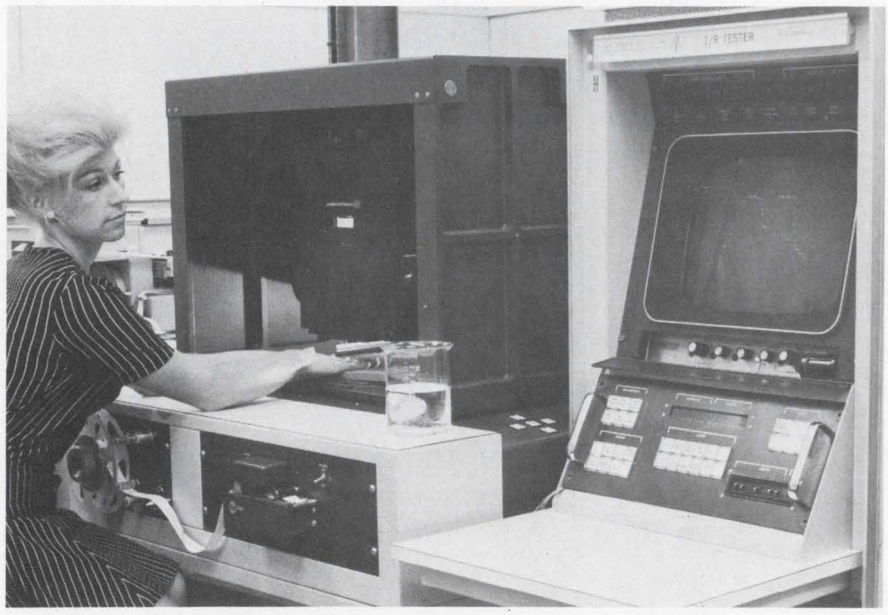
As an example of its sensitivity, Dr. Marriner points out, the device will detect subtle changes in the heat distribution of a smoker's finger before and after he smokes a cigarette, due to the effect of the nicotine on his circulatory system.

"If you take a picture of a smoker's finger four or five hours after he has had a cigarette and then take another picture just after he has had a drag, it almost scares you to death," Dr. Marriner says. "The heat pattern on the finger has changed markedly."

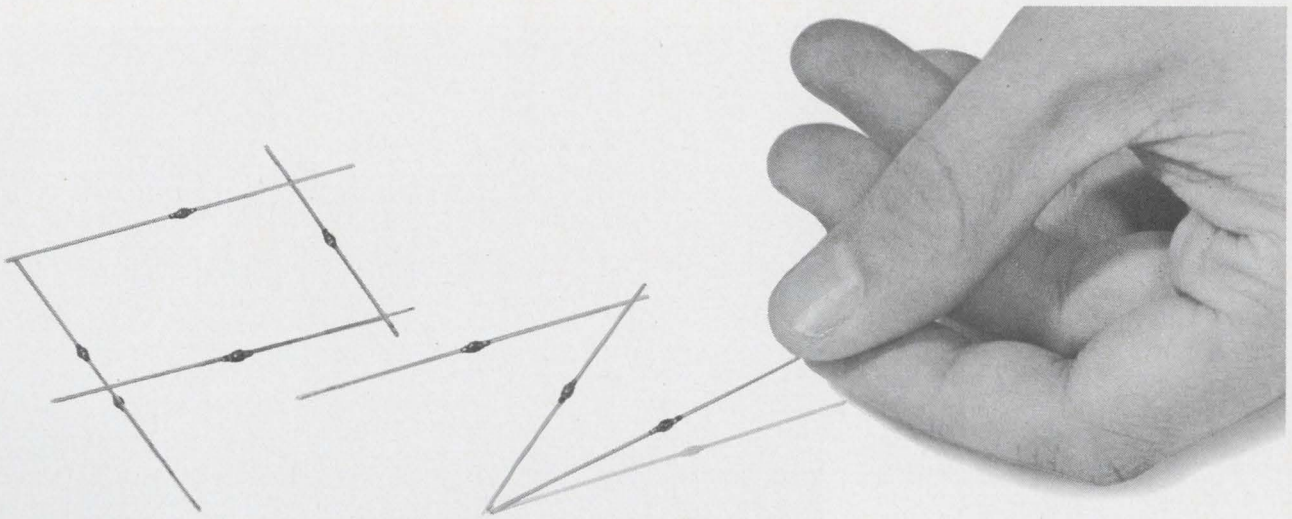
The changed heat pattern, he points out, is due to changes in the flow rate of the blood caused by constrictions of the blood vessels in the finger.

These local constrictions may, in turn, indicate that the smoker has some arteriosclerosis of the coronary arteries and therefore may be subject to a heart attack at some later time, according to Dr. Ashutosh Roy, a heart specialist and staff member of Life Sciences Operations at Autonetics.

Changes in the heat pattern of the skin may indicate a variety of causes besides a change in the blood flow rate in the subcutaneous veins, Dr. Roy notes. Local abnormalities, such as incipient cancer in some part of the body, will also



IR temperature-sensing instrument, developed at Autonetics to detect flaws in microcircuits, detects minute temperature differences on the surface of the human body and displays them on a CRT screen.



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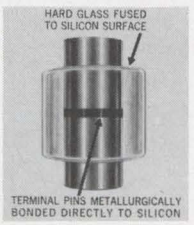

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INFORMATION RETRIEVAL NUMBER 18

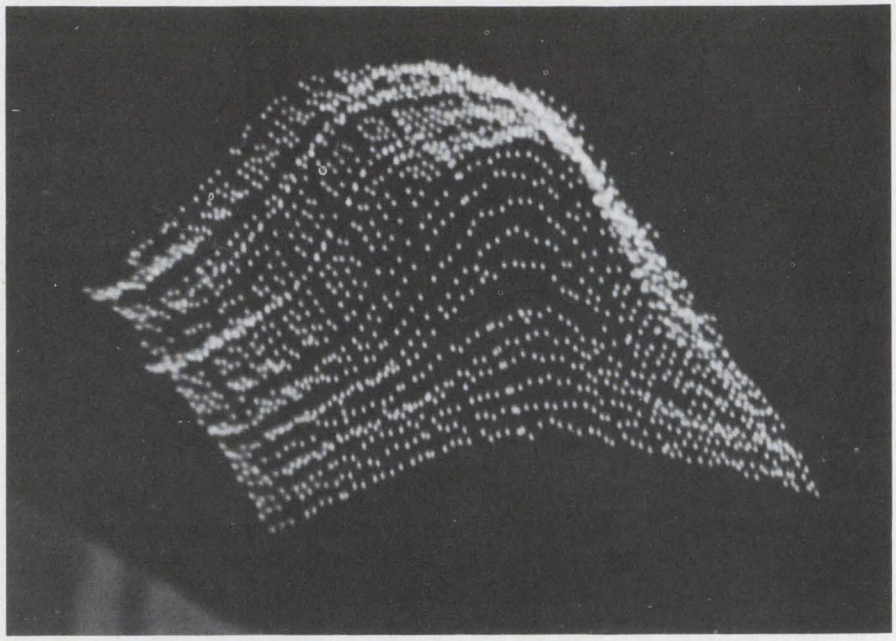
(**Cancer Detector** *continued*)

cause a "hot spot" in the skin above it.

"A cancer of the breast, for example, shows up on a picture of the whole body as a local hot spot in that area," Dr. Roy points out. "Then if the doctor wants to examine that spot in more minute detail, we have a zoom system which allows him to zero in on that spot and determine exactly how much heat it is generating. Any of the commonly found breast cancers give a certain known amount of heat—about 8° to 10°F above the surface body temperature near the afflicted area.

"There can also be hot spots due to an inflammation of the breast—an abscess, for example. But in that case, the heat generated would be somewhat higher. So if we relate the quantity of heat generated to the type of abnormality, we can diagnose more precisely."

Although interpretation of the photos is difficult—in view of the number of possible reasons for the appearance of a hot spot—Dr. Roy indicates that specialists at Autonetics, a division of North Amerian Rockwell, and others in the medical community feel they have a powerful diagnostic tool and that, with practice, they can accurately interpret the photos. A research program is under way to develop nomograms to simplify the ask of diagnosis. ■■



This is what a human fingertip looks like normally to the Autonetics instrument. The warmth at the tip stands out in a 3D effect. After smoking, the hot and cold pattern would change markedly.

Moon rocks analyzed for clues to human life

How did life originate? The moon rocks brought back by the Apollo 11 astronauts may help answer this question, say scientists at NASA's Ames Research Center, Mountain View, Calif., where the rocks are being pulverized, leached by organic solvents, bathed in helium, broken into molecular fragments and shot through electric fields to isolate and identify any traces of organic materials they may contain.

Electronics is playing an important role in this isolation and identification process. Tools for the search include:

- Chromatographs with electronic detection systems.
- Mass spectrometers.
- Microdensitometers.

And of course the computer.

Preliminary investigation at the Houston Manned Spacecraft Center indicates that the lunar rocks, which appear to be as old as the earth itself, contain minute traces of organic materials. The Ames scientists hope to find out whether they contain any of the basic "building blocks" of which all living organisms are composed. These include the amino acids, sugars, nucleic acid bases, fatty acids, aromatic hydrocarbons, alkalines and porphyrin. Most of them have been synthesized in the laboratory.

The search for organics

"By analyzing the lunar samples, we are looking to see whether these same materials were formed in nature's own laboratory somewhere else than on the earth," says Dr. Cyril Ponnamperuma, chief of the Ames chemical evolution branch. "The theory is that any planet should experience some outgassing at some stage in its early history. If any of various forms of energy —such as ultraviolet radiation, electricity and others— act on this outgassing, the result is the synthesis of organic material in which will be found those molecules necessary for life. If we find such molecules in the lunar rocks, we will have pretty strong support for the hypothesis that life results naturally from the evolutionary sequence of matter."

Because of the minute quantities of organic materials in the lunar samples, extremely sensitive instrumentation is required for the analysis. Unknown organic materials are separated by some form of chromatography and then detected. When the separated substance is a liquid, it is commonly mixed with a color reagent and detected by a monochromatic photocell.

When the unknown substance is in gaseous form, flame ionization is the most sensitive detection technique. ■■

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Self-renewing computers reach for the stars

JPL prototype points way to models that will diagnose their own failures and repair them enroute

David N. Kaye
West Coast Editor

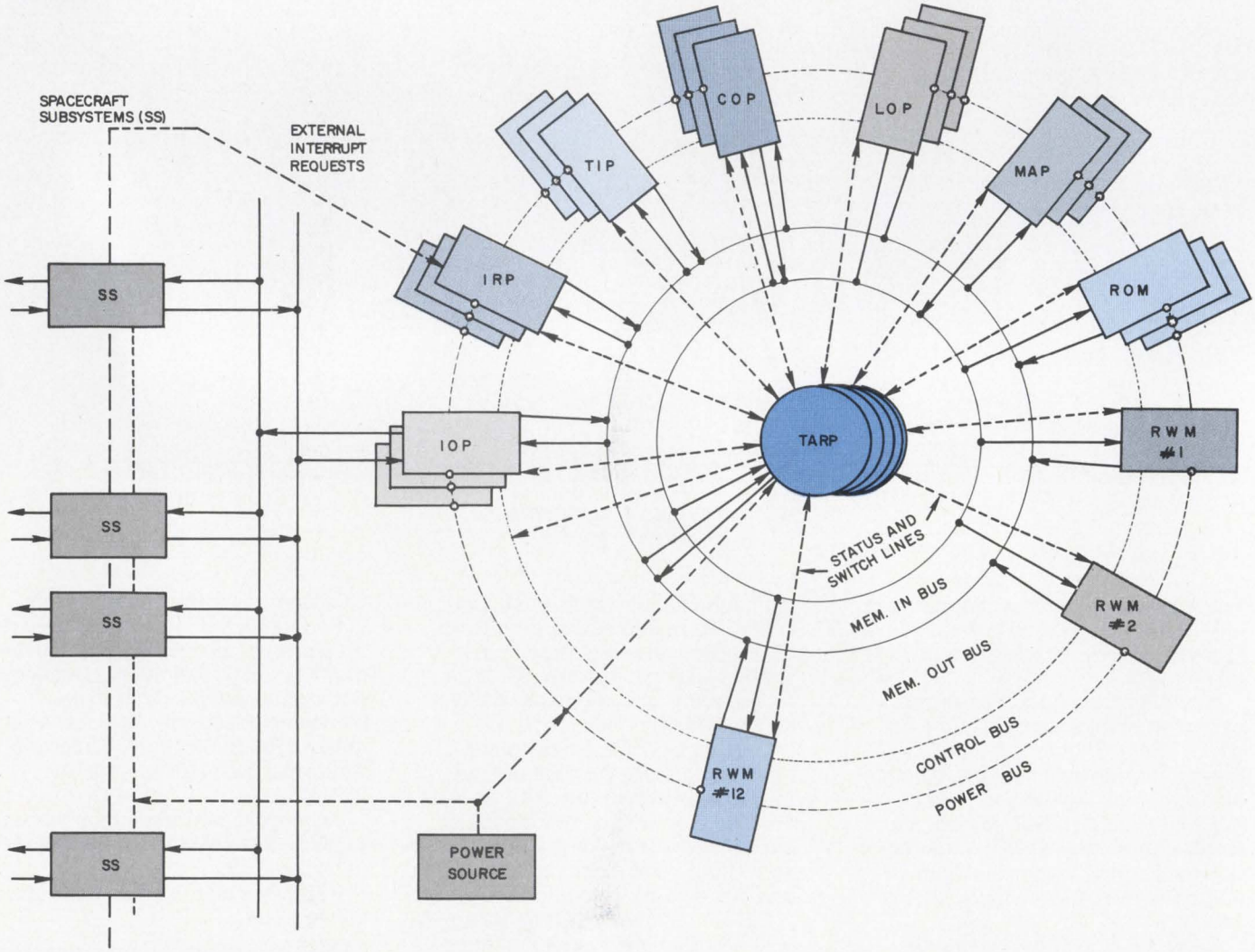
Unmanned spacecraft, embarking on space trips that require several years to complete, are going to need computers that are both self-controlling and self-maintaining. One such model—the first computer able to detect its own failures and repair itself—has already passed preliminary tests at the Jet Propulsion Laboratory in Pasadena, Calif. It is considered the first breadboard model for the spacecraft guidance systems of the 1970's and 1980's.

Called the STAR—for self-testing and repairing—the computer is essentially a replacement system. Each subsystem has one or more spares available that are held in an unpowered state and used to replace operating units when a permanent fault is discovered.

Not only will later models of the STAR aid spacecraft to navigate outer space—and intergalactic space beyond—but they can cut routine hospital work to a minimum for doctors and nurses by monitoring as many as 100 to 200 bed patients at a time. Failure of one of its parts would not interrupt the work, for within 1/100 of a heartbeat a faulty unit would be replaced by a spare, while the computer would request repair and return of the rejected unit to its spare-part bank.

This was reported on at the Aerospace Computer Systems Conference of the American Institute of Aeronautics and Astronautics held in Los Angeles last month.

Referring to the outer-space



Self-testing and repairing computer (STAR) block diagram. The computer is essentially a replacement system. Test and repair processor (TARP) monitors status reports from all working subsystems, and decides whether there is an error. If so, faulty unit is checked again before being replaced.

trips, Dr. Algirdas Avizienis, father of the STAR project, says "We are aiming for the 90% probability of lasting 15 years." That would be enough time to control spacecraft operations to Neptune or Pluto, outermost targets in multiplanet Grand Tours of the solar system envisioned by NASA for the late 1970's (see "Hop to Jupiter: Takeoff, 1972. Arrival, 1974," ED 10, May 10, 1969, p. 25).

A trip to Neptune, via Jupiter and Uranus, would take 7 to 9 years, and the trip to Pluto, by way of Jupiter and Saturn, up to 11 years, according to current NASA projections. On voyages such as these, self-control and self-repair would be imperative, since a radio signal from the earth to the vicinity of Neptune or Pluto would take some four hours, and four more hours would pass before a reply arrived.

Monitor uses majority vote

The monitor that keeps an eye on the inner workings of the computer is called TARP—test and repair processor. This monitor receives status reports from all working subsystems and, in effect, decides whether behavior is normal.

Furthermore, like any good conscience, TARP also checks itself. For this, it is built like a three-lobed brain. The computer actually has three active monitors, which operate by majority vote. Whenever at least two monitors indicate an anomaly somewhere along the line, the decision is made to repair the malfunction. The suspected unit is tried once more, then replaced if it persists in its errors.

"If the vote had been two to one," according to Avizienis, "the majority members of the TARP unit would disconnect the power of the disagreeing monitor and replace it with a spare. Later, the rejected member may be tried again and re-used if the previous fault proves temporary."

The organization chart

"The STAR computer," says Avizienis, "may be thought of as a collection of small special-purpose computers tied together by two 4-wire information buses." The buses are designated as the Mem-

(**computers,** *continued*)
ory-In Bus (MI Bus) and the Memory-Out Bus (MO Bus). Computer words of 32 bits are transmitted on these two buses in bytes of 4 bits each. As instruction words appear on the buses, each unit samples the operation code and performs the operation if required.

"For example," Avizienis points out, "if the command CLA 1000 appears on the MI Bus, the memory unit that contains the address 1000 outputs the required word onto the MO Bus. Simultaneously, the arithmetic processor unit loads the word appearing on the MO Bus into its accumulator register."

TARP controls replacement

Three control signals are sent from TARP through the 3-wire control bus to synchronize the operations of the functional units. Otherwise, these units operate autonomously. The functional units are identified as follows in the block diagram:

COP—The control processor—contains the location counter and index registers.

LOP—The logic processor—performs logical operations on data words (two copies are powered).

MAP—The main arithmetic processor—performs arithmetic operations on data words; it contains the accumulator and M/Q registers.

ROM—The read only memory—has 16,384 permanently stored words.

RWM—A read-write memory unit—has 4096 words of storage (at least two copies always powered, 12 units directly addressable.)

IOP—The input/output processor—contains a transfer register and peripheral unit buffer registers.

IRP—The interrupt processor—provides communication links with systems outside the computer.

TIP—The timing processor—acts as an interrupt-generating interval timer.

TARP—The test and repair processor—serves as a central controller and as the diagnosis unit. (Three copies are powered, two more are spares.)

CHK—bus checker. Two are contained in each TARP to check for coding errors in words being transmitted on the MI and MO buses.

Unless otherwise noted, one copy of each unit is powered at any given time.

Cure by replacement

According to Avizienis, the principal features of the STAR replacement system used to implement error diagnosis and repair are these:

- All machine words (data and instructions) are encoded in error-detecting codes to provide concurrent fault diagnosis. In other words, fault detection occurs at the same time as the execution of the programs.
- The computer is subdivided into a number of replaceable functional units containing their own operation code decoders and sequence generators. This decentralization of the system allows simple fault location procedures and simplifies system interfaces.
- Fault detection, recovery, and replacement are carried out primarily by special-purpose hardware. In the special case of memory damage, software is used to augment the recovery hardware.
- Transient faults are identified, and their effects are corrected by the repetition of a segment of the current program. Permanent faults are eliminated by the replacement of faulty functional units.
- The replacement is implemented by power switching; units are removed by turning the power off and connected by turning the power on. The information lines of all units are permanently connected to the buses through isolating circuits; unpowered units produce only logic "zero" outputs.
- The error-detecting codes are supplemented by monitoring circuits that serve to verify the proper synchronization and internal operation of the functional units.
- The hard core test and repair hardware is held to a small size and protected by complete replication and immediate replacement.

The Stanford Research Institute developed the magnetic power switch which disconnects faulty units, and the Massachusettes Institute of Technology Instrumentation Laboratory built the system's "read only" storage unit for permanent programs.

When the STAR flies

In its breadboard stages, STAR is now a 10-unit computer that can diagnose and cure a failure within 1/100 second. While the STAR test model fills three 6-foot racks now, Avizienis says that its parts can be miniaturized easily to fit spacecraft requirements. The flying STAR will not exceed 2 cubic feet in volume, nor consume more than 50 watts of electrical opwer.

Miniaturization of the computer will come through liberal use of MSI. At a later date, the JPL group may come up with an LSI version of the STAR computer that would be even smaller.

Medical use possibilities

On the earth, STAR could speed the development of the automated hospital. Avizienis says this computer could take routine measurements every second, look for abnormalities, and ring an alarm when something goes wrong in any bed in the ward or hospital.

Moreover, failure of one of its own parts would not cause STAR to forsake its vigil. Within 1/100 of a heartbeat, the faulty unit would be replaced by a spare. The computer would then request repair and return of the rejected unit to its spare-part bank.

Such split-second action also may save anxious moments for pilots of future supersonic passenger planes, and for astronauts on extended manned space flights in the coming decades. Avizienis explains:

"The flight-control STAR would automatically handle most malfunctions, making spare-part substitutions as needed. Only in rare cases of overwhelming fault conditions would the computer request the pilot or co-pilot to take over. And that alarm would be registered within a tenth of a second."

Copies of the proceedings of the conference can be obtained from the AIAA at $20 for members, $30 for non-members. Write to Preprints Dept., AIAA Subscription Service, 1290 Ave. of the Americas, New York, N. Y. 10019 ■■

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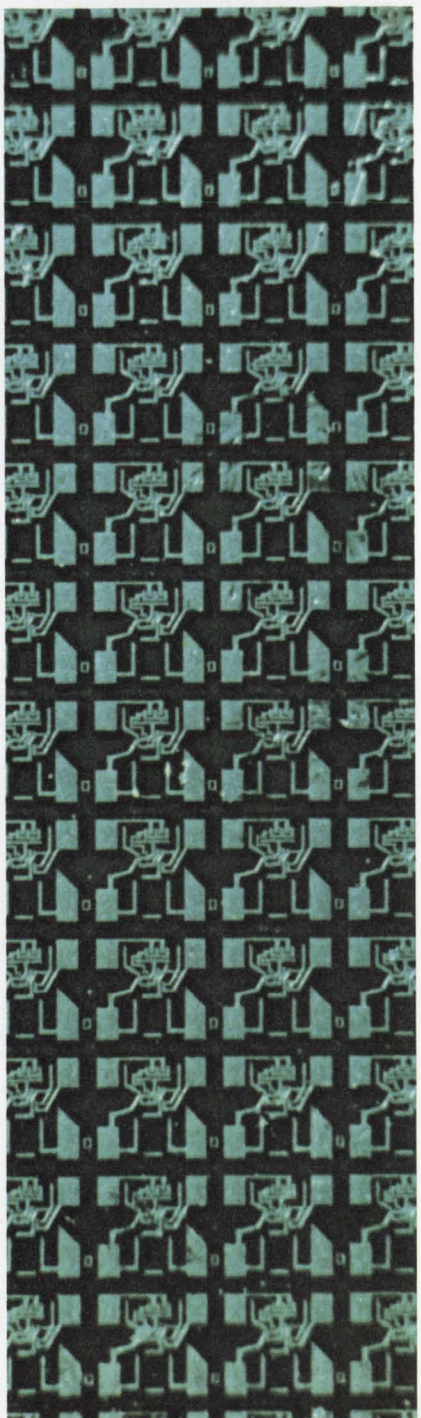
INFORMATION RETRIEVAL NUMBER 21

The Hall Effect: Success at 90

by Jim McDermott
East Coast Editor



Some 90 years after the discovery of the Hall Effect, solid-state, magneto-sensitive devices are at the threshold of wide application. The emerging technology embraces not only Hall devices—generators and magneto-resistors—but two new devices: the magneto-diode and magneto-sensitive transistor.

This success follows four false starts in the development of Hall devices in this country in the last 10 years. The first premature venture was the introduction of these devices, in 1959, by Siemens of Germany. U.S. ventures included their manufacture by Ohio Semiconductor (See p. 68), Beckman Instruments, and Westinghouse five or six years ago. In general, these ventures failed to catch on in the U.S. because of four major shortcomings: The devices were too costly, too complicated to apply, unstable in changing temperatures and not especially reliable.

But with the vast strides in semiconductor technology in the last three years, a brighter picture is emerging. Thin-film devices have brought the cost down, temperature stability has been improved and reliability is substantially better. The devices are still somewhat complicated to apply, but their other advantages are outweighing this drawback.

Today Hall devices are turning up in the following applications:

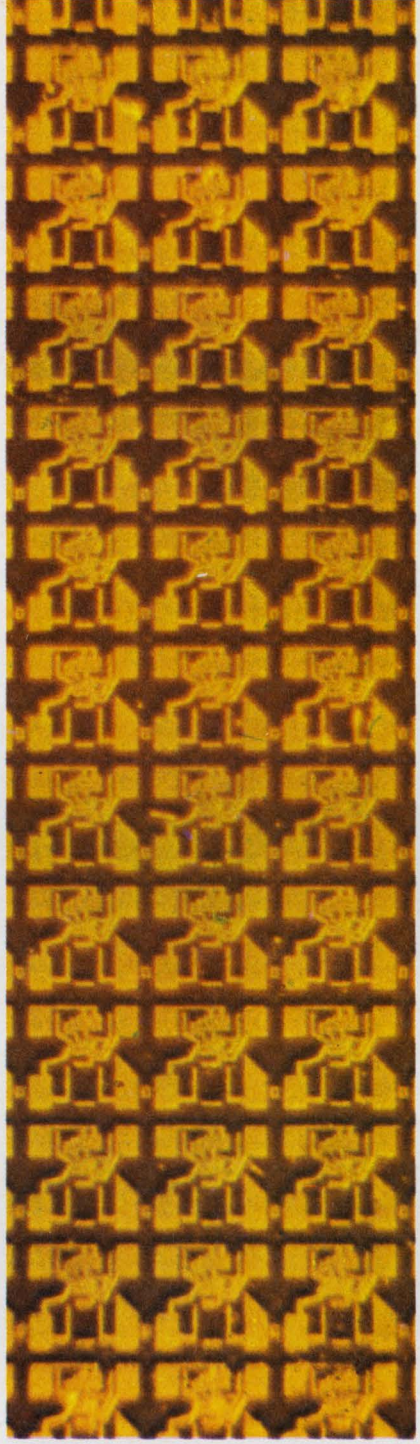
- In solid-state contactless switches for computer terminal and instrument keyboards.
- As a computer printer paper-feed positioning control.
- In a gyroscope pickoff for the Boeing 747 Carousel inertial navigation system.
- As an aircraft two-axis compass element for an autopilot heading control.
- In brushless motors for precision video tape drives, 150,000-rpm laser-beam scanners, lunar vehicle drives and spacecraft attitude control systems.

Arrays shown on these pages are diced into chips for the Honeywell solid-state, contactless Hall switch.

New devices still unproved

The magneto-diode and magneto-sensitive transistor—called a Magnistor—are, as yet, still unproved devices. But they are competitive in both price and sensitivity with Hall devices, and potentially they have comparable applications.

Magneto-diodes, which were introduced by Sony of Japan last year are sensitive, low-level devices that change resistance under the influence of a magnetic field. They are fabricated as thin, rectangular slabs of germanium with P+



doping at one end and N+ at the other. The magneto-sensitivity is due to a change in the mean effective lifetime of injected carriers, which are deflected by the applied magnetic field.

The response is unique at room temperature, in that the resistance increases with one direction of field, while a reversal of field decreases it. However, the devices are highly temperature-sensitive, and at about 35°C the bidirectional effect ceases and there remains only a decrease in resistance for either direction field.

Partial compensation for temperature change is obtained by using magneto-diodes in fabricated matched pairs.

Magnistor: a patented device

The newest magneto-sensitive device to make the scene is the Magnistor, a transistor invented and patented by Edward C. Hudson Jr., president of Hudson, Inc., Manchester, N.H. The Magnistor, which is now available in sample quantities, is a twin-collector device fabricated on a microcircuit chip and sealed in glass.

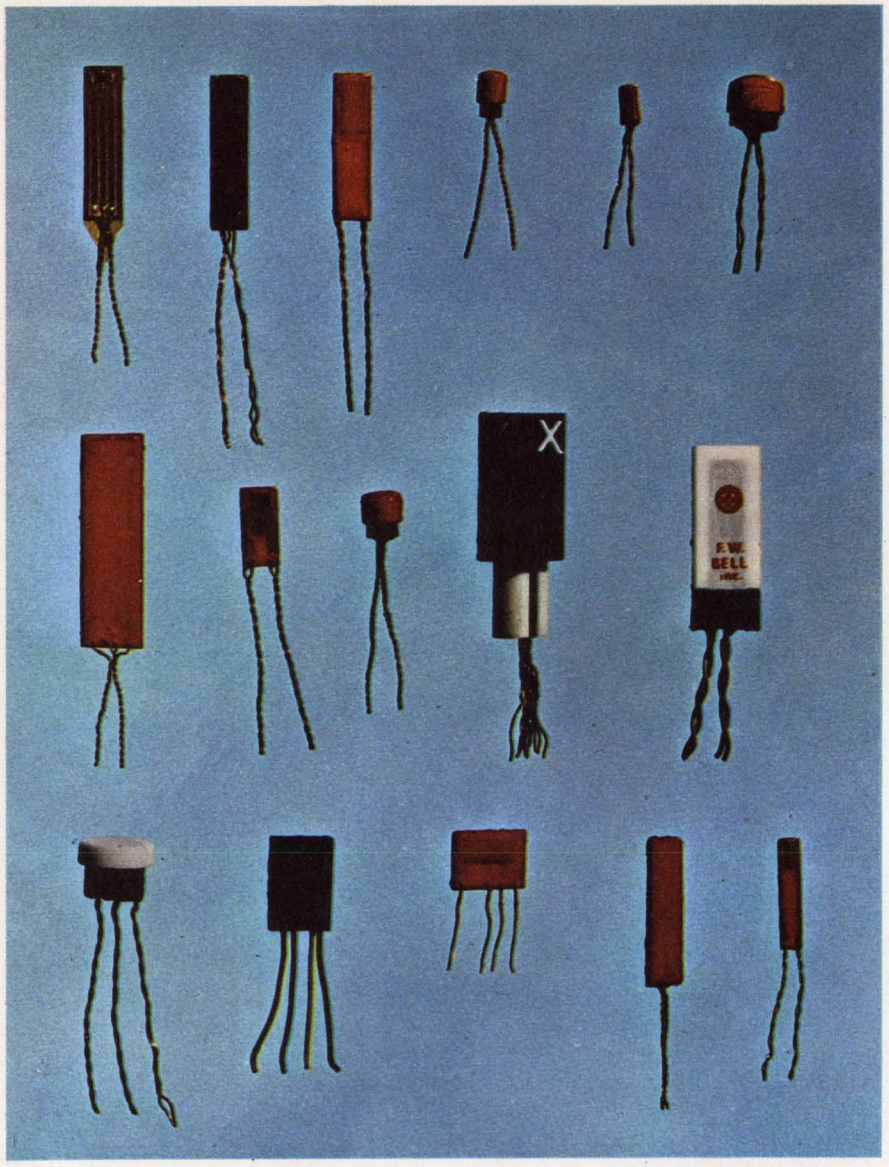
According to Hudson, when in the quiescent state with zero flux incident on it, the collector current is shared equally by both collectors, and the differential voltage between the collectors is zero. With application of a magnetic field, the depletion layers adjacent to the collectors are distorted, unbalancing collector currents and producing a differential voltage between collector loads.

The sensitivity of the Magnistor is high, making it well adapted for use with weak fields.

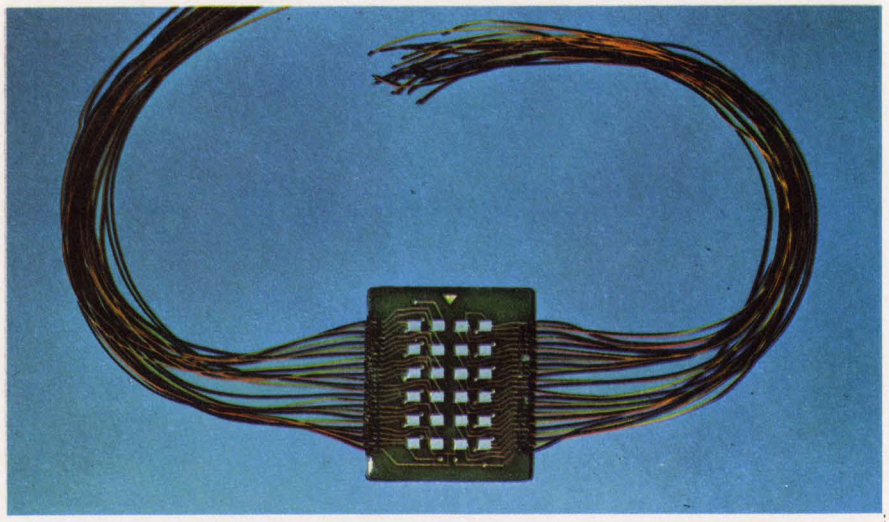
Compounds form Hall devices

In Hall devices, the current progress in materials and semiconductor technology has produced generators of micron-thin wafers or of deposited thin films with sufficient output, linearity and temperature stability for a wide range of uses—from dc to microwave

Magneto-sensitive devices are starting to go into wide use as former obstacles of cost and stability are overcome—Two new devices join rising trend



A wide variety of Hall generators is available. Those above from F. W. Bell, Inc., include devices for transverse and axial magnetic field applications, as well as a special three-axis probe. Packaging includes miniature and subminiature versions, as well as ferrite mountings.



This array of 24 thin-film "flip chips" made by F. W. Bell, forms a hybrid Hall generator assembly suitable for high-density keyboards.

instrumentation.

While silicon and germanium exhibit the Hall Effect, Hall generators are made of the intermetallic compounds of indium antimonide (InSb), indium arsenide (InAs) and indium arsenide phosphide (InAsP), because these materials are orders of magnitude more sensitive.

The Hall voltage is obtained by passing a magnetic field at right angles through the generator and passing control current through it. Typical outputs for Hall generators are bounded by a lower open-circuit output of 5 mV per kilogauss, extending to an upper limit of 70 mV per kilogauss (Fig. 1).

Special, high-sensitivity probes have outputs considerably higher. The use of flux concentrators of ferrite or permalloy, attached to the Hall generator, improve the effective sensitivity several hundred fold. This is particularly useful for working with weak magnetic fields, such as the earth's.

When a Hall generator is placed in a magnetic field, the resistance increases between the terminals conveying the control current (Fig. 2). This effect is termed magnetoresistance and is the basis for two terminal magneto-resistive elements, which are fabricated to enhance the sensitivity of the effect. They can be substituted for Hall generators in many applications, and in some cases with improved sensitivity.

Two forms of generators

Hall generators are fabricated in two forms. The first is a sub-millimeter-thin rectangular wafer—called the "Hall plate" or "Hall crystal"—which is sliced from an ingot of the bulk semiconductor material and polished to the required thickness.

The second form of Hall generator is a deposited thin film of the semiconductor material.

Hall crystals are substantially more costly than the thin-film types due in large part to the expense in fabricating the Hall crystal from the parent material. But the crystal offers superior temperature stability and output linearity.

Both the plate and thin-film generators are made of the same materials—namely one of the syn-

thetic intermetallic semiconductors of indium antimonide, indium arsenide and indium arsenide phosphide. These intermetallic compounds have a high Hall voltage output and low internal resistance. The desired Hall characteristics are obtained by doping these materials; the process is a trade secret of each manufacturer.

By far the most sensitive material is indium antimonide, but its decrease in sensitivity with a rise in temperature is marked. Both the arsenide and the arsenide phosphide are substantially more temperature-stable, but this comes at a cost of sensitivity.

The low output impedance of the Hall crystal—from less than one to a few ohms—has created problems in applying it. But thin-film fabrication has raised this value and has markedly improved sensitivity—which means that less control current is required, thus minimizing one of the greatest problems with sensitive Hall device application: compensation for temperature rise effects.

In general, sensitivity is highly dependent on the material doping, and it should be noted that with either the bulk crystal or the deposited thin film, the prime tradeoff is between sensitivity, temperature stability and output linearity of the device.

Although slow, good progress has been made in producing better Hall generator characteristics, according to Robert Easley, manager of the semiconductor department of F. W. Bell, Inc., Columbus, Ohio. He is confident that future improved materials will retain the higher sensitivities and yet be more temperature-stable and have improved linear response.

The cost of certain Hall generators with potential mass application has been substantially lowered by using the thin-film-deposited Hall elements.

For example, thin-film generators with an active area of 0.125 by 0.10 inch, are available today from F. W. Bell for $1.75 to $2.50 in single units. They are supplied in three versions: flip chip; with long wire leads; or with a flexible printed-wire strip attached. Sensitivity ranges from 7 to 12 mV per kilogauss.

In Hall generator applications, the sensitive crystal or thin-film elements are mounted, or deposited, on some sort of supporting substrate. Leads are attached, and the device is usually encapsulated for environmental protection. When thus assembled, the generator is called a probe.

Modern methods of lead attachment have virtually eliminated one of the principal early sources of device failure: lead detachment.

A wide variety of probes has been developed for all kinds of applications. For example, special multiplier probes are available with a small effective air gap, suitable for insertion into sensitive multiplier magnetic circuits or for measuring small, bundled magnetic fields. The control leads are attached in a special manner to cancel out errors caused by currents in the connecting wires.

Axial-field probes are shaped particularly for insertion into bore holes, such as for measurement of the long, axial fields of traveling-wave-tube magnets.

Another type of probe is especially long and thin for measurements in extremely small air gaps.

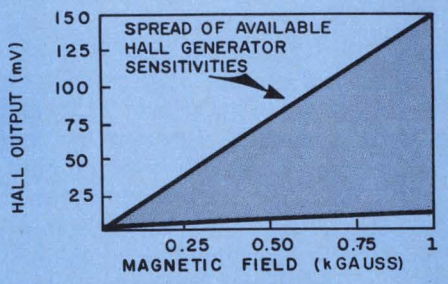
For cryogenic superconductivity measurements, both flat and cylindrical forms are made, operative down to −270°C.

A special three-axis probe by F. W. Bell consists of three matched Hall elements mounted mutually perpendicular to each other and molded into a small epoxy package. This type of unit makes it possible to measure the magnitude and direction of the three orthogonal components of a magnetic field vector. But its cost is high—more than $500.

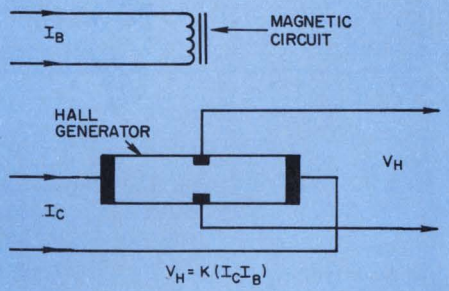
Microcircuiting spurs uses

The increasing application of Hall devices has been spurred by the development of microcircuit techniques. Hall generators are essentially low-signal devices requiring amplification. Not too long ago the electronics associated with amplifying and processing the Hall outputs occupied a sometimes intolerable volume. But today, microcircuits can readily be tucked in alongside Hall probes.

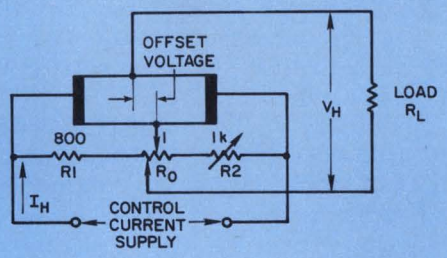
But what is of greater significance is the fact that two recent Hall developments place the elec-



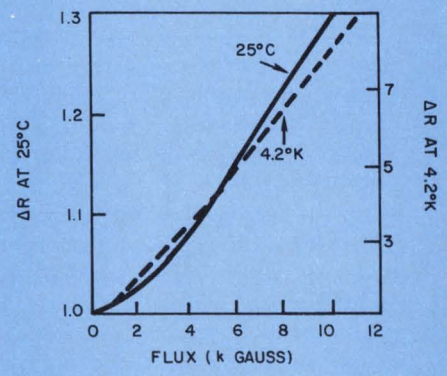
1. **The maximum open-circuit** Hall voltage sensitivities for available devices fall within the shaded area.



2. **The value of a magnetoresistor** increases with increasing flux density. Typical useful change is shown here.



3. **Hall connection misalignment** is a principal problem. The circuit above compensates for the offset voltage.

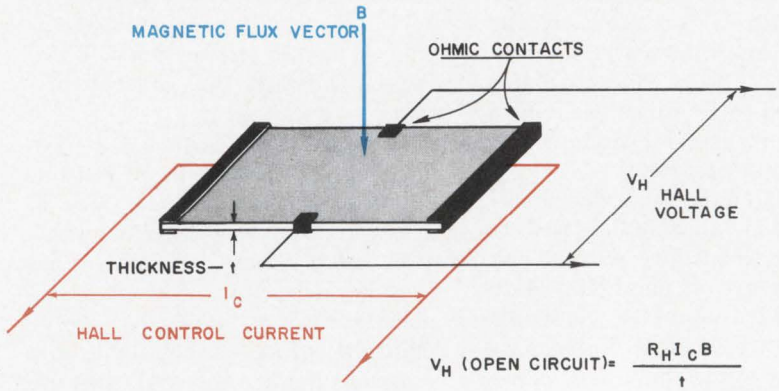


4. **The basic Hall multiplier** is formed by applying a controlled magnetic field to a Hall generator.

Hall Effect gains fame at ninetieth birthday

In October of 1879, physicist Edward H. Hall discovered that, when a strong magnetic field passed through current flowing in a thin film of gold, a voltage appeared between the edges of the strip. This effect is utilized in Hall generators made of intermetallic compounds that increase this effect to useful proportions.

The Hall generator is set at right angles to a magnetic field. A control current is passed through the long dimension, and the Hall voltage appears between the center contacts.



The Hall generator output is a voltage that is proportional to the product of magnetic field intensity and control current.

tronic circuits on the same substrate on which the Hall generator is deposited. This technique has been demonstrated by competitive versions of a contactless switch for computer and instrument keyboards, one by F. W. Bell and the other by the Microswitch Div. of Honeywell, Freeport, Ill.

In the contactless switch applications, the output is digital—that is, on or off. Since the Hall generator output is analog, switching circuitry is necessary for the conversion.

In F. W. Bell's unit the switching transistors are mounted on the substrate, which also contains thin-film resistors and zener diodes in chip form. The Hall generator is a low-cost, thin-film indium-arsenide device deposited on a flip chip, which is soldered to the substrate. Three leads provide power input and signal output.

The Hall microcircuit assembly produced by Honeywell, for its solid-state, contactless computer terminal keyboard, is mounted in a plastic assembly that has input and output terminals. In a significant departure from conventional Hall technology, the generator is fabricated as an integral part of the switching and output amplifier circuits through the use of conventional silicon-device technology.

Although silicon is inferior to the indium compounds as a Hall device, the Honeywell design of the switching and amplifying circuits on the chip has more than compensated for this. An advantage in terms of reliability is the fact that the connections to the Hall element are an integral part of the microcircuit, rather than independently attached.

The Honeywell device uses a 5-volt power supply and provides a fan out of two 3.5-volt logic outputs. Triggering is effected by moving a U-shaped magnet assembly (See Fig. 6) in a pushbutton, down over the Hall device, which is secured at the bottom of the switch assembly.

The reliability and performance of this device has encouraged Honeywell to market the Hall assembly by itself and also to repackage it in single pushbutton switches (see New Products, page 138).

New computer application

A radically different computer application is found in the new Honeywell H-112, low-cost, 300-line-per-minute computer printer. The devices used here are two magneto-resistors that pick up impulses from toothed magnetic wheels to control the advancing of paper on a roll and the alignment of the printout (see cover photo).

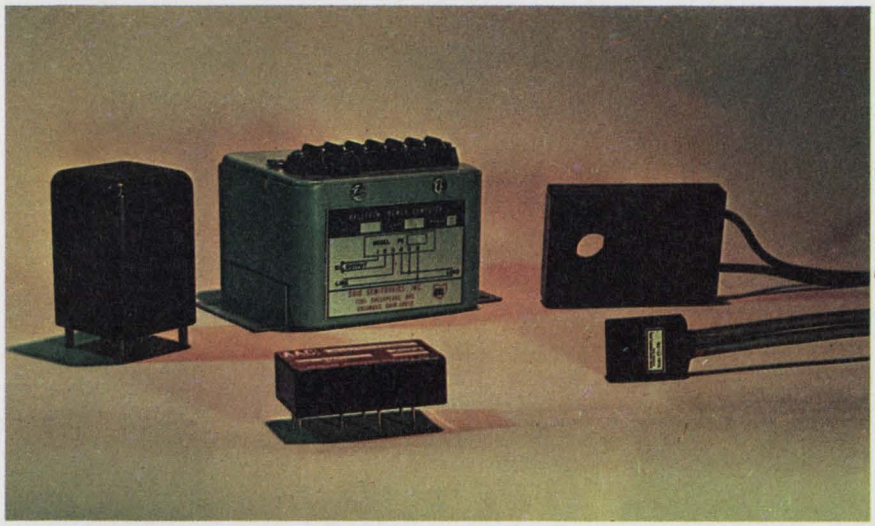
William Campbell, Honeywell project engineer, in demonstrating the printer operation for ELECTRONIC DESIGN, said that use of the magneto-resistors, supplied by Instrument Systems Corp., Huntington, N. Y., had simplified previous designs that used photocells and slotted wheels. The cost of the equipment has been reduced, he reported, reliability increased and maintenance simplified through easier operator access—all in line with the original design goals of producing a low-cost printer to mate with the Model 120 or Model 200 rental computer systems.

Gyro pickoff proves superior

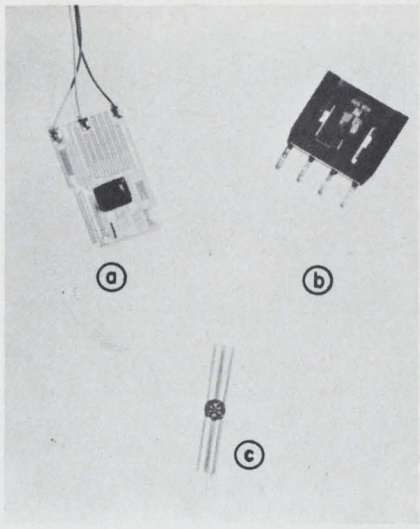
It was about 10 years ago that engineers at A. C. Electronics, Milwaukee, producers of the Carousel inertial navigation system, first decided that a Hall device would have substantial advantages as a gyro pickoff. But at that time, according to George Campbell, a product manager at A. C. Electronics, hardware was not available.

In constrasting the now-successful Hall pickoff with other methods with which the company has had extensive experience—such as optical and magnetic-core-and-lamination types—Campbell cites these advantages:

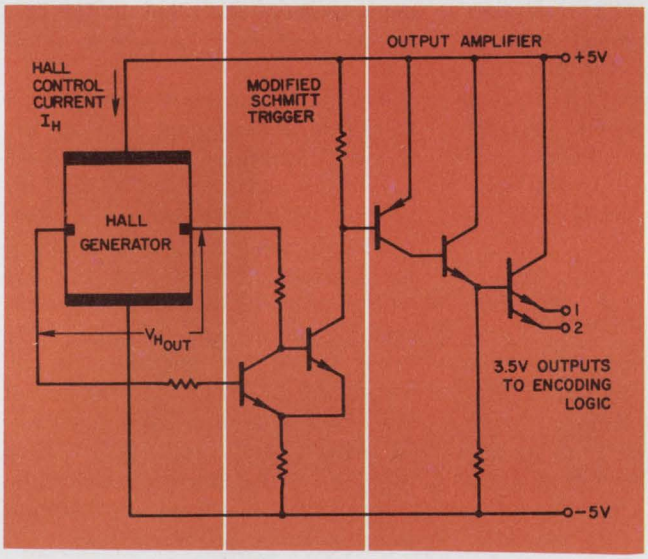
"To begin with, its small size [about 1/8th inch square by 0.010 inch thick] is well suited for miniature instruments. This is in contrast to relatively bulky coils and laminations required for magnetic pickoffs. But use of Hall generator wasn't possible until the development of microcircuit preamplifiers



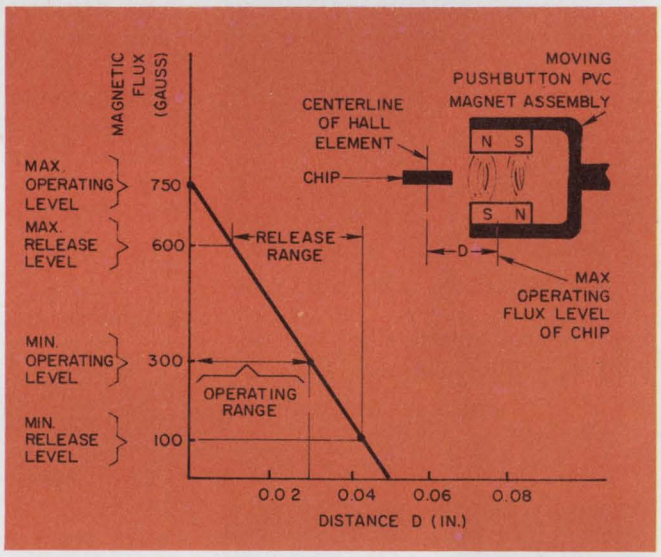
Multipliers using Hall generators (left rear, by Instrument Systems Corp.) and magneto-resistors (front, from American Aerospace Controls) are shown here together with other Hall devices such as a wattmeter transducer (rear center) and two types of current probes (at right, from Ohio Semitronics).



Latest magneto-sensitive devices include: (a) F. W. Bell hybrid switch assembly; (b) Honeywell Hall switching unit; (c) Hudson Magnistor.



5. **The modified Schmitt trigger** converts the analog output of the Honeywell keyboard Hall device to a digital signal. The output amplifiers provide two 10 mA outputs.



6. **A U-shaped piece of iron** with two polyvinyl magnets is the magnetic structure of the Honeywell solid-state switch. The chip is stationary, and the magnets move.

that can be mounted alongside the Hall generators.

"Because the device is thin, it reaches thermal stability rapidly.

"Also, we don't have to worry about the signal-to-noise ratio, since it is fundamentally a low-noise device."

A. C. Electronics' experience has been that the Hall systems are extremely reliable—more so than optical or other pickoffs.

Further, there is no bias torque or residual torque that ordinarily is caused by the excitation of magnetic pickoffs, Campbell says. The frequency range is more than broad enough, and the Hall devices can interface easily with other instrumentation systems.

Campbell reports that his company is now using Hall generators in its top precision instruments.

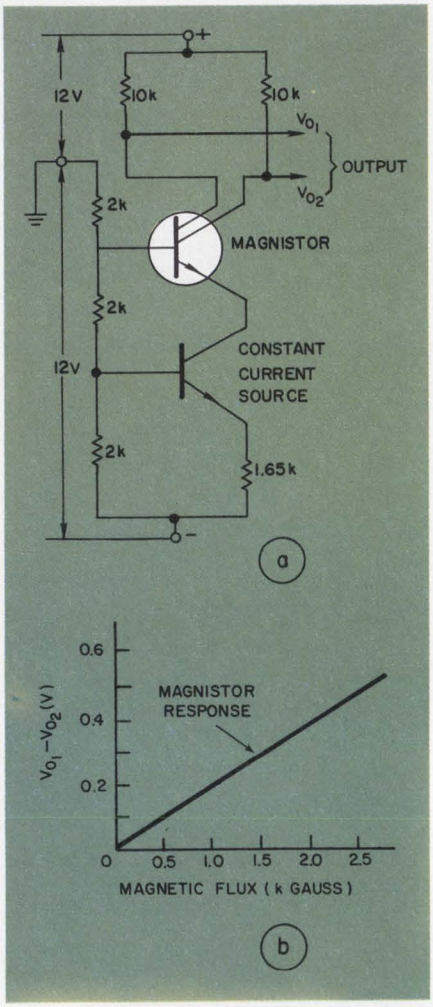
For the Carousel gyro, Hall generators are used in pairs, one on each side of a 1-inch float. More than 1000 of these gyros have been built.

"And we expect to sell thousands more," Campbell says.

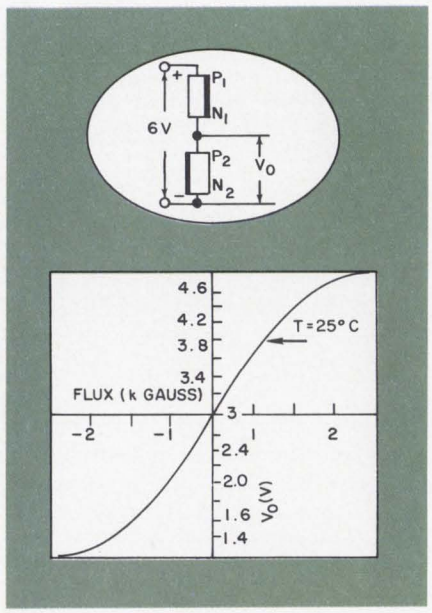
Low-field sensing achieved

A two-axis compass element for an autopilot is a good example of increasing the sensitivity of Hall generators to weak magnetic fields —such as the 0.5-gauss field of the earth—by the use of flux concentrators. These are ferrite rods extending several inches from each side of the Hall generators. According to Wilbur B. Canfield, vice president of Airborne Navigation Corp., Prescott, Ariz., the two-axis unit samples the longitudinal and cross-axis components of the earth's field with respect to the aircraft.

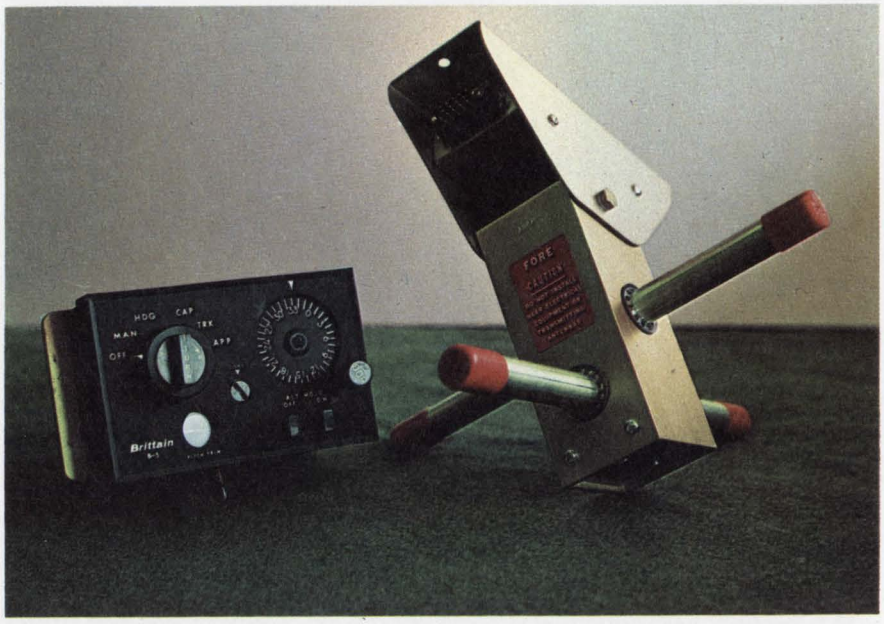
The outputs of the Hall generators are applied to a resolver in an autopilot made by Brittain Indus-



7. **The Magnistor is connected** in the circuit shown above. The outputs from the two collectors are then applied to a differential amplifier.



8. **Magneto-diodes are sensitive devices.** The output for a matched pair is linear up to about 1 kilogauss.



Pickoffs used on the gyros in the Carousel inertial navigation system are Hall generators. They have proved superior to previous approaches. The Hall device is mounted on the rim of the assembly.

tries, Hawthorne, Calif., and this allows the pilot to select a heading at any point of the compass. The assembly is mounted in the plane on a pivot which permits swinging along the fore and aft axis and keeps the compass element level when the plane is climbing or descending.

Brushless motors redesigned

The day of brushless motors that employ Hall generators for commutation has arrived. Ampex Corp., Redwood City, Calif., is using in-house designs by Albert Stahler, a corporate consultant and member of the research staff, for precision video-recorder capstan servo drives. Ampex is also developing high speed motors for laser beam scanners (rotating mirrors) that operate at up to 150,000 rpm. These are for the Naval Ordnance Laboratory, Silver Spring, Md.

The Avionics Controls Dept. of General Electric, Binghamton, N.Y., is using Hall Effect brushless dc motors and tachometers for lunar roving vehicle motors and also for a classified Air Force program. In addition, Gary Auclair, a project engineer at GE, has designed Hall Effect motors for a reaction wheel controller, part of a spacecraft attitude-control system.

The approach used by Ampex, and General Electric, and others is to provide orthogonal Hall sensors to sense the position of the permanent magnet rotor. The motor field is designed as a two-phase winding.

The Hall generator outputs are amplified and applied to the two-phase windings—thus, in effect, providing a two-phase motor operating with a dc input.

Auclair reports that efficiency is high—over 90 per cent for the motor and 75 per cent for the over-all motor and electronics to drive it. Motor torque is easily controlled and is independent of the speed. Standby losses are close to zero. And reliability, both Stahler and Auclair stress, is high.

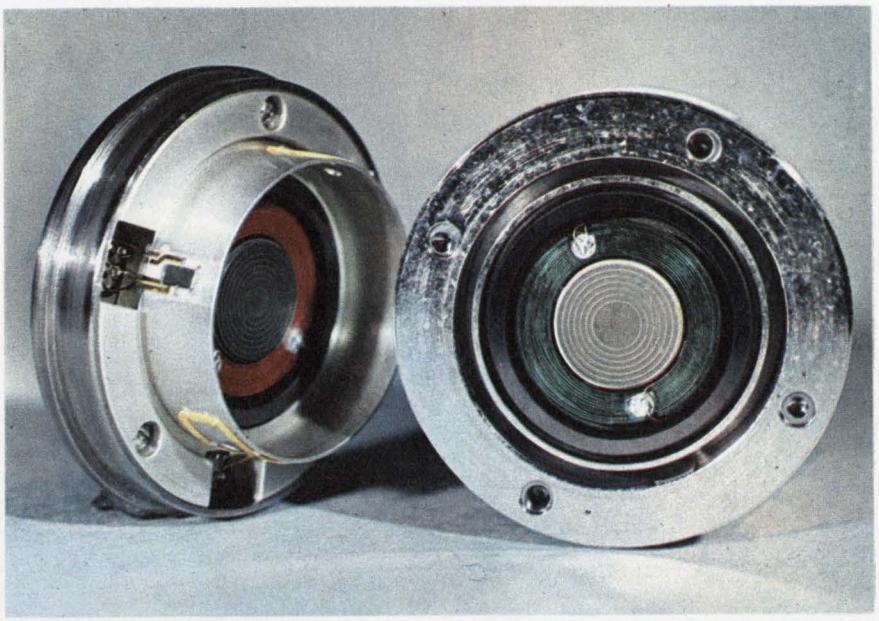
For RFI-sensitive applications, motor noise is extremely low.

Magneto-resistors can be used

Magneto-resistors, which depend upon the Hall effect for their operation, can be substituted for Hall generators in practically all applications. They are made of thin-film grids of bismuth or of thin "field plates" of indium-antimonide compounds.

In weak magnetic fields, the resistance change of these two-terminal elements is proportional to the square of the flux, and consequently they are very nonlinear, particularly at the lower flux ranges. But their use in bridge circuits compensates for much of this nonlinearity.

Unlike the Hall generator, the change in resistance is related to



This two-axis Hall compass element, by Airborne Navigation Corp., provides compass headings in an autopilot by Brittain Industries. The long arms are ferrite flux concentrators, which increase sensitivity.

Here's what's needed

All Hall applications use a magnetic field, the Hall control current, or both as a measured or controlled quantity. Best known Hall equipments are: magnetic-field measuring instruments, wattmeter transducers, current sensing probes, and multipliers.

For devices like multipliers, the Hall probe is fixed in the gap of a solid magnetic structure having a field winding. Field strength is varied by changing winding current. The Hall output is proportional to the product of the field winding and control currents.

For proximity-operated devices, the field is supplied by a permanent magnet which moves to, or away from, a stationary Hall generator.

flux intensity only and is not affected by flux direction. But as in the Hall generator, sensitivity decreases with temperature rise. Upper frequency response is generally limited to about 1 MHz, due to magnetic circuit limitations.

In fabrication, the zero-field resistance of magneto-resistors can be made to vary widely—from 1 ohm to over 10,000 ohms—and consequently a strong point is that they can be rather easily matched to the input impedances of the variety of electronic amplifiers and signal processing circuits with which they are used.

A principal advantage of magneto-resistors, according to Robert Gitlin, president of American Aerospace Controls, Inc., Farmingdale, N.Y., is that for bridge-type configurations, more voltage change per unit flux is generally available than with Hall generators. Also, while the generators require a current source, the magneto-resistor does not.

An important new application is in the Honeywell computer printer mentioned above. But they also appear in multipliers, watt transducers, current measuring devices, choppers, and low-frequency modulators.

Magneto-diodes for digital uses

Magneto-diodes, which change resistance under the influence of a magnetic field, have a high intrinsic sensitivity. Introduced last year by Sony, they are currently available only in limited sample lots, at $5 for a single diode and $10 for a balanced pair.

Some of the suggested applications are in brushless motors, proximity switches, magnetic detectors, and solid-state volume controls. However, response is highly temperature-sensitive, so it seems likely that digital applications will be their strong point.

When asked why availability of the devices was so limited, Dr. O. Mabuchi, vice president of the U. S. engineering division of Sony, in New York, told ELECTRONIC DESIGN that essentially all of their current production is being taken up in Japan by their new (and first) automatic phonograph record-changing turntable. In this, the magneto-diodes are used as position-sensing elements for the phonograph arm, providing the automatic return feature.

Unless someone comes up with a real large-scale application, present production facilities are not likely to be expanded.

Magnistor is versatile device

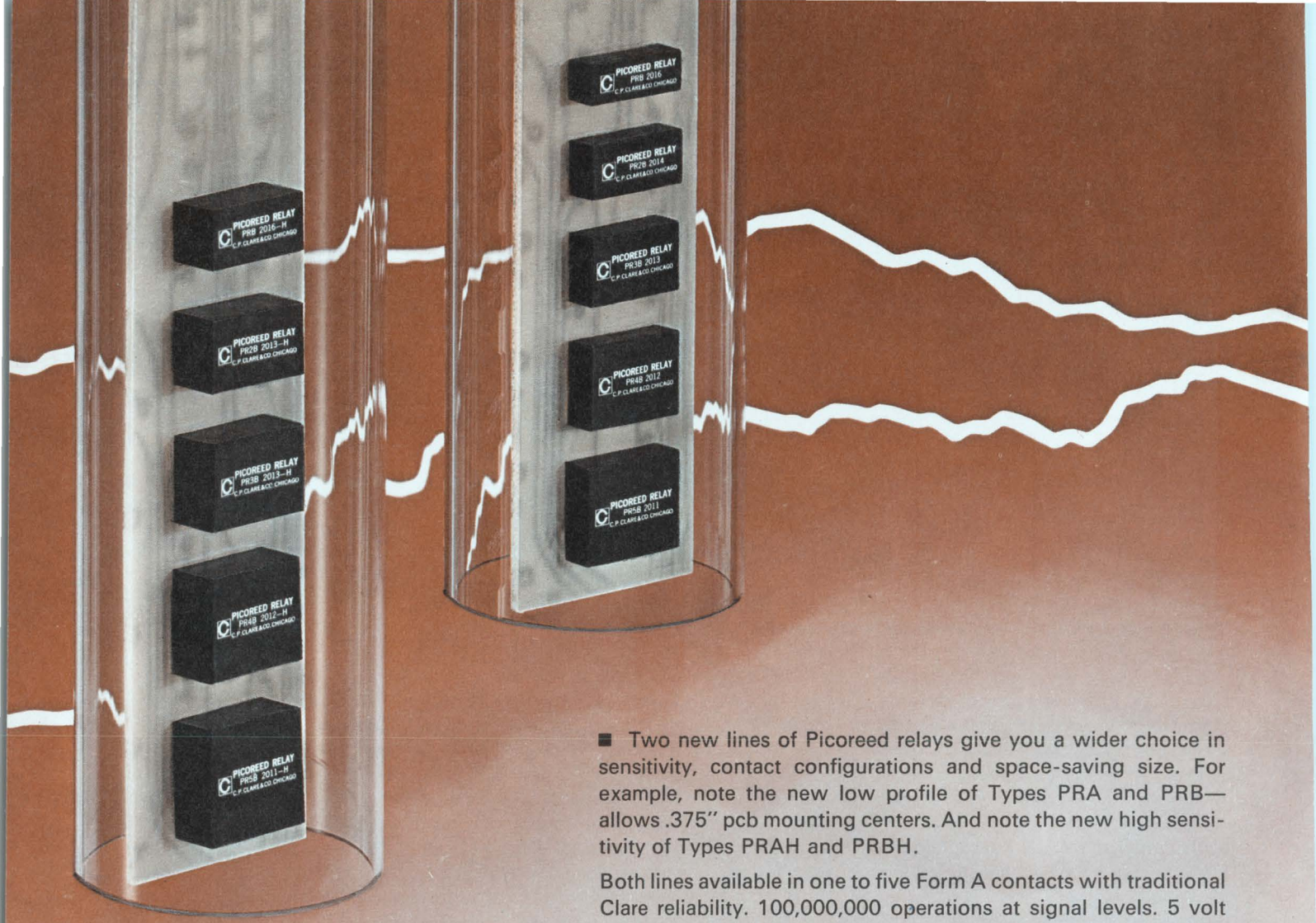
The Magnistor, or magneto-sensitive transistor, is currently being produced in limited quantities by the Hudson Corp., Manchester, N. H. The device comes in a six-leaded, glass package (see photo), 0.125 inch in diameter and 0.030 inch thick. The sensitivity is 0.2 mV per gauss, with a transistor beta from 2 to 4.

Edward Hudson, the inventor, claims that the gain-bandwidth product of the device itself is 100 MHz. But like the Hall devices, which have an inherent high-frequency response in the microwave region, the realizable frequency response is dictated by the magnetic elements of the magnetic circuit in which it is used. For practical purposes, the maximum frequency response of all magneto-sensitive devices is a few MHz.

Wideband Magnistor noise (0 to 6 MHz), with a load of 5 kΩ and a collector current of 2 mA, is 100 microvolts.

The uncompensated temperature coefficient is 0.33 per cent per degree C, which should pose no problems for many of the digital applications that Hudson initially sees for the device. These include solid-state switches for push buttons, keyboards and toggles, and digital memory readouts. With flux concentrators the device is sensitive enough for measurement or operation by weak fields, such as that of the earth, which is approximately 0.5 gauss.

The Magnistor, like the Honeywell and Bell microcircuit assemblies, are capable of being mass-produced using conventional integrated circuit techniques. Once in production, cost of these Magnistors should be reasonable. ■■



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Both lines available in one to five Form A contacts with traditional Clare reliability. 100,000,000 operations at signal levels. 5 volt (must-operate 3.75v), compatible with standard 5 v DTL and TTL logic families. 6, 12 and 24 volt standard relays also available.

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Low Profile

Type PRA

Type PRB

High Sensitivity

Type PRAH

Type PRBH

Electrical and Dimensional Characteristics	Types PRA/PRB—Low Profile		Types PRAH/PRBH—High Sensitivity	
	Form 1A	Form 5A	Form 1A	Form 5A
Operate time, including bounce	500 μs	600 μs	600 μs	900 μs
Average nominal power for 5 volt units	65 mw	250 mw	46 mw	140 mw
Pcb mounting centers	.375"	.375"	.500"	.500"
Length	.781	.800	.800	.800
Width*	.250	.675	.400	.800
Height	.187	.225	.350	.350

*Widths vary according to number of switches. One through 5 available.

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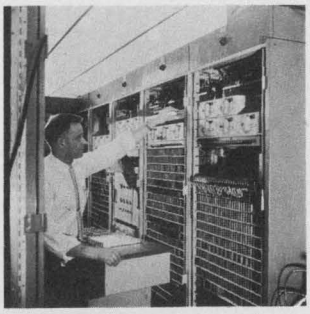
Washington Report

CHARLES D. LAFOND
WASHINGTON BUREAU

Post Office looks at technology



Send mail by electronics?

In an attempt to make a giant leap over the mountains of mail now sitting in post offices around the country, the Post Office has contracted General Dynamics to study some really far-out ways of effecting person-to-person communication.

A $147,046 contract for a "state of the art" study of electronic communication techniques has been awarded, Postmaster Gen. Winton M. Blount has announced, for a 44-week study of all methods of applying electronic technology to the mails, including transmission by microwave and laser. Preservation of letter sanctity in any electronic transmission process has been emphasized as a must.

Highlights of the study will include:

1. Long-range predictions 10 to 15 years in the future, as well as an analysis of present-day applications.
2. Delivery of "hard copy" to addresses would have to be considered as a first possibility for any electronic communications by mail. However, an eventual alternative could be visual delivery on a home facsimile printing device.
3. The study might indicate that receipts, notices, bills and short routine announcements could be worked out by computers, which would "mail" them to customers.

The study will be conducted by scientists, engineers and other experts in the electronics fields from five General Dynamics plants. The company's Electronics division at its San Diego, Calif., plant is the project manager.

Educational TV for India

India will be the first underdeveloped country to put up a satellite system to provide direct broadcasting of educational television programs to thousands of virtually isolated villages. Scheduled to become operational in 1972, the system will be built under a joint agreement between the U.S. National Aeronautics and Space Administration and the Indian Space Research Organization.

The system will enable India to provide its people in 5000 Hindi-speaking villages with programs on planting and cultivating crops, the use of pesticides and birth-control practices. It will enable NASA to test the potential value of satellite technology in the rapid development of effective mass communications in developing countries.

The satellite will be the Applications Technology Satellite, the sixth in NASA's applications technology series. Once in synchronous orbit, the relay station will open a 30-foot-wide antenna and transmit a focused beam with a power of 80 watts. Use of high power will cut the cost of ground terminals considerably. Initially, ground stations will cost about $500 each. Increased production could cut this to $200.

Western Union expanding for the 70s

While Western Union has spent more than half a billion dollars since 1965 in keeping pace with customer demands for computer-based technological innovations, it is now embarking on an all-out push—that may cost another half billion by the mid-Seventies—to build a "new-type national computer-based communications company."

At a recent Telecommunications Seminar in New York City, Western Union's chairman and president, Russell W. McFall, said, "In a scant two decades communications has moved from an industry that has relied for more than a century almost solely on the telephone and telegraph into one that is based on the relatively revolutionary concept of total integrated communications."

Washington Report CONTINUED

"Present plans," he said, "call for even larger, more sophisticated computers, still greater integration of services, and increased diversification within the fast-growing record/data handling communications industry." The company's proposed restructuring should also improve the company's ability "to more aggressively expand into nonregulated communications activities that are not subject to the stringent financing and operational restraints associated with the telegraph operations."

The restructuring plan calls for the formation of an entirely new company—Western Union Corporation, with the Western Union Telegraph Company as a wholly-owned subsidiary. The plan is subject to approval by shareholders at a special meeting next month and by regulatory agencies.

Satellites prevent air collisions

A new air traffic control system that uses satellites to prevent airliners from colliding in flight is proposed by TRW Inc. of Redondo Beach, Calif.

The satellites, the aerospace producer said, would relay special signals from each plane to ground stations below, where computers would be able to plot the aircraft's location within 50 feet in latitude and longitude and 80 feet in altitude. Such a fix would be 60 times more accurate than any approach using current radar techniques, according to David Otten, a TRW systems manager.

As explained by Otten, the computers would alert ground controllers whenever aircraft were approaching a collision path. The ground controllers would then warn the planes, using conventional radar techniques.

The TRW system would require six satellites—four for active use, two as spares—in orbit over the U.S. A. K. Theil, a vice president and general manager of TRW's space vehicles division, said the idea has been presented to the Federal Aviation Administration and other government agencies. The government, he said, appears receptive to using satellites in air traffic control.

E-2C continues with DOD's help

The Defense Dept. gave a small transfusion ($8.6 million) to the Navy's E-2C early warning carrier aircraft to keep the project alive until the Senate and House Armed Services Committees get together next month to decide its fate. The Senate committee voted against the project in July because, it said, the E-2C, equipped with an advanced radar that looks down for low-flying enemy planes, was too similar to the proposed AWACS, Airborne Warning and Control System, which the Air Force hopes to get. The House committee, on the other hand, is for the Navy's plane.

A plus for the aircraft is the good record its predecessor, the E-2A, has made in Vietnam controlling air strikes and finding pilots downed in the sea. (ED 16, Aug. 2, 1969, p. 21, "New Navy plane facing the ax in Congress.") Anxious developer of the aircraft is Grumman Aerospace Corp., Bethpage, N.Y.

Rescue sub to take plunge soon

The Navy's first deep-submergence rescue vehicle will slip into the sea off the coast of San Diego sometime in December, according to project manager, Capt. William M. Nicholson, of the Deep Submergence Systems Project Office in Washington, D.C. Sea trials will begin early in 1970. The second rescue vehicle will be launched early next year.

Funds for the remaining four will be released after the Navy sees how the first two vehicles work out. The first one cost $41 million; the second and succeeding ones, $20 million. The vehicles can be rushed to a submerged submarine by jet cargo plane or can ride piggyback on a mother submarine. Any submarine can be modified quickly to accommodate one of the rescue vehicles. The Navy plans to keep two of the vehicles ready to go at three strategic points.

Prime contractor is Lockheed Missiles and Space Co., Sunnyvale, Calif.

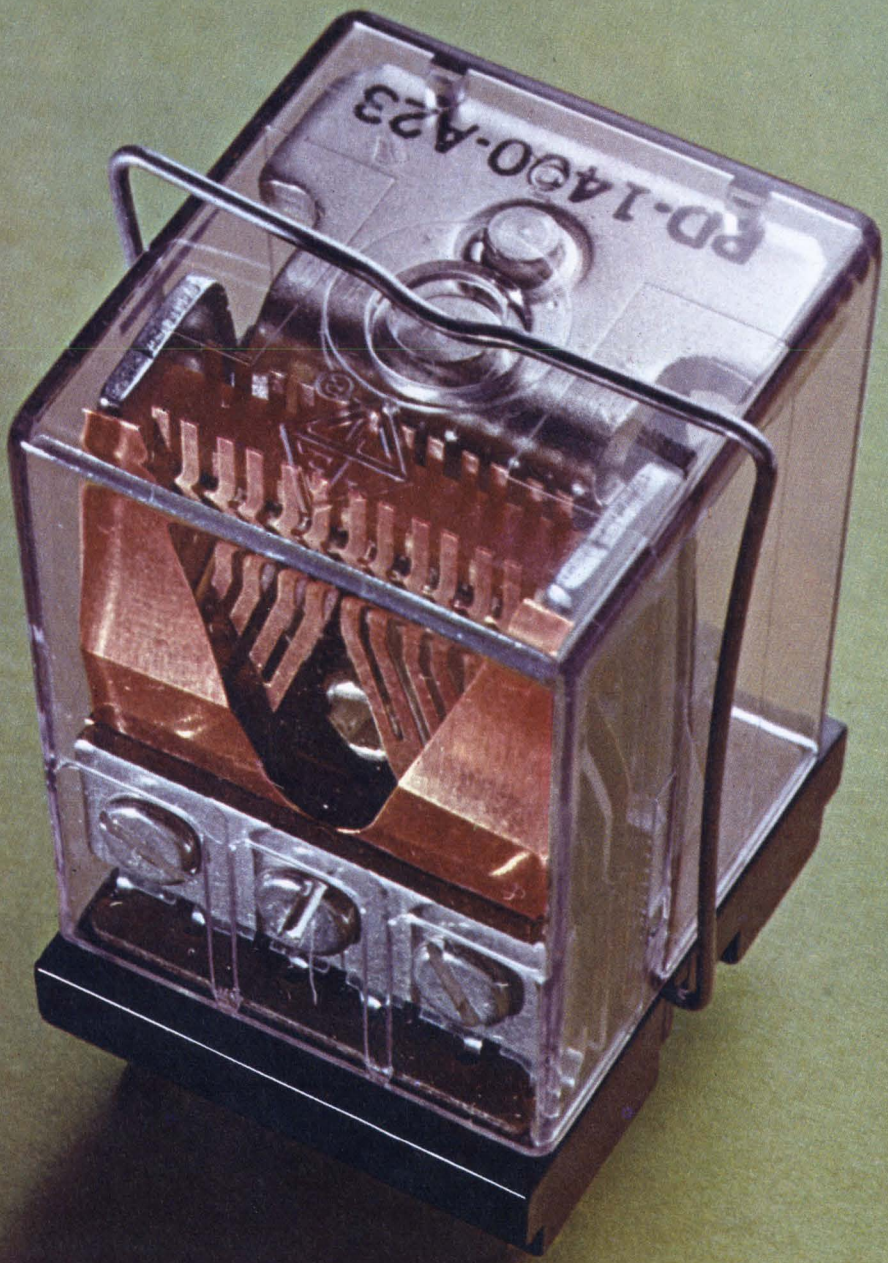
Our 5-band carbon comps are cats of a different stripe

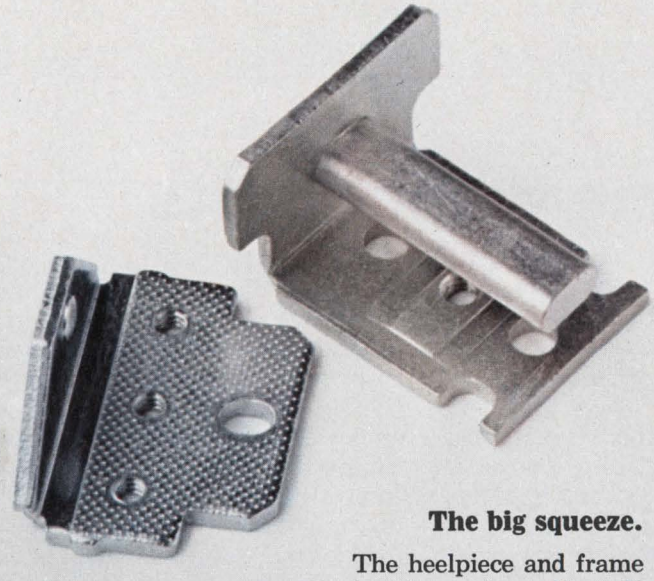
Okay, so the other leading brand is also great on military specs. But our Speer resistors have still more to offer. ☐ They provide superior soldering characteristics. They're backed by the first and most sophisticated on-line computerized resistor quality control system. They're delivered in an exclusive foil pack. ☐ And they're accompanied by written documentation. ☐ Another helpful note—both our ½-watt and ¼-watt types qualify under the new Established Reliability Specification at the S level. ☐ Our 4-band carbon comps are something special, too—particularly now. They offer all of our traditional quality features—plus competitive prices. ☐ To learn more about our resistors—and the reliable customer service that backs them up—write AIRCO SPEER ELECTRONIC COMPONENTS, St. Marys, Pennsylvania 15857. ☐ Five "stripes" or four—you may even decide we're a whole new breed.

The passive innovators at AIRCO Speer

Speer resistors ☐ Resistor and conductor paste ☐ Jeffers JC precision resistors ☐ Jeffers JXP precision resistors and networks ☐ Jeffers inductors ☐ Jeffers capacitors ☐ PEC variable resistors and trimmer potentiometers.

Reliability is 756 little dents and one big one.





The big squeeze.

The heelpiece and frame are the backbone of our Class H relay. The slightest squiggle or shimmy out of either and the whole relay is out of whack.

756 tiny dents on the heelpiece, plus one big one on the frame, make sure this'll never happen.

They're the result of planishing, a big squeeze. Planishing is an extra step we go through in forming the pieces to add strength and stability by relieving surface strain. It also makes the parts extra flat.

This takes the biggest press in the industry and the biggest squeeze. Both exclusively ours.

A different kind of coil.

The heart of a relay is the coil. If ours looks different, it's because we build it around a glass-filled nylon bobbin. It costs us more, but you know how most plastic tends to chip and crack.

Also, moisture and humidity have no effect on glass-filled nylon. No effect means no malfunctions for you to worry about. No current leakage, either.

The coil is wound on the bobbin automatically. No chance of human error here.

We didn't forget the solder.

We use a solderless splice. That's because solderless splice connections are sure-fire protection against the coil going open under temperature changes, stress, or electrolysis.

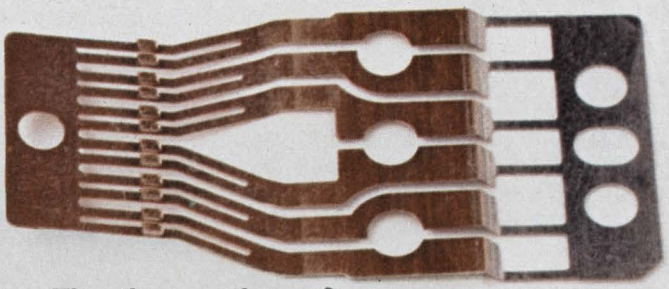
A solderless splice is more expensive to produce, so it's usually found only on the most reliable relays. AE is the only manufacturer to use this method on all of its relays.

Finally, we wrap the whole assembly with extra-tough, mylar-laminated material. A cover is not really necessary here; but why take chances?

Springs and other things.

We don't take any chances with our contact assembly, either. Even things like the pileup insulators (those little black rectangles) get special attention. We precision mold them. Other manufacturers just punch them out.

It makes a lot of difference. They're stronger, for one thing; and because they're molded, there's no chance of the insulators absorbing even a droplet of harmful moisture. Finally, they'll withstand the high temperatures that knock out punched insulators.



Then there are the contact springs. Ours are phosphor-bronze. Others use nickel-silver. Our lab gave this stuff a thorough check, but found nickel-silver too prone to stress-corrosion. Atmospheric conditions which cause tarnish and ultimately stress corrosion have almost no effect on phosphor-bronze.

Two are better than one.

Our next step was to make sure our contacts give a completed circuit every time. So we bifurcate both the make and break springs.

Each contact works independently to give you a completed circuit every time.

Edge-tinned contact springs save you the job of solder tinning them later. Also, edge-tinning enables you to safely use the same relay with sockets or mounted directly to a printed circuit board. A simple thing, but it takes a big chunk out of the inventory you have to stock.

Etc. Etc. Etc.

There's a lot more to tell about what makes our Class H relay reliable. Now we're waiting to hear from you. Automatic Electric Company, Northlake, Ill. 60164.

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INFORMATION RETRIEVAL NUMBER 26

LSI computer to cut time-sharing costs

In a time-sharing system, the billing begins when you contact the computer, and charges mount until you hang up. This forces you to organize your material off-line and type it into the computer as fast as you can. You have neither the time nor the mental conditions necessary to interact freely with the system.

What if you could purchase a small, inexpensive computer that you could convert at will into a scientific machine, an accounting system or a calculator simply by plugging in a magnetic-tape cassette and typing a key word?

Such a computer is being built by Four-Phase Systems, Inc., a new company in Cupertino, Calif., formed by a group of semiconductor, systems and software experts. According to Cloyd Marvin, vice president of marketing, the system will solve problems with up to about 50 variables.

"This means," he says, "that you can solve a good 75 per cent of your circuit problems—including sophisticated transient, ac and dc analysis—in your own office without accessing a central computer."

This will be one of the first general-purpose computing systems built entirely with MOS LSI. Its computing power will be contained in less than a dozen chips. The main, or "core" memory will consist of semiconductor random-access chips with a capacity of 10k to 100k bytes (1 byte = 8 bits). In addition to the computing chips and the semiconductor memory, the system will include a keyboard input, CRT output and two magnetic-tape cassettes for storing the programs and the finished computations. According to Marvin, the entire system will be about the size of an oscilloscope.

The company expects to announce its completed system by the end of the year at a price of $10,000 to $20,000, Marvin says, depending on the amount of semiconductor memory the customer wants.

"This means that if you now use a time-sharing system more than an hour a day," he points out, "this computer will save you money, even if you keep the time-share subscription and use our computer as an adjunct."

Costs cut by one-third

The typical daily cost of a time-share subscription, he notes, is about $40.

"For every hour you use the system, you pay $16 or so—about $12 for the computer connect time and another $4, average, for the use of the phone lines" Marvin says, "So for one hour's use, you pay $20.

"By contrast the daily cost of our computer might be $12.50—assuming a monthly leasing charge of $250. For this basic cost, you will be able to do most of your computing problems at the local level without accessing the central computer at all. So the total daily cost of using our computer with the time-share system might be less than the $20 you now pay for one hour's use of the time-share computer alone."

The user will plug in a prerecorded cassette that contains the desired programs and formats and will select the one he wants by typing a key word. The computer will search the tape and display a format on the CRT screen. The user then will enter data via the keyboard, while the computer makes the required computations and displays the results on the screen. When the problem is completed, the results will be stored in a second blank cassette. If the user prefers, he will be able to enter the program from the prerecorded tape into computer memory, replace this cassette with a blank tape and let the computer control both cassettes while he spools the data back and forth.

In a large company, he suggests, local systems in each engineer's office could be tied in with the central company computer. Not only would this expand the storage capability of the local system, but also it would allow the interchange of information between departments within the company.

"For example," Marvin says, "suppose the engineering manager uses his local terminal in scheduling the procurement of parts for a particular project. When he has finished, he stores the data in the central data base. Then when the procurement man is ready to make up purchase orders, he requests the transfer of this and similar data to his own terminal, where he sorts it by supplier." ■■

Powerful laser generates tiny nuclear blasts

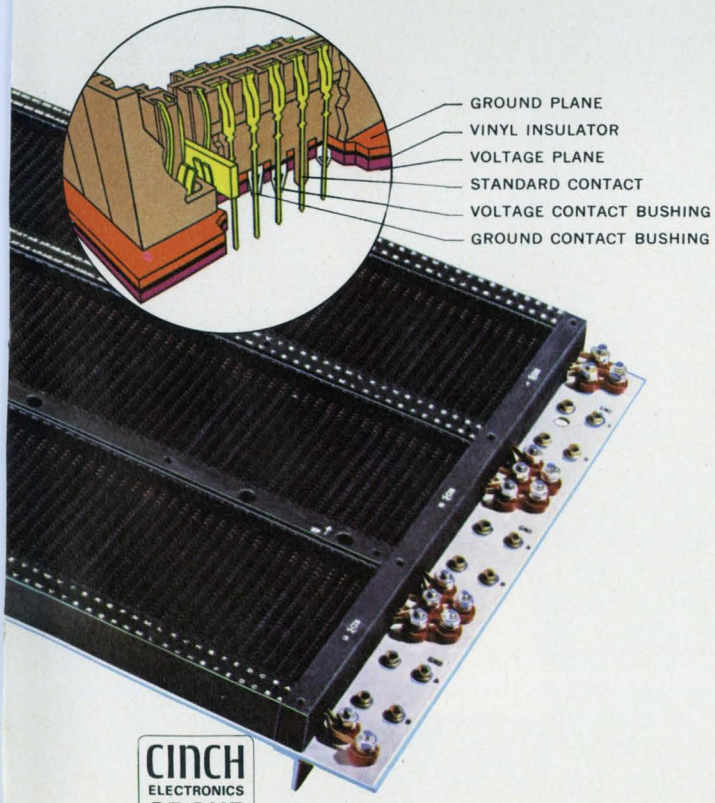
By aiming a powerful laser beam at deuterium, French scientists report that they have generated a succession of tiny thermonuclear explosions.

In tests conducted by the French Atomic Energy Commission, a neodymium-doped glass laser was aimed at a tiny deuterium target frozen to near absolute zero. A series of 4 gigawatt pulses, each with a duration of 5 nanoseconds, heated the material to about 15 million degrees F, releasing a small but explosive burst of energy.

Experimenters hope eventually to produce a "puff-puff" series of explosions—like those in an internal-combustion engine—that could be harnessed for power generation. Such a system, they say, would not require the magnetic "bottles" that have figured in most efforts to control fusion reactions. ■■

IMITATED—BUT NOT EQUALLED.

CINCH BACK PLANE CONNECTOR SYSTEM



Today, most back plane connector systems are being modified to include features first developed by Cinch. But only the Cinch back plane was designed to incorporate these innovations as basic design considerations, not modifications of already existing devices.

Cinch design leadership produced the *first* back plane connector system with these important features:

1. Replaceable buss bars that permit removal and replacement of bussing contacts.
2. Easily replaceable voltage plane and ground contacts, including bussing.
3. Precision monoblock insulators that eliminate modular construction.
4. Cantilevered, preloaded contacts.

Cinch didn't stop with the product. Special design molded styrofoam carriers completely eliminated damage during transit.

Combined with cost reducing techniques of selective gold plating, simultaneous insertion of contact rows and a unique method of terminal positioning, these features result in the most efficient and most economical back plane connectors system you can buy.

For information on this or other Cinch interconnection devices, contact your local Cinch Electronics Group office or write to Cinch Manufacturing Company, 1501 Morse Avenue, Elk Grove Village, Illinois 60007.

C-6914

CINCH

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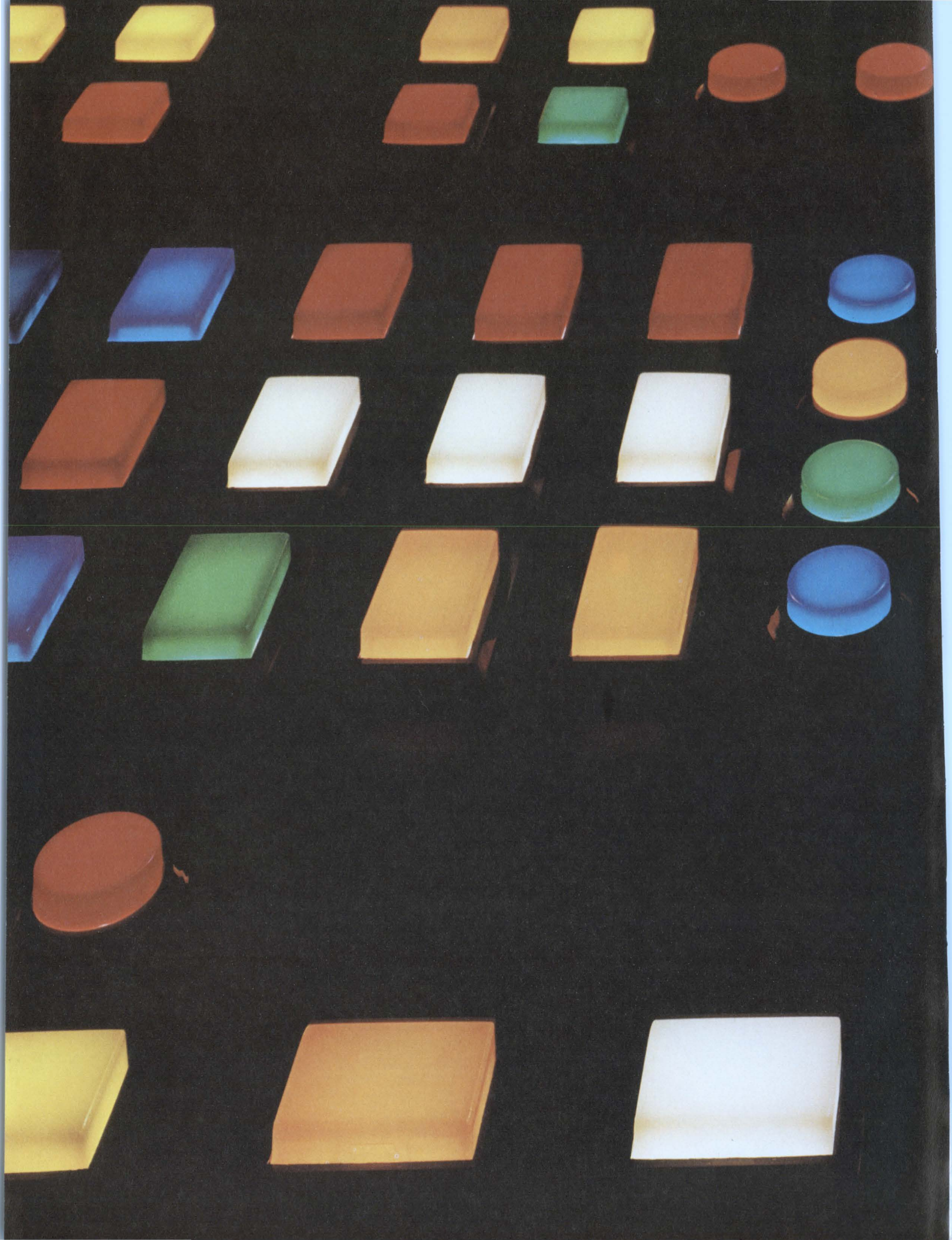
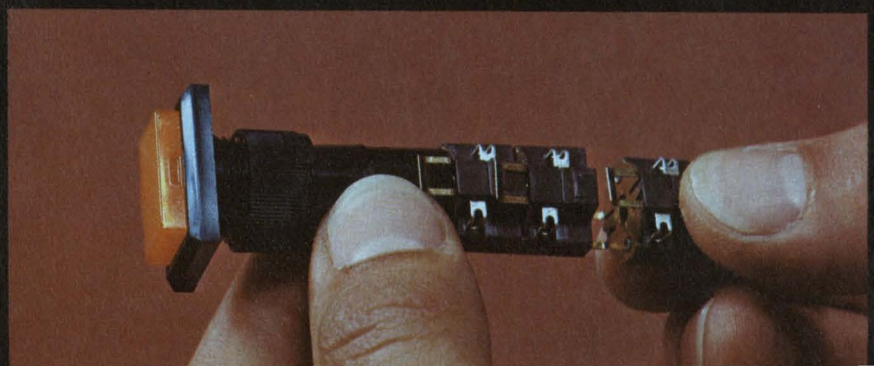
CINCH ELECTRONICS GROUP.



Meanwhile, back on earth. Arrow-Hart scores a breakthrough in lighted push-button switches. Snap-on contact blocks make up to 4-pole double throw form Z switches. 31 stock components = 25,344 different variations. Six colored lenses in three shapes. Is your imagination beginning to run away with you? Write or wire for folder. We call all this Adapt-a-Switch. You'll call it ingenious.



Arrow Hart

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HARTFORD, CONN.

Intech takes on the Op Amp Boys.

We're a David among Goliaths. And we know it.

So does Philbrick/Nexus, Analog, Burr-Brown, et cetera, et cetera.

They're our competition, and maybe your present Op Amp supplier.

We're out to change that... and to give you better FET input op amps.

Here's our story.

We've put together the best component and design engineering talent the industry had available. We let them have the run of the house.

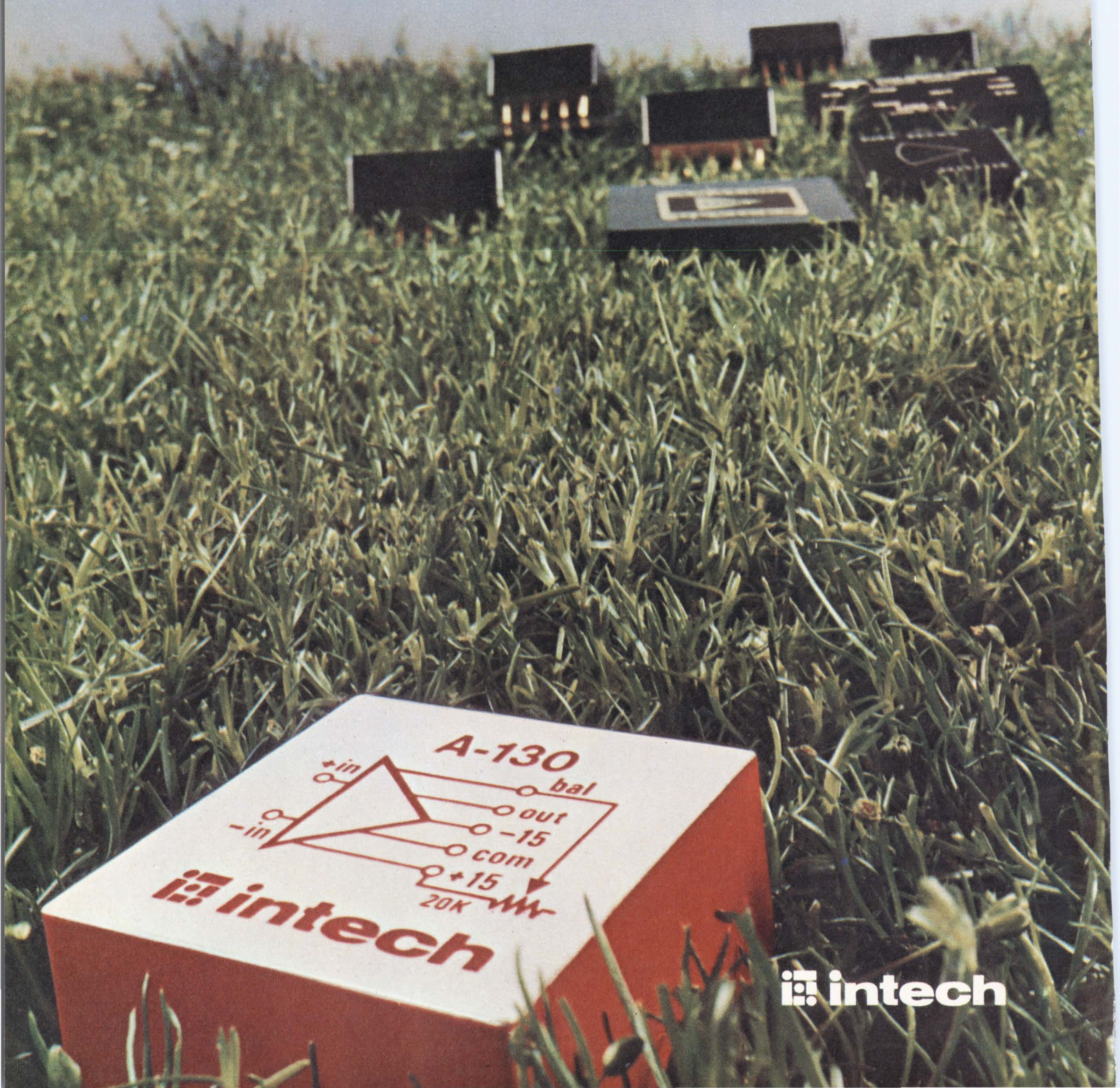
What they do constantly amazes us.

Like the A-130: a high speed, FET input Op Amp that has a slewing rate of 600V/μs (typ) and a settling time to 0.01% of final value in less than 0.5 μs in an amplifier with a 6 dB roll-off. The price is almost half of the competition's.

Don't believe us, or our engineers, though. In this business specifications, performance, and price are the considerations. A test is worth a thousand words.

For more information on our operational amplifier line, contact your nearest Intech representative, or call or write us direct.

Intech Incorporated, 1220 Coleman Avenue, Santa Clara, California 95050. (408) 244-0500.



Letters

"Editorial is a public service"

Sir:

Having had 25 years engineering experience, I wish to applaud (the editorial of July 5, 1969). I think that it is absolutely right, and that it is a public service.

Unfortunately, the NSPE (to which I used to belong) represents C.E. employers, just as the IEEE represents E. E. employers, as a glance at its list of officers shows.

Magazines such as ED have been the only sources of information on the realities of economic life to employed engineers. I think that the correctness of this policy is attested by the fact that several of the engineering technical societies have reportedly been in financial difficulties, while the best commercial technical magazines, such as ED, have not been.

What appear to be engineering failures, such as the F-111, are obviously not due to the engineers, but due to the overlay of complex economic and political considerations. Engineers must let this be known, or they may be blamed for everything.

Again, I wish to say that your editorial is a service, not only to employed engineers, but to the American public.

J. L. Borges
625 S. Oak Knoll Ave.
Pasadena, Calif. 91106

"My freedom is more important than security"

Sir:

I refer to your editorial of July 5, 1969. My freedom as an individual is far more important to me than any "security" that I might achieve through any collective engineering organization. My own observations indicate that these organizations rapidly become an end in themselves and the individual becomes the pawn of two masters, his employer and his "union." A further criticism which I have of these organizations is that they attempt to create artificial shortages of talent by 1) restricting admission to the profession and 2) feather-bedding. The NSPE (I am a former member) is especially guilty of 1) with its incessant demands for compulsory engineering registration.

Security is ultimately a function of the individual's ability and willingness to provide a valuable service to his employer.

Thank you for listening,

Fred D. Campbell, MTS
Aerospace Corporation
Los Angeles, Calif.

"Engineers need a power structure"

Sir:

Your editorial, "Aren't Engineers Entitled to Job Security Too?" (ED July 5, 1969) is timely and courageous. I was pleased to note that you favored pressure or "coercion" by engineers through an effective organization."

I am a project engineer . . . . and have been a practicing engineer for 25 years . . . I hold both the BSEE and MSEE. My engineering experience has been gained with five different corporations, so I have a down to earth feeling for an engineer's problems and his need for a *power structure* to represent his interests . . .

My employers would probably "red-line" any engineers working with an engineers organization so please don't identify me.

Kansas City Engineer

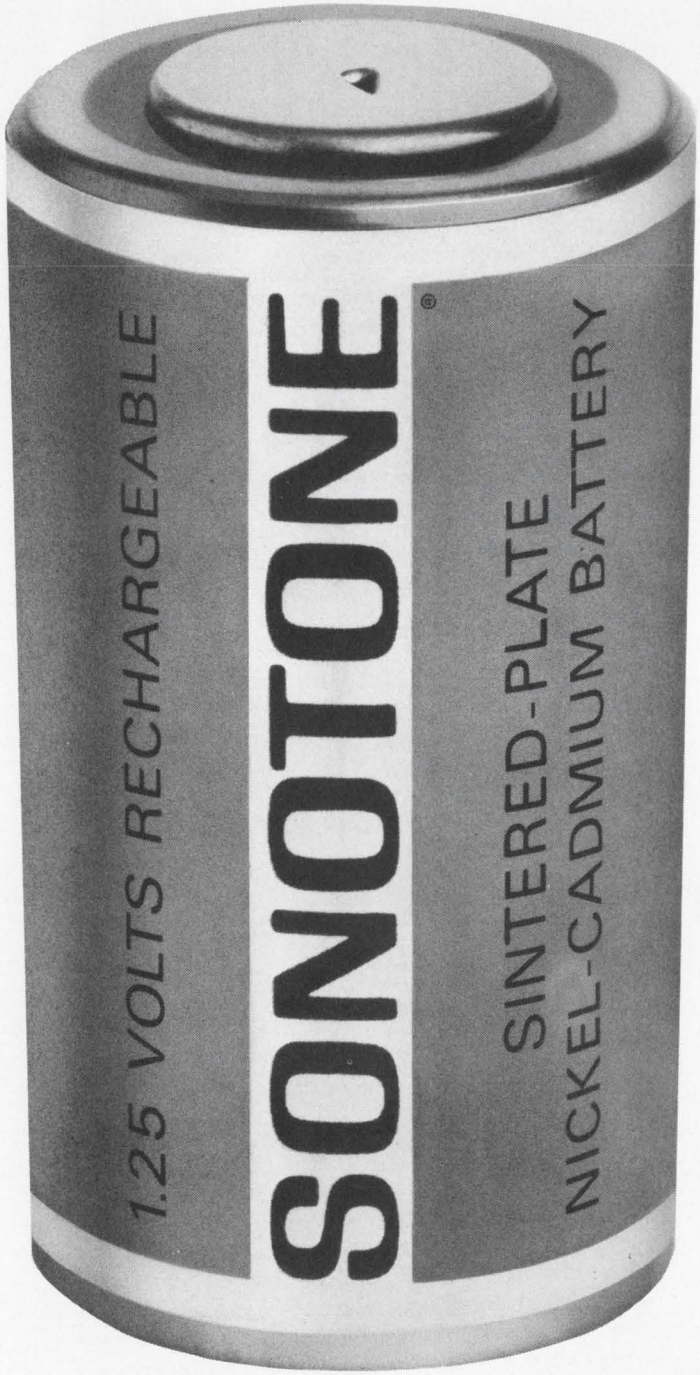
Cold power might solve two major problems

Sir:

I was very intrigued by an article entitled "Cold Power: Tomorrow's Electric System?" in the July 5, 1969, issue (ED 14, p. 30). It describes a superconductive power transmission cable development being done by Linde Div. of Union Carbide. The cable described con-

(continued on p. 60)

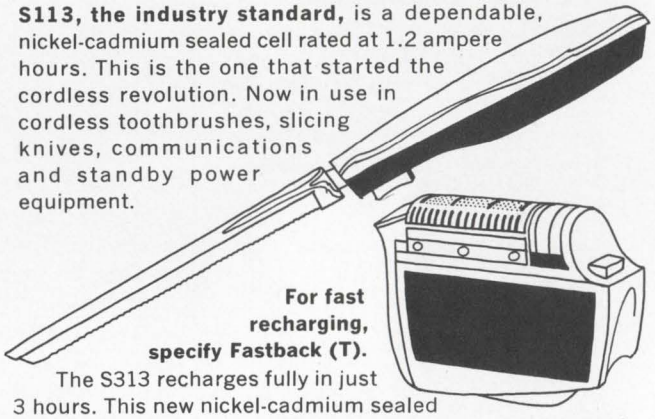
Sonotone's Sub-C Cell.



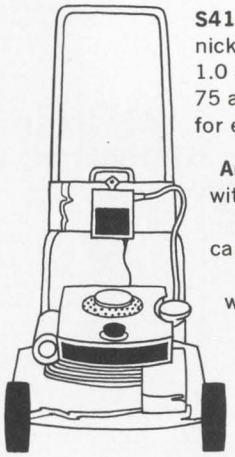
One size, four power ratings supply the power needed for any cordless product.

Now you can match power to product with one of Sonotone's Sub-C nickel-cadmium sealed cells. Pick from these four:

S113, the industry standard, is a dependable, nickel-cadmium sealed cell rated at 1.2 ampere hours. This is the one that started the cordless revolution. Now in use in cordless toothbrushes, slicing knives, communications and standby power equipment.



For fast recharging, specify Fastback (T). The S313 recharges fully in just 3 hours. This new nickel-cadmium sealed cell is rated at 0.9 ampere hours. Currently used in cordless shavers and cordless hair clippers.



S413 is a high rate discharge nickel-cadmium sealed cell with 1.0 ampere hours. Puts out up to 75 amps. of surge power . . . ideal for engine-starting applications.

And finally, the economical S213 with performance the same as the S113, except 0.7 ampere hour capacity. It is used in many of the same applications as the S113 where running time is less critical and economy most essential.

What we've done with the Sub-C cell, we can do with any of our battery products. Write for full information: Sonotone Batteries, Elmsford, N. Y. 10523.

SONOTONE

INFORMATION RETRIEVAL NUMBER 30

This Howard Cyclohm Fan was engineered to run 10 years. So far it's been running 12 years, 6 months, 21 days.

Our modest 5-year guarantee on Cyclohm Fans and Blowers is based on an engineered lifespan of 10 years. So, what do we tell our customers when they report the fans are still blowing strong 12 or even 14 years after installation? We tell them we goofed—and they benefit.

There's more to the Howard Cyclohm Fans and Blowers success story than just long life. There's the high reliability of Howard's unit bearing motor that never needs maintenance or re-lubrication. And all metal construction. Indestructible nylon blades. Standard mounting on 4-1/8″ centers. UL yellow card listing. All units are off-the-shelf . . . available for immediate delivery from Standard Motor Product Sales. All the facts are in the newly-published, 14-page Cyclohm Fans and Blowers Catalog ED109. From Howard.

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414-632-2731 TWX 910-271-2387

INFORMATION RETRIEVAL NUMBER 31

(continued from p. 57)

sists of three copper pipes whose inner surfaces are coated with niobium and cooled to the point of superconductivity. Such a system could solve many future power distribution problems, and the development cost was stated to be approximately $8 million.

I have thought of an interesting extension to such a system: Why not use those superconducting hollow pipes as waveguides for large-channel-capacity low-loss communications, as well as transmission of power? In this way we might solve two future problems simultaneously—the needs for added power and communications. As a matter of fact, one might even conceive of the power industry and communications industry sharing the costs of development and installation of such a system.

These thoughts represent only my personal opinion of the subject.

Dr. R. J. Chaffin
Sandia Corp.
Albuquerque, N. M.

LSI testing systems need not be costly

Sir:

Since one of the major products of this company is an LSI test system, the article, "LSI Testing is a Large-Scale Headache!" in your August 2, 1969, issue was read here with considerable interest. The article aptly and accurately stated the salient points of the "headache." For the most part we agree. Considerable space was devoted to descriptions of proposed hardware solutions with price tags from $150,000 to $300,000 or more. We think a solution with a $40,000 starting price also should be considered.

We produce two basic models of LSI test systems. Both of these systems are sensibly priced, capable of complete LSI functional testing, and proven in daily use by major array manufacturers.

We surely agree that the LSI test problem was a tough one, but so was the trip to the moon. These (unequally difficult) problems have both been conquered through aggressive engineering.

Alfred J. Homann
Vice President
Educational Computer Corp.
Sicklerville, N. J.

Noise-figure omission could cause trouble

Sir:

Messrs. Grove and Hsu gave a good discussion of semiconductor noise in "Don't Just Fight Semiconductor Noise," ED 17, Aug. 16, 1969, p. 228, but the noise figure explanation in the box on p. 234 failed to mention the crucial condition that the input noise must equal that of a matched ideal resistance at the IEEE standard temperature of 290° Kelvin.

Failure to observe this condition in measurements of antennas and communications equipment, where the effective temperature of the source can range from a few degrees Kelvin to many thousands of degrees, has led others to serious error.

Indeed, it is easily seen in the third unnumbered equation presented by Grove and Hsu to describe noise figure

$$F = 1 + \frac{N_{amp}}{GN_{in}}$$

that if N_{in} were not restricted to a standard value, no unique noise figure could be defined.

Many authors avoid this technicality by dealing with "equivalent noise temperatures" instead of "noise figures."

Dr. John R. Copeland
Jackson Associates
Columbus, Ohio

Campus problems? Or national symptoms?

Sir:

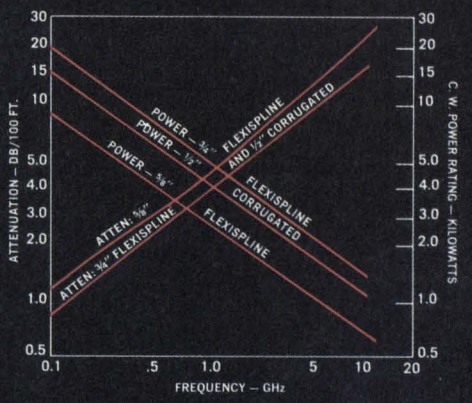
I read with considerable interest and concern your editorial, "It's the Alumni's Turn to Demonstrate," (ED 12, June 7, 1969, p. 47). I say

(continued on p. 65)

One of the toughest demands ever thrown at coaxial cable designers came along with the new high-flying, high performance manned military aircraft such as the F-111, and EA-6B etc. A lightweight, flexible cable with low VSWR and high temperature capability was needed for easy installation in tight locations, to accommodate aircraft length tolerances, and to connect to shock mounted equipment.

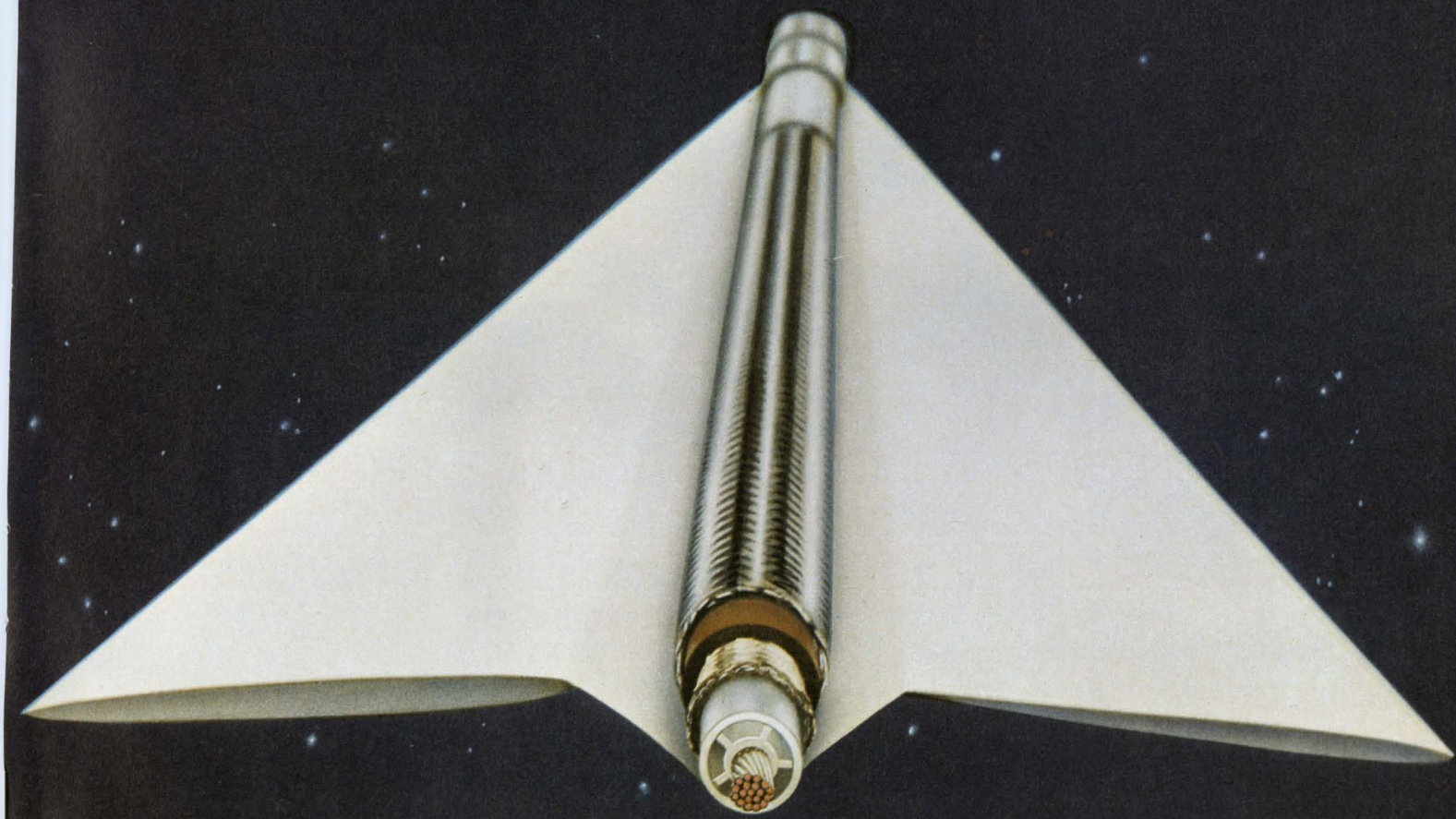
Our response was to develop and qualify Flexispline*, a flexible coaxial cable with a TFE air-space dielectric which operates to 12 GHz. It handles high cw power levels at elevated temperatures and altitudes while exhibiting low loss and low VSWR. Straight and right angle connectors of N, TNC and SC types are available. Typical VSWR for a 20-foot cable assembly is 1.25:1 from 4 to 8 GHz and 1.35:1 from 8 to 12 GHz.

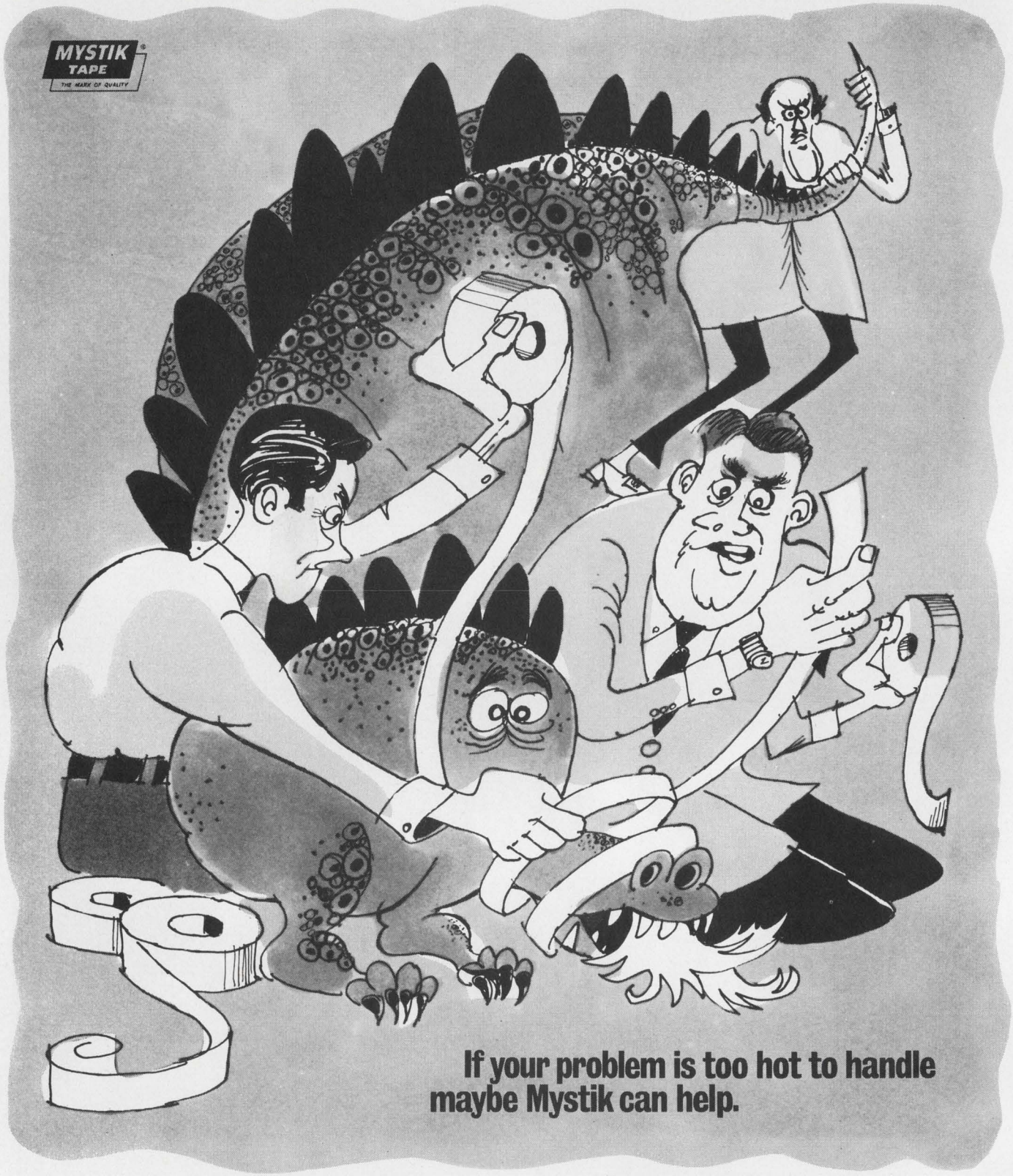
Times also furnishes semiflexible coaxial cable having corrugated aluminum outer conductor with TFE air-cell dielectric (no pressurization required) . . . with even lower loss and higher power-handling capability (see graph). We've won our wings on many tough interconnect problems. Let us work with yours. *Test Data Available



TIMES WIRE & CABLE
Subsidiary of INSILCO
Wallingford, Conn.

How We Won Our Wings.





You can't beat us when it comes to taking the heat off.

Take our Teflon® film tape, for example. It can withstand temperatures of —100 degrees F to 450 degrees F. It's an excellent insulator for all kinds of electrical equipment.

If you're more interested in shielding against heat, we'd recommend our aluminum foil/glass cloth tape. It's been known to withstand as much as 6,000 degrees F during rocket blast-off.

We have plenty of other tapes, too, for all kinds of jobs. Printed circuits. Motors and generators. Transformers. Just about any tape connected with the electronics and electrical fields.

For a complete description of Mystik's full line of electrical and special purpose tapes write:

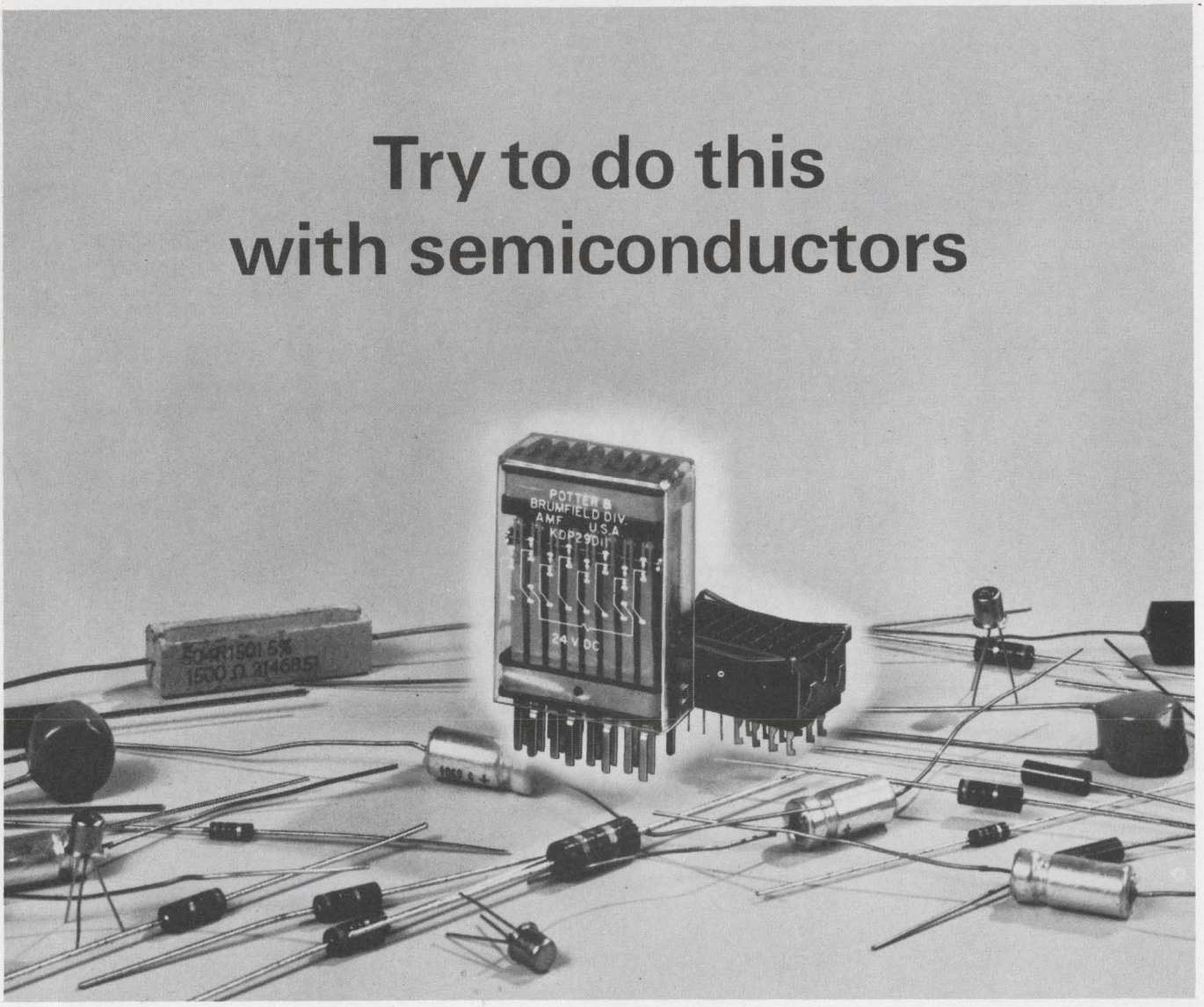
Dept. MT-7, Mystik Tape, Division of Borden Chemical, Borden Inc, 1700 Winnetka Ave., Northfield, Ill. 60093.

BORDEN™

Teflon® is a DuPont registered trademark.

INFORMATION RETRIEVAL NUMBER 45

Try to do this with semiconductors



Where else can you get 8 Form C switching in a package that measures just over a cubic inch and costs less than 50¢ per pole?* You can't with semiconductors. You'd wind up with a much larger, more expensive array.

Speaking of cost, the KDP has a single lot price of $9.35. The list price, by the way, is less than two of our most popular 4-pole relays.

The compact KDP is ideal for logic circuits where a single input will give you a fan-out of eight. Open-minded engineers will find that a strong case for this relay over solid state switching. Remember, too, you get electrical isolation on both the input and switching sides.

Bifurcated contacts are rated at 1 ampere at 30V DC or 120V AC, resistive. Standard relays have an 8 Form C contact arrangement. Combinations of Form C and Form D (make-before-break) are available on special order. Coil voltages range from 6 to 48V DC.

Order prototype models today from your local P&B representatives or call us direct. Potter & Brumfield Division of American Machine & Foundry Company, Princeton, Indiana 47570. 812-385-5251.

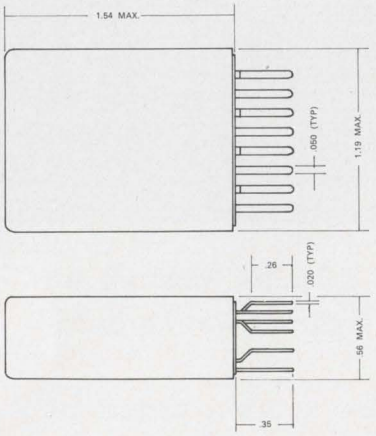
*Maximum discount

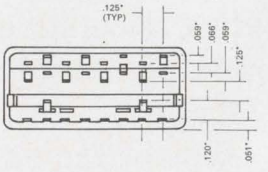
KDP SPECIFICATIONS

General
Temperature range −45° to +70°C.

Contacts
Arrangements: 8 Form C (8PDT).
Rating: 1 amp at 30V DC or 120V AC, resistive.

Coils
Voltages: To 48V DC
Duty: Continuous
Pick-up @ 25°C: DC, 75% of nominal voltage.
Operate Time: 15 ms maximum at nominal voltage @ 25°C.





AMF | POTTER & BRUMFIELD

INFORMATION RETRIEVAL NUMBER 47

(continued from p. 60)

"interest" because few persons in your position of editorial responsibility seem to care enough about this issue to put "extraneous" material of this nature into their professional magazines; and "concern" because I believe you have seriously oversimplified the issue.

Your analysis of the differences between engineering and arts students is in many aspects correct; but the question "Are there solutions for the campus problems?" is based upon the premise that it is a "campus problem." I believe that the campuses have experienced only the first symptoms of our national disease.

It is my view that these symptoms are evidence of a deep-seated pathological condition of our society, which has abdicated its concern for human values. The pathology is recognized by college students for a number of reasons, including these: (a) they have the time to think about things, and they are encouraged to look into the basics; (b) they have less vested interest in the status quo; and (c) they are in personal physical peril on account of at least one of the elements of the pathology. These reasons also bear upon the differences between engineering and arts students.

There are many evidences of the national pathology, and many of them can only be characterized as national scandals. They include (a) the war (and you may be assured that the "campus problems" will not vanish when the war is over); (b) the development of a national defense state managed by a scientific and technological elite (to which Professor Eilenberg referred); (c) the deterioration of the cities; (d) the welfare scandal; (e) the public elementary and secondary school scandal; (f) hunger endemic among ten percent of our own people; (g) the helpless poverty of state and local governments in the midst of enormous industrial and commercial wealth; and many, many more.

(You will have noticed that I omitted any explicit reference to the problem of our blacks. To some extent it is subsumed under the symptoms named above. To the extent that it is not included, it is now quite beyond the control and reach of the white majority. In the recent mild disturbances at this school, the blacks completely withdrew at the beginning: they have their thing, and they don't want it confused with others'.)

The breathtaking accomplishments of the Apollo adventure have demonstated our technical ability to achieve man's dreams. Less spectacular accomplishments in recent years have had far greater impact upon human affairs: consider, for example, the breakthrough in rice genetics. I look forward to the day when man's genius and ingenuity are devoted to providing adequate food, clothing, housing, and health; a meaningful education and worthwhile leisure for all men. This dream is no more beyond our grasp today than flying to the moon was 20 years ago, but to achieve these goals we shall need a conscious reassessment of priorities and a broad reallocation of our strength.

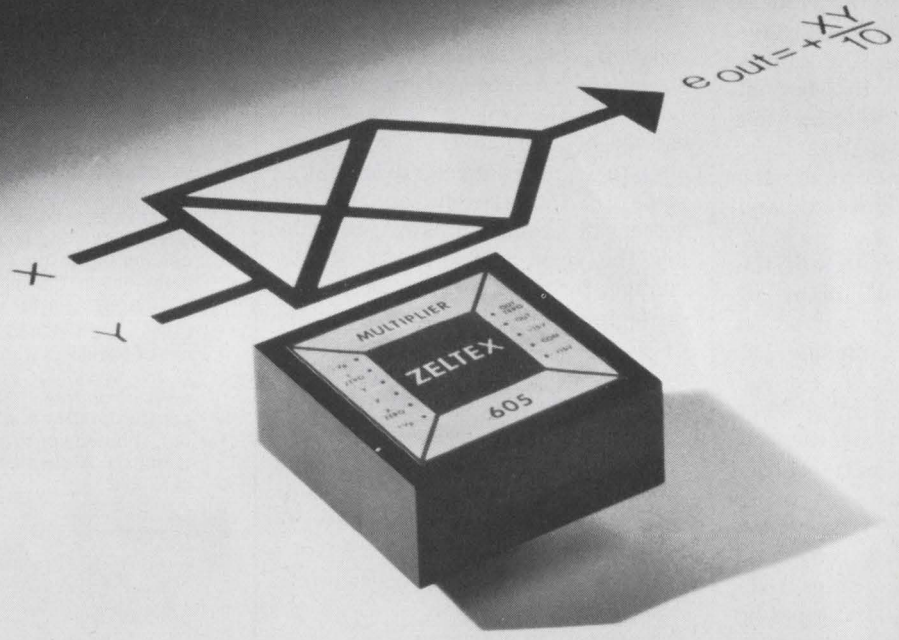
Many people believe these things can be done within the present economic and social and political structure: we call them liberals. Some people believe these things cannot be done unless the present structure is changed drastically: some call them revolutionaries and some call them nihilists, but they are the yeast and catalyst of any change, for the liberals have proved quite impotent. The vast majority of the concerned students stand between these positions. To the extent that the liberal position is one of futility, the concerned students turn to more radical positions and more revolutionary action in their search for the changes that need to be effected in our society.

Berol L. Robinson
Associate Professor
Department of Physics
Case Western Reserve University
Cleveland, Ohio

Accuracy is our policy

New product release on miniature rfi/emi filters (ED 18, Sept. 1, 1969, page 118, circle no. 278) should cite U. S. Capacitor Corp. as the manufacturing source, rather than United States Capacitor Corp.

MODEL 605: THE LOW-COST MULTIPLIER
1% ACCURACY
NO TRIM POTS



Compare specifications and you'll see that the Zeltex 605 beats every other low-cost multiplier on the market. It provides full-power output to 100 kHz, and small-signal frequency response is 500 kHz. *Yet the price, in quantity, is only $39!*

To get your copy of Bulletin 1056C containing complete specifications and Applications Bulletin 1063A, circle the reader service number below, or write or phone

Other key specifications include:

Output	10 V @ 4 mA
Noise	2 mV rms
Slew Rate	6 V/μs
Size	1.5 x 1.5 x 0.62 inches

ZELTEX, INC.
A Subsidiary of REDCOR CORPORATION
1000 Chalomar Road, Concord, Calif. 94520
(415) 686-6660

INFORMATION RETRIEVAL NUMBER 49

Columbus, Ohio—"Hall capital" of U. S.

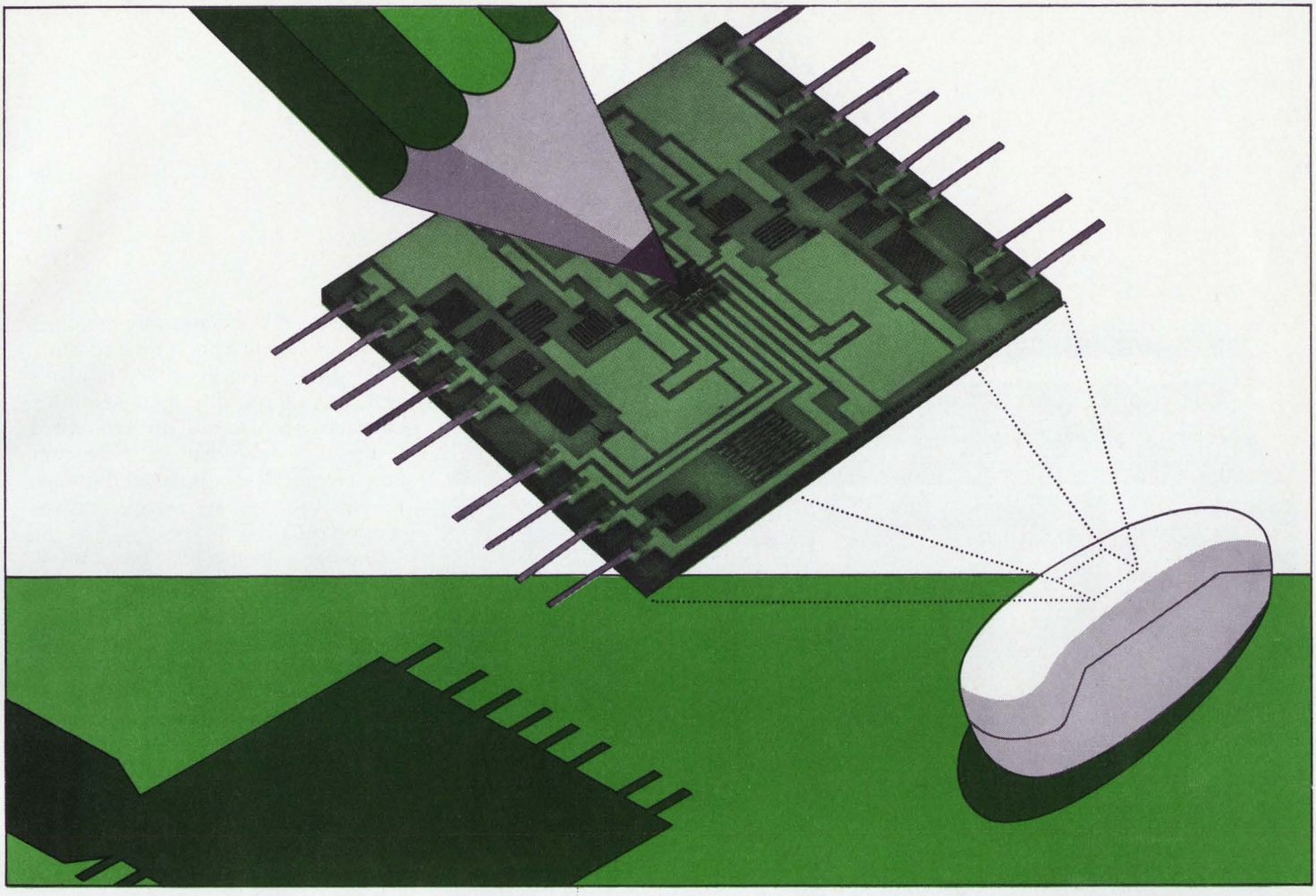
When East Coast editor Jim McDermott set out to do his story on Hall Effect devices (see p. 38), his research tour nearly turned into a one-stop stand—at Columbus, Ohio. For four big companies make Hall devices there: F. W. Bell, Inc., and Ohio Semitronics, Inc., makers of generators; Halmar Electronics, Inc., specialist in high-current measuring equipment; and Scientific Columbus, Inc., builder of power monitoring equipment for utility power network computer systems.

The "daddy" of the American market is Dr. Warren (Gene) E. Bulman, president of Ohio Semitronics, Inc. As a researcher with Batelle Memorial Institute— also in Columbus—working on the development of the Type III and IV intermetallic compounds in this country, he realized that the materials made by commercial chemical suppliers were not pure enough to produce best results. He then formed Ohio Semiconductor, Inc., in 1956, for the sole purpose of refining these materials and selling them.

In addition, the company fabricated bismuth telluride for use in thermoelectric cooling plates. It began to produce generators, magneto-resistors and thermoelectric cooling systems. These last it sold out to Tecumseh Products (maker of refrigeration compressors), but Tecumseh lost interest and phased out the division.

When Tecumseh cut off the supply of Hall generators, Floyd W. Bell, who depended on them for his gaussmeters, began manufacturing his own. In 1964, Dr. Bulman formed Ohio Semitronics, Inc., which makes custom devices.

By insisting on pure materials—and making them—Dr. Warren E. Bulman was partly responsible for today's boom in Hall devices.



Big future for little circuits

Bell Laboratories engineers have developed a special TOUCH-TONE Trimline® handset that suggests great possibilities for designers of future telephones. In this one, the musical tones you hear when you push the buttons are generated by two oscillators in a "hybrid" integrated circuit (one combining tantalum and silicon technology).

Such tiny, inexpensive circuits free designers from limits imposed by bulky, costly to assemble, discrete components—which restricted the type and complexity of circuit functions that could be designed into a telephone handset. Now, designers can think of people first—of what is easy to use—knowing that the electronics can be made to fit. The postage-stamp size, rugged integrated circuit above, for instance, contains 14 transistors, a diode, and 16 resistors in the silicon chip (under the pencil point), and 19 resistors and 8 capacitors made with tantalum film on the substrate.

Much of Bell Laboratories' integrated circuit work combines tantalum thin-film circuits (for precision passive components) and silicon integrated circuits (for active devices). To unite the two, we invented beam leads—small gold conductors which are formed as an integral part of the silicon circuit. They allow us to bond the silicon to the tantalum circuit in a simple one-shot operation. We've also developed a chemical-metallurgical system which fully seals off and protects the vulnerable parts of the circuit from environmental damage. So, we don't need costly vacuum-tight enclosures.

The extreme operational and environmental conditions of telephone use gave us some problems: Tailoring the resistance of thin-film resistors so that the resistance-capacitance product remains constant despite changes in temperature. Designing oscillator circuits whose output frequencies are not affected by varied loadings due to differing cable lengths between telephone and central office. Finding an encapsulant to adequately insulate closely spaced conductors in high humidity.

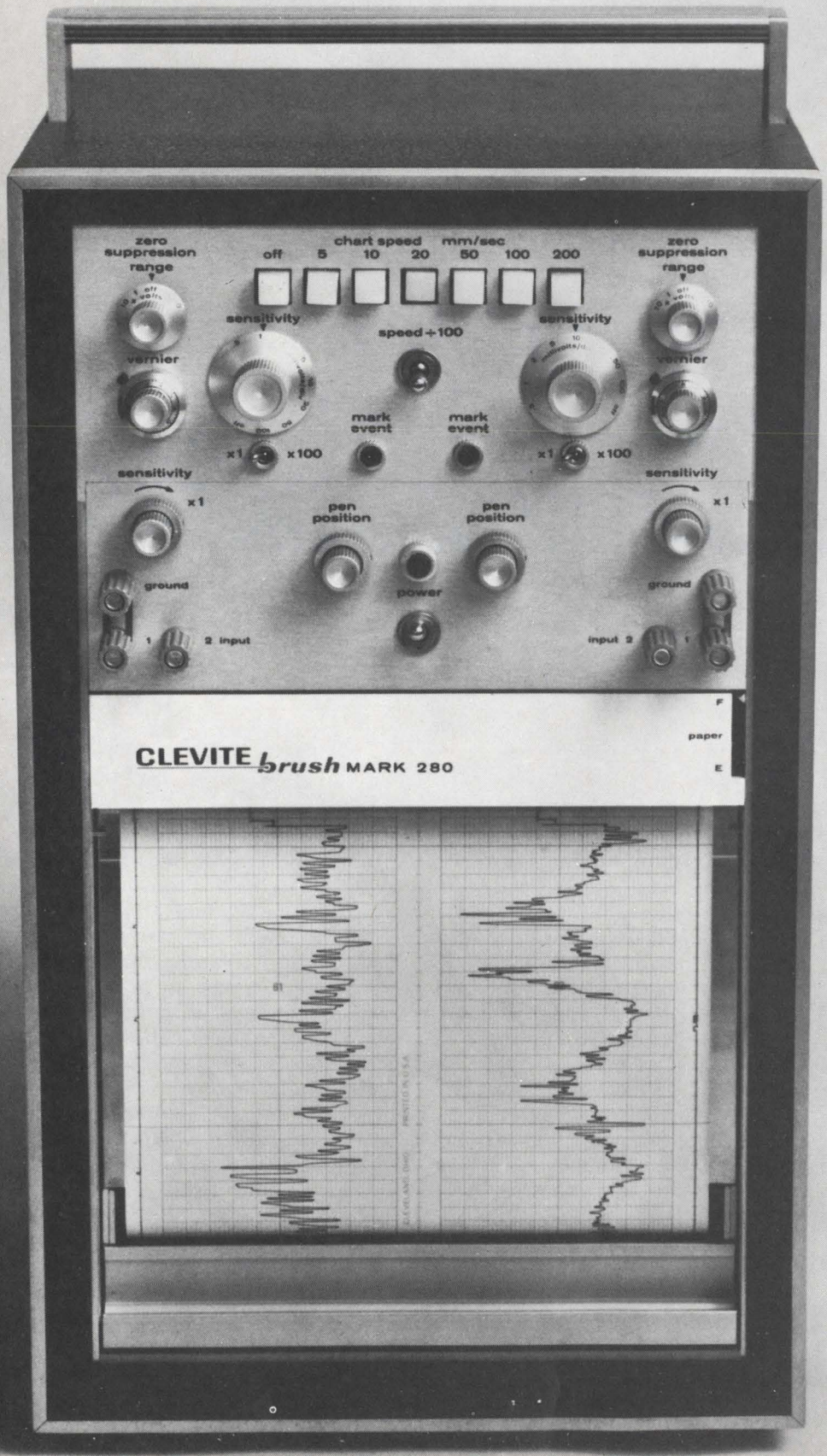
To customers who use them, handsets with this new circuit will seem like other TOUCH-TONE Trimline sets—though a trifle lighter. But this new telephone technology opens the way to greater freedom for designers and even better telephones for Bell System customers.

From the Research and Development Unit of the Bell System—

Bell Labs

Facts come in loud and clear on the Brush Mark 280.

Twice as loud and clear.

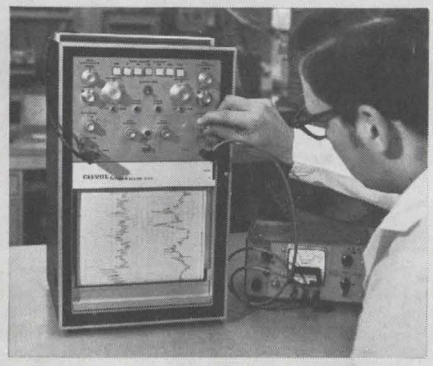


The Mark 280 is the best way yet to get high precision in a portable recorder.

The facts come in on 80mm channels, twice the width of conventional channels. Thus resolution is doubled — because measurements, no matter how complex, are displayed on twice the usual scale — are twice as easy to see and read.

The traces are just plain beautiful — clear, sharp and uniform at any writing speed — so there's no questioning the values you've recorded. They're produced by a pressurized fluid writing method that forces the trace into the paper—not just on it. Never a smudge or smear. The writing's dry on contact.

Accuracy? We guarantee 99½%, and most Mark 280's do even better—thanks to our foolproof pen-position feed-back system that *enforces* accuracy. Frequency response? To 35 Hz at full 80mm scale — out to 200 Hz at useable amplitudes. Calibrated zero suppression. It's one of many options.



Doubled resolution, near-perfect accuracy, crisp clear traces, high frequency response. That's what you can expect from the Mark 280. Ask your Brush sales engineer for a demonstration. Or write for complete details. Clevite Corporation, Brush Instruments Division, 37th and Perkins, Cleveland, Ohio 44114. We'll include our handy "Chart Running Time" calculator and slide rule.

CLEVITE BRUSH

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Let's broaden those automobile safety standards

A somber anniversary passed last month, unnoticed by all but a very few. The occasion—the 70th anniversary of the first traffic fatality in the United States.

When the victim, Henry H. Bliss, was struck down by what the next morning's newspapers called "an electric taxicab," one of the less attractive statistics of American life began.

Just last year, over 50,000 Americans joined the growing statistics, and the National Safety Council estimates that the 2 millionth victim will die about one year from now. This is a staggering number, considering that the total American deaths in all of the wars fought by the United States is around 1,200,000.

What is being done to bring the highway carnage under control?

The Federal standards imposed largely through the efforts of Ralph Nader are a start—but they are only a start. Next, how about mandatory electronic devices and aids?

Head rests are now mandatory—but how about an automatic alarm system for dozing drivers?

Seat belts are also mandatory—but how about electronic antiskid systems for safe braking under slick road conditions?

Improved-grade tires are now required—but how about systems for giving dashboard indications of tail-light status, brake-fluid status, and other conditions that need checking?

The chances that Detroit auto makers will ever voluntarily incorporate such electronic devices and systems as standard features are slim. The money they cost would most certainly have to be passed on to the purchaser. This can be done if they are offered as options, probably on top-of-the-line models. Safe driving, though, should not be the exclusive province of only those willing to buy more expensive cars.

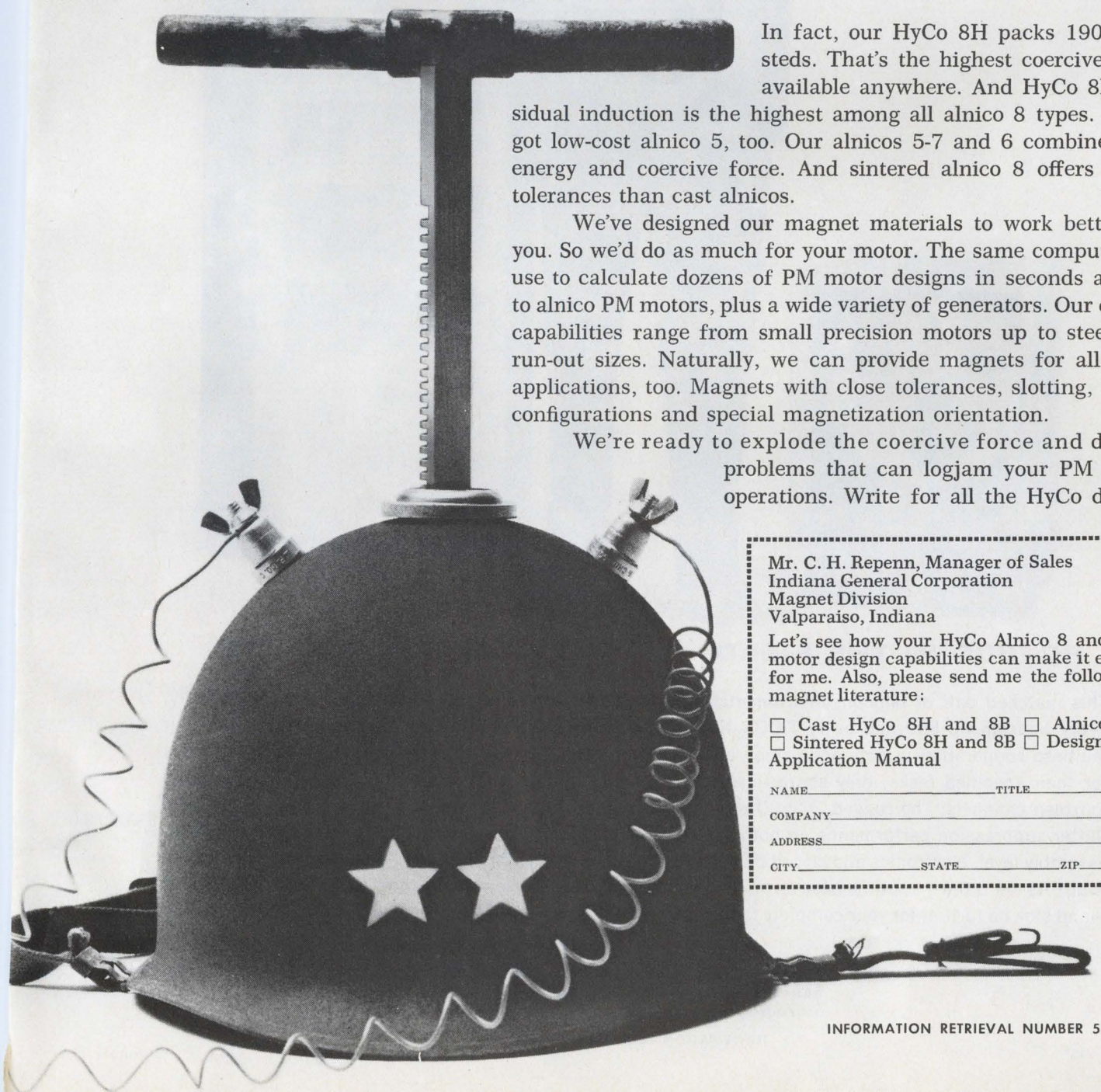
Unfortunately, it appears that uniform safety and the devices that promote it must be legislated by the Federal Government. But the passage of such legislation requires convincing technical arguments, coupled with persistent effort, combined with an appreciation of mass public relations.

What the electronics industry needs is a little of the Ralph Nader spirit to demonstrate that it could, indeed, contribute to traffic safety on the nation's highways.

FRANK EGAN

For stronger, smaller, lighter PM motors, our alnicos pack quite a charge.

INDIANA GENERAL *We make it easy for the design engineer.*



In fact, our HyCo 8H packs 1900 oersteds. That's the highest coercive force available anywhere. And HyCo 8B's residual induction is the highest among all alnico 8 types. We've got low-cost alnico 5, too. Our alnicos 5-7 and 6 combine high energy and coercive force. And sintered alnico 8 offers closer tolerances than cast alnicos.

We've designed our magnet materials to work better for you. So we'd do as much for your motor. The same computer we use to calculate dozens of PM motor designs in seconds applies to alnico PM motors, plus a wide variety of generators. Our design capabilities range from small precision motors up to steel mill run-out sizes. Naturally, we can provide magnets for all these applications, too. Magnets with close tolerances, slotting, varied configurations and special magnetization orientation.

We're ready to explode the coercive force and design problems that can logjam your PM motor operations. Write for all the HyCo details.

Mr. C. H. Repenn, Manager of Sales
Indiana General Corporation
Magnet Division
Valparaiso, Indiana

Let's see how your HyCo Alnico 8 and PM motor design capabilities can make it easier for me. Also, please send me the following magnet literature:

☐ Cast HyCo 8H and 8B ☐ Alnico 5-7
☐ Sintered HyCo 8H and 8B ☐ Design and Application Manual

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INFORMATION RETRIEVAL NUMBER 54

TELEMETRY'S MOST COMPATIBLE PAIR

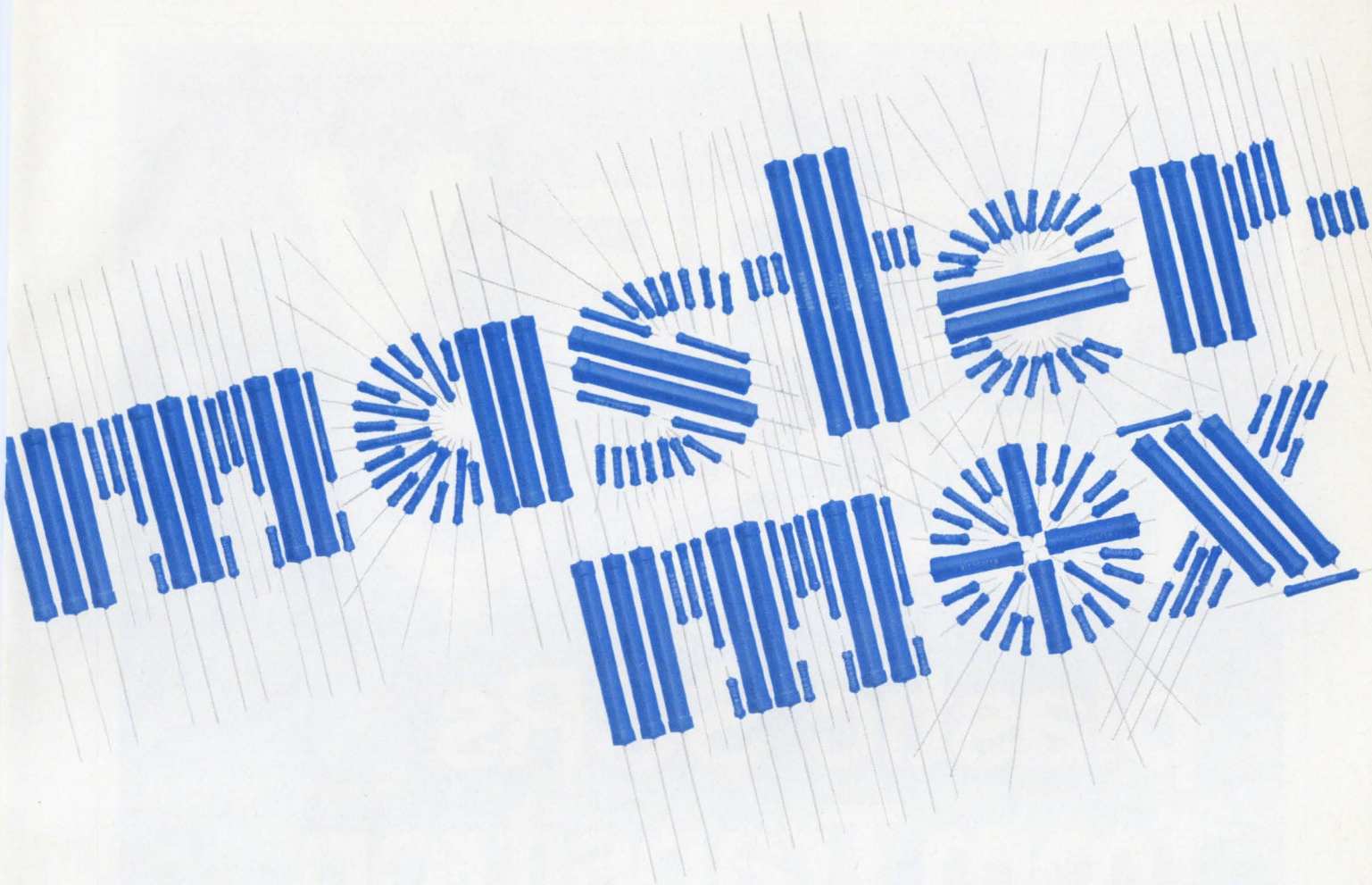
PC-500 IN THE FIELD **TICOR III IN THE LAB**

This matched pair of Mincom Instrumentation Recorder/Reproducers are right out of the same family. Every Mincom PC-500 and every TICOR III grow up together—literally—and this proves out in their faultless cooperation in data acquisition and reduction. They are the industry's most advanced systems for their specified tasks, they share telemetry's ultimate compatibility while providing up to 2 MHz on fourteen channels. The rugged PC-500 was designed from the blackboard up to complement TICOR III's flutter suppression performance. In both systems the basic servo design thinking is identical. At the subassembly level, electronics and circuit design are the same. Add to this TICOR III's unmatched servo bandwidth, its low $\pm 0.4\ \mu$ sec time base error, its highly successful two years of field test as Mincom's Model 32 —and look no further for **your** complete (and compatible) data team. Write us for details and specifications.

Mincom Division 3M COMPANY

300 SOUTH LEWIS ROAD • CAMARILLO, CALIFORNIA 93010

INFORMATION RETRIEVAL NUMBER 55



A Mastermox is something more than a metal film.

A Mastermox is a metal oxide glaze resistor. Mastermox resistors combine metal powders with molten glass to bring resistor technology to a new high. Revolutionary design creates high resistance range accuracy — 10K ohms to 10,000 Megohms. Space-savings too. Provides more watts per cubic inch.

Stability? Drift as low as 1% full-load in 2000 hours. On the shelf — less than 0.1% drift per year. Changes in voltage and temperature barely influence Mastermox performance.

Obtain Mastermox critical capability in high voltage dividers and bleeders, meter multipliers, high voltage probes, oscilloscopes and vacuum tube voltmeters, plate load resistors, pulse forming networks, and similar applications.

Mastermox. Victoreen's master resistor.

Model	Resistance Range	Power Rating @ 70°C	*Max. Oper. Volts	Length Inches	Diameter Inches
MOX-400	1 - 2500 megs	.25W	1,000V	.420±.050	.130±.010
MOX-750	1 - 5000 megs	.50W	2,000V	.790±.050	.130±.010
MOX-1125	1 - 10000 megs	1.00W	5,000V	1.175±.060	.130±.010
MOX-1	10K - 500 megs	2.50W	7,500V	1.062±.060	.284±.010
MOX-2	20K - 1000 megs	5.00W	15,000V	2.062±.060	.284±.010
MOX-3	30K - 1500 megs	7.50W	22,500V	3.062±.060	.284±.010
MOX-4	40K - 2000 megs	10.00W	30,000V	4.062±.060	.284±.010
MOX-5	50K - 2500 megs	12.50W	37,500V	5.062±.060	.284±.010

*Applicable above critical resistance. Maximum operating temperature, 220°C. Encapsulation: Si Conformal. Additional technical data in folder form available upon request. Or telephone: (216) 795-8200.

VICTOREEN INSTRUMENT DIVISION
10101 WOODLAND AVENUE • CLEVELAND, OHIO 44104
EUROPE: ARNDALE HOUSE, THE PRECINCT, EGHAM, SURREY, ENGLAND • TEL: EGHAM 4887

VICTOREEN

INFORMATION RETRIEVAL NUMBER 56

MORE V
LESS ¢
plastic SCRs from Transitron

New, silicon planar SCRs in plastic, rated to 300V, at industry's lowest prices*

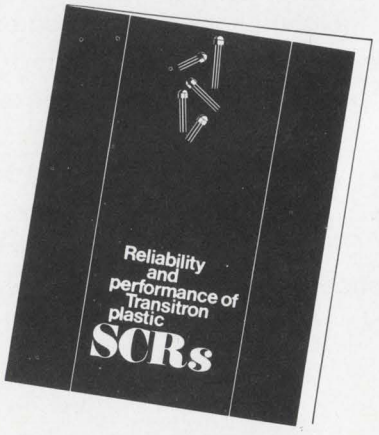
Transitron's low-cost RTJ Series plastic SCRs offer new scope to designers of commercial and consumer electronic equipment. Now, for the first time, inexpensive plastic SCRs with documented reliability are available with 200V ratings (for 115V applications) and even 300V ratings for special requirements. Plastic-encapsulated in a TO-92 package, the new units are designed especially for applications requiring long life and high performance.

RTJ02 & RTJ05 SERIES
- **Ratings to 300V @ .8A RMS**
- **Triggering sensitivities to 20μA**

Now also available: 2N5060 Series

* RTJ0201 (15V rating): $.44 in 100-quantities, with immediate availability at your local Transitron Distributor. Production quantities, 2-4 weeks ARO.

- Supported by the industry's first reliability and performance report on plastic SCRs . . . 24 pages of valuable information for design engineers — available free.
- Also available . . . up-to-the-minute application data on full plastic SCR line.



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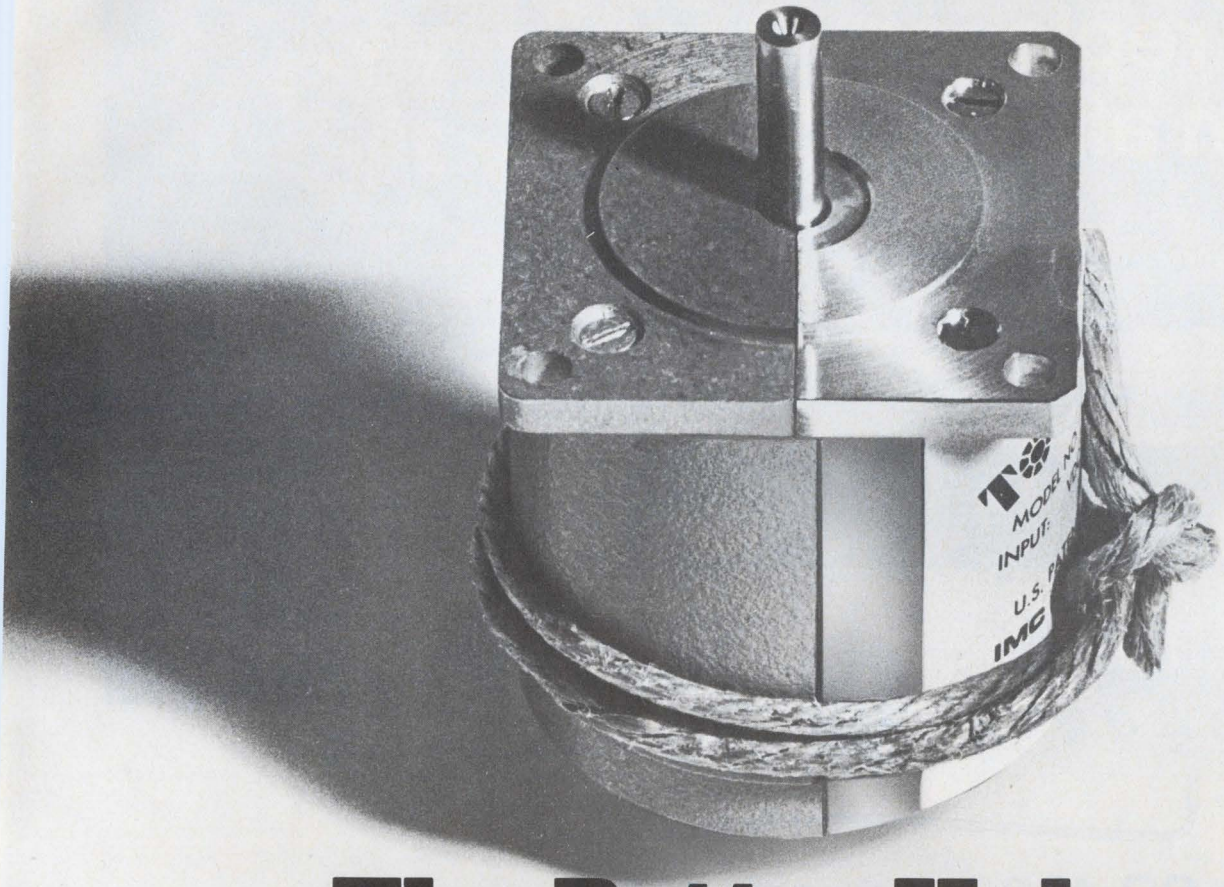
INFORMATION RETRIEVAL NUMBER 58 ►



The Better Halves.

Or how to get the best of 2 single source suppliers.

Have the best of choices.

Try IMC's newly patented Tormax 200.

It's directly swappable with the other one.

Steps in 1.8-degree increments at rates up to 550 steps/sec.

Turns at 72 rpm from a 60-Hz input.

Backed by IMC's extensive stepper design and manufacturing capability.

Available immediately in standard models.

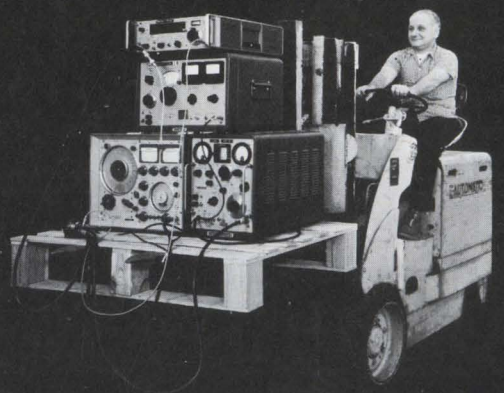
A little longer for dual shafts, splines, keyways, different mounts, and so forth.

IMC Magnetics Corp., Western Division, 6058 Walker Avenue, Maywood, California 90270, Tel. (213) 583-4785, TWX 910-321-3089.

imc

Signal Generators...

here's the one that replaces them all.....*



The New SG-1000 outperforms all other signal generators from LF to UHF (singly or in combination)

The new Model SG-1000 Signal Generator has obsoleted all others within its frequency range . . . singly or in combination. The specifications of this 5¼" high instrument are unequalled . . . and are rarely approached.

- LF to UHF coverage . . . 61 kHz, to 512 MHz, extendable to 1024 MHz with simple passive doubler
- Output frequency is read directly on three digit display with two digit extension
- Unsurpassed frequency accuracy and resolution . . . typically 0.005% . . . without the commonplace problems of human error in readout.
- Unparalleled modulation capability, AM, FM, pulse, video (100 MHz bandwidth!) . . . simultaneous combinations such as AM/FM, FM/pulse, etc. with negligible interaction
- Automatic leveling . . . within ±0.25 dB over *entire* frequency range from +20 dBm to −146 dBm
- Doubles as a frequency counter for measuring external signals between 100 Hz and 2 MHz

And if you are still not convinced that the Model SG-1000 has obsoleted most of your present signal generating equipment, consider the fact that its spectral purity approaches that of a crystal oscillator . . . that it has negligible warm-up drift . . . *no* "settling time" after band switching . . . and many other performance features not found in ordinary generators.

For additional technical information, or for Singer's new Application/Data Bulletin SG-10, contact your nearest Singer Field Representative or write directly to The Singer Company, Instrumentation Division, 915 Pembroke Street, Bridgeport, Conn. 06608. (203) 366-3201. *In Europe contact:* The Singer Company, Instrumentation Division, P.O. Box 301, 8034 Zurich, Switzerland, Telephone: (051) 47 25 10

SINGER
INSTRUMENTATION

** Hewlett-Packard Models 608F, 606A and 5245L/5253B./ Marconi Model 1066B/6, Pin Diode Modulator, Coaxial Switch*

INFORMATION RETRIEVAL NUMBER 59

Programming was pretty slow...
Now, the Beckman 6401 is programmable to 136 MHz

In the Model 6401 Programmable Counter and Timer, Beckman offers a general purpose laboratory and production instrument that does what you want it to, at a price you can't resist... $1375.

The 6401 provides direct frequency measurements to 136 MHz and complete programmability from contact closures. And the 6401 makes new measurements that were "unheard" of in the Good Old Days —like pulsed RF frequency or burst frequency measurements and period measurements from both channels for calibrated phase timing.

Timing measurements are a breeze with the exclusive trigger point monitor lamps in the 6401 for optimum attenuator and trigger adjustments. And maximum utilization of field replaceable IC's assures highest reliability and the lowest cost of ownership.

The 6401 is provided in a compact 3½" rackable package to conserve systems panel space, with 1-2-4-8 BCD outputs and scope markers as standard features. Options for serial input and output data, for nine digit display, and oscillator options with stabilities to 5 parts in 10^{10} per 24 hours are available.

Regardless of what "programmable" meant in the good old days, take advantage of what Beckman has to offer today. For complete information, contact your local Beckman office, sales representative or the factory direct.

Specifications

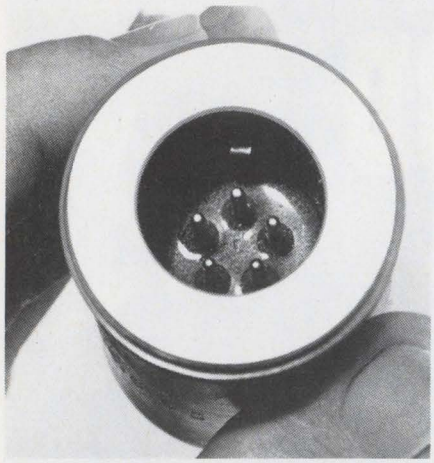
Measurement Modes: Frequency: Input A, 0-136 MHz; Input B, 0-10 MHz. Burst Frequency: 0-136 MHz. Time Interval: A to B, 0.1 μsec to 10^8 sec. Period: Input A, 0-10 MHz. Period Average: Input A, 1 to 10^8 in decade steps. Ratio: (Fx ÷ Fy) x M with Fx = 0 to 136 MHz, Fy = 0 to 10 MHz, M = 1 to 10^8. Totalize and Scale: Input A, 0-10 MHz scale; 136 MHz count, 1 to 10^8 in decade steps. *Sensitivity:* Inputs A & B, 100 mV rms. *Crystal Frequency:* 10 MHz. *Stability Aging Rate:* Temperature: 2.5 x 10^{-6} from 0°C to 50°C; Line Voltage: 1 x 10^{-7} for ± 10% line voltage change. *Oscillator Output:* 10 MHz. *External Oscillator Input:* 10 MHz. *Time Base Output:* 3 V p-p. *Display:* 8 digits with overflow indication. Storage ON-OFF. Sample Rate: fast recycle and .1 sec to 10 sec display. Gate Lamp. *Remote Programming:* by switch closure to ground; BCD data at rear panel. *Temperature:* 0-55°C. *Power:* 115/230 V ± 10%; 50-400 Hz. *Price:* $1375. *Options:* ACL: Laboratory Stability Oscillator, 3 parts in 10^9 per 24 hrs; $400. ACN: Ultra-high Stability Oscillator, fast warm up, 5 parts in 10^{10} per 24 hrs; $800. 9 digits: $100. Rear Inputs (A and B): $50.

Beckman® INSTRUMENTS, INC.
ELECTRONIC INSTRUMENTS DIVISION
RICHMOND, CALIFORNIA • 94804

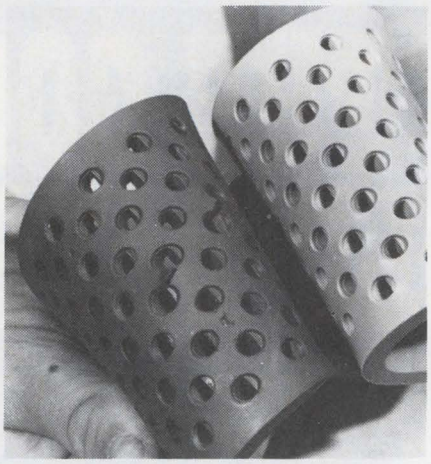
INTERNATIONAL SUBSIDIARIES: AMSTERDAM; CAPE TOWN; GENEVA; GLENROTHES, SCOTLAND; LONDON; MEXICO CITY; MUNICH; PARIS; STOCKHOLM; TOKYO; VIENNA

INFORMATION RETRIEVAL NUMBER 60

5 GE silicone problem solvers.

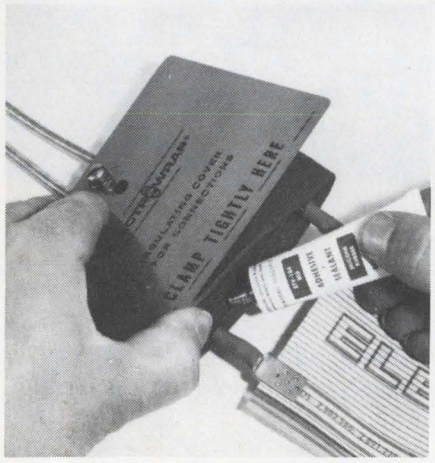


Invisible seal against moisture. Translucent GE RTV-615 silicone rubber used on this underwater connector assures clear identification of terminals, and improved dielectric strength under high voltage. RTV has excellent electrical properties.



Mold life doubled. New RTV-630 silicone molds last twice as long as conventional silicones in molding epoxy parts for electronic modules. Tear strength of 100 lb/in (die B) makes "630" the toughest RTV yet... without sacrificing flexibility.

Durable marking labels made of GE silicone rubber withstand temperature extremes, aging, moisture, chemicals, fire. RTV adhesive/sealant keeps flexible labels in place permanently on cable, industrial equipment.



Beats heat and cold. Electrical heating strip on pipes keeps temperatures constant, indoors and out. GE silicone rubber "jacket," sealed with RTV, has high dielectric strength, resists aging, corona, from −65° to 600°F.

Cheaper than gaskets. GE RTV-109 silicone rubber seals plate assemblies of food slicer to keep juices out. Non-toxic, inert RTV-109 is applied easily, forms permanent, moisture-proof bond. Contact GE for FDA data on RTV-109.

And 500 others waiting in the wings.

Chances are you're wrestling with a design problem that could be solved with a GE silicone.

But *which* GE silicone? We have over 500 varieties to choose from. And thousands of success stories to back them up.

Let's make a deal. You tell us what your problem is, and we'll help you solve it.

Without fail.

Write to Section L10311R1, Silicone Products Department, General Electric Company, Waterford, New York 12188.

GENERAL ELECTRIC

INFORMATION RETRIEVAL NUMBER 61

ACTUAL SIZE

Relays: 1/6-Size Relay Model BR10

☐ Dry Circuit to 1 Amp. ☐ DPDT

☐ Welded or Soldered ☐ Universal Contacts ☐ To MIL-R-5757

Babcock's Model BR10 1/6-size crystal can relay packs a lot of performance in a small package. Its unique universal contacts give you "non-stop" operation from dry circuit to 1 amp...one subminiature relay to meet all your requirements for high-density circuit-board applications—at no cost premium.

You'll find that this small, versatile, DPDT unit has everything. Designed to specification MIL-R-5757, it features rugged unitized construction for increased shock and vibration resistance. Both soldered or welded versions are offered. Regular and gold-plated plug-in, solder-hook, and long-lead terminal styles are available, in standard circuit-board grid pattern, with a range of mounting types.

The Model BR10 has a record of dependability, attested by its proven conformance to MIL-R-5757 and specified use in programs requiring operation under the most severe environmental extremes. Built-in reliability, outstanding performance, application flexibility...all assurances that your relay is *better because it's Babcock.*

The Babcock Model BR10 relay has proven its reliability in a variety of aerospace and commercial avionics applications. Its subminiature size makes it ideal for single and multi-relay circuit-board installations. In fact, a brace of four BR10's has been found to take less board space than a similar group TO-5 units. You get efficient high-density packaging, *plus* full 1-amp. capability.

Need 2-amp. performance? The Model BR10 will operate dependably at 2 amps. (28 VDC), through 100,000 operations, in the temperature range −65 °C to +125 °C. Contact our Applications Engineering Group for further details.

SPECIFICATIONS

Contact Rating	**1 amp. @ 28 VDC**
Operate/Release Time	**3.5 ms., max.**
Pull-In Power	**100 mw**
Bounce Time	**2 ms., max.**
Shock	**50 g's (11 ms.)**
Vibration	**30 g's, 38-2000 Hz**
Operating Temp.	**−65 °C to +125 °C**
Life	**100,000 operations, min.**

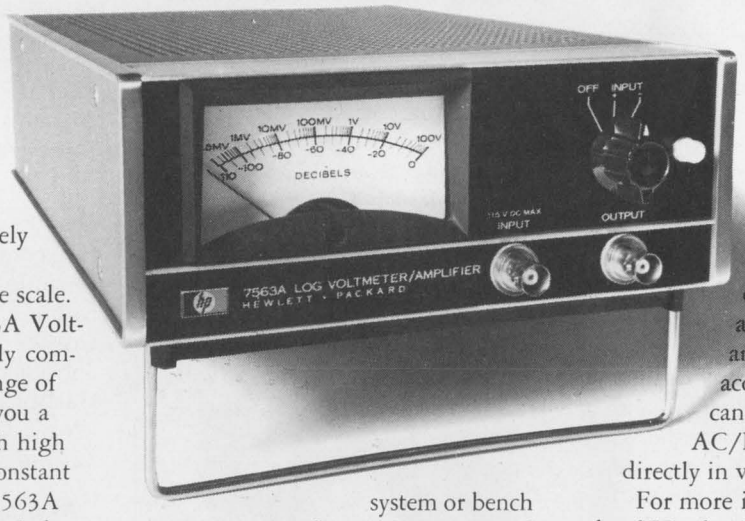
Get complete information on the versatile, subminiature Model BR10 today...contact Babcock Electronics Corp., Relays Division, Subsidiary of Esterline Corp., 3501 Harbor Blvd., Costa Mesa, Calif. 92626. CALL COLLECT (714) 540-1234 or TWX 910-595-1517.

Available off-The-Shelf from AVNET, POWELL or PDQ.

Challenging opportunities now exist at Babcock for experienced relay-switch engineers.

INFORMATION RETRIEVAL NUMBER 62

Even if your data goes from to you can see it all on one display.



Some of your data will barely twitch an indicator.

Some of it goes right off the scale.

No problem. The HP 7563A Voltmeter/Amplifier logarithmically compresses data with a dynamic range of 110 dB—110 dB!—and gives you a single output that includes both high and low amplitude data with constant resolution and accuracy. The 7563A accepts positive or negative signals from vibration tests, geophysical measurements, pulse height analyzers, computers and similar sources, compresses the amplitudes logarithmically and feeds the results directly to a recorder or oscilloscope. The front-panel meter gives an instant visual display in dB. And when it's not performing that job, the 7563A will double as a voltmeter (calibrated from 0.3 mV to 100 V) for system or bench use. How's that for a voltmeter/amplifier with the modest price of $695 and one of the widest dynamic ranges you can buy?

To add AC log conversion and voltmeter applications to DC, use the 7562A with its 80 dB dynamic range. It's the only converter on the market that can measure the true rms value of an AC voltage. Turn it loose on vibration studies, biochemical data, seismographic studies, audio research or similar data with large asymmetrical wave forms and it will give you the most accurate log conversion you can get in AC. Or use it as an AC/DC voltmeter, calibrated directly in volts. Price is $995.

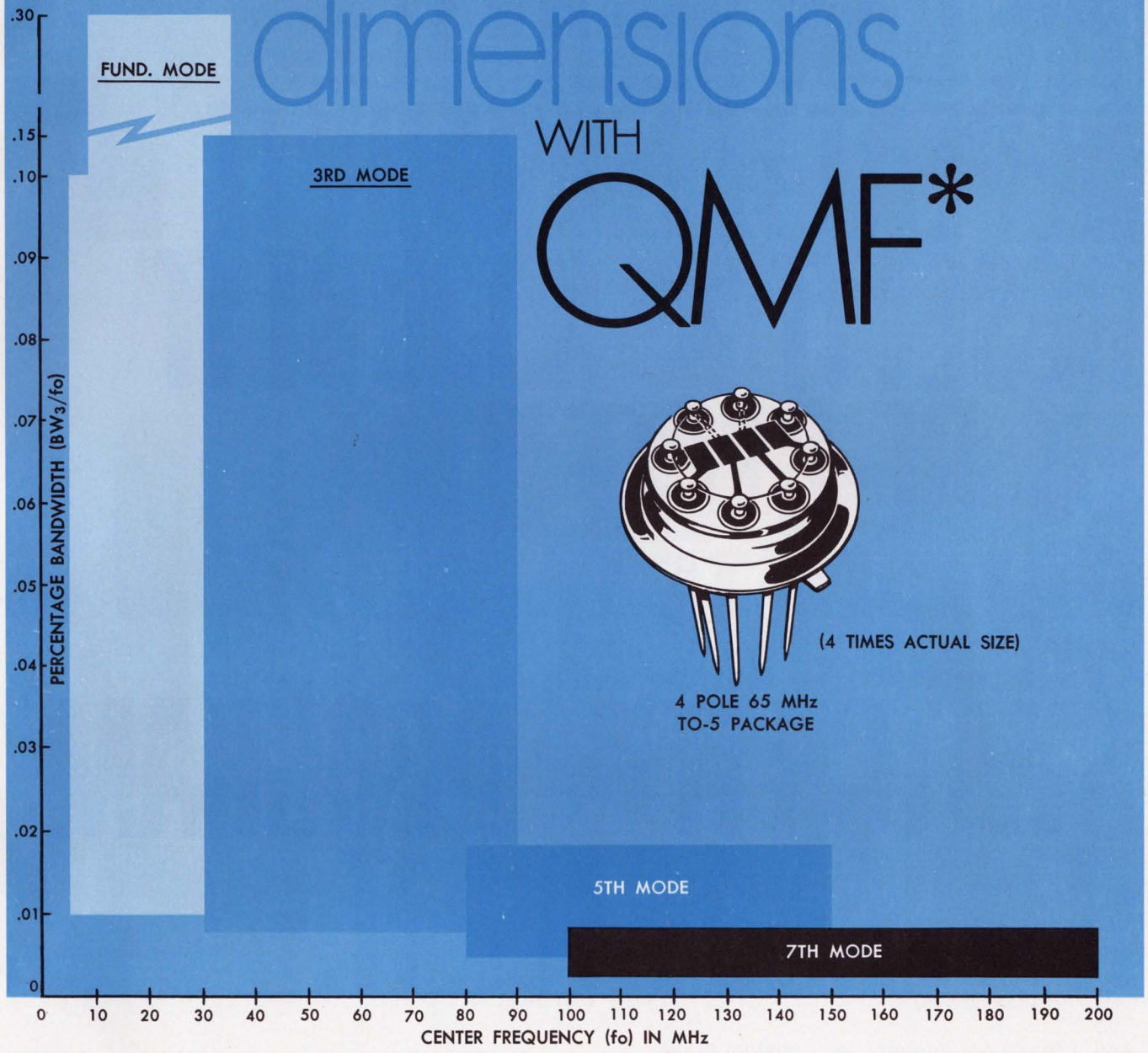
For more information, call your local Hewlett-Packard field engineer or write Hewlett-Packard, Palo Alto, California 94304; Europe: 1217 Meyrin-Geneva, Switzerland.

HEWLETT hp PACKARD

11907A

INFORMATION RETRIEVAL NUMBER 63

new dimensions WITH QMF*



(4 TIMES ACTUAL SIZE)

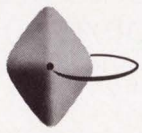
4 POLE 65 MHz
TO-5 PACKAGE

(here's valuable bandwidth information you'll want to save)

Regardless of what they are called, McCoy Electronics Co. makes available the most complete offering of multi-electroded devices in the industry. From 5 to over 200 MHz, both crystal and filter technologies are combined to provide you assurance of competence, quality and reliability. We engineer and fabricate...

***Quartz Mechanical Filters**
Uncoupled Filter Devices
Custom Innovations...

Put our experience to work for you!



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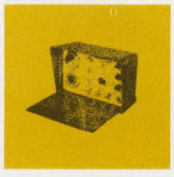
IT  AND STOP IT.

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INFORMATION RETRIEVAL NUMBER 65

Technology

"Feedback amplifiers," says John DeFalco, an engineer of Honeywell's Computer Control Div., "are a snap for network topology." p. 98.

Fred Palenschat points to a dual JFET that provides low common-mode voltage to an IC amplifier's input. p. 86.

Also in this section:

Build digital models of analog systems with a component block program. p. 90.
Cut binary-to-BCD conversion costs with this special circuit. p. 104.
Preparing a technical paper? These steps will help you. p. 112.
Ideas for Design. p. 117.

Consider dual JFET input stages

when the requirements call for high input-impedance, low common-mode voltage and good temperature tracking.

Are you faced with the problem of creating an amplifier with high dc input impedance, low bias currents, and low temperature drift—perhaps for use as a long-time constant integrator or with a nanoampere transducer? Your solution may be the dual junction FET, which facilitates the design of amplifiers requiring low offset voltages and good temperature tracking.

Serious objections have been raised to the use of discrete field-effect transistors at the input of a high-impedance dc amplifier. These include:

- Junction field-effect transistors (JFETs) are notorious for their wide parameter spread; I_{dss} currents may vary by a factor of ten.
- A pair of JFETs can show a wide divergence of I_{dss} and pinchoff voltage as a function of temperature.
- High pinchoff voltage in a JFET used in the source follower mode driving a linear IC appears as an applied high common-mode voltage, and a high gate-source voltage applied to the inputs can result in latchup or breakdown of an input stage.

The dual JFET has matched characteristics that minimize the first two problems, and careful design of the input network reduces the third to acceptable levels.

Matching characteristics are a big plus

As an example of what dual JFET matched characteristics can accomplish, a 2N5199 has a maximum offset voltage of only 15 mV, and its temperature tracking specifications hold to better than 40 $\mu V/°C$. In a laboratory temperature test of the 2N5199 used to drive a 741 op amp in a unity gain—high input impedance configuration— a $\pm 30°$ change in temperature, resulted in less than 0.5 mV of drift.

However, the disadvantage of the high pinchoff voltage that is inherent in JFETs, discrete or dual, must be taken into account. It has been common practice to place a potentiometer in the source (Fig. 1) or gate (Fig. 2) of one or both of the JFETs in order to "balance" the differential output voltage seen by the operational amplifier. These are weak solutions to a perplexing problem. First of all, the pots do not reduce the possible magnitude of common-mode voltage that could be applied to the op amp. Secondly, if discrete JFETs were used, zeroing of the closed-loop circuit would necessarily be very touchy.

But a new circuit design method using dual JFETs minimizes large expected pinchoff voltage levels to tolerable limits without using a potentiometer except for an offset null adjust.

Common sense indicates that, if the pinchoff voltage were split so that JFET units at either extreme of a given type number might yield a plus or minus common-mode voltage, the problem would be divided in half. A pair of diodes or zeners in each source is one way of doing this, except that finding the correct number of diodes or zeners to split the pinchoff voltage exactly might prove to be a bigger and even more complicated problem.

However, if the magnitude of the maximum expected pinchoff voltage could somehow be made to appear to be reduced and then have this value split, the resulting benefits are obvious. Then the common-mode error voltage applied to the IC would be minimized without an extra time-consuming and expensive calibration step. Except for the offset adjustment mentioned previously, no other dc compensating adjustments are necessary—a boon to any production run. In fact, if the maximum offset of the amplifier is insignificant compared to the magnitude of the input signal, or if ac coupling is used, no zeroing adjustment need be made at all.

This leads to a second important benefit of dual JFETs: calibration costs on the final amplifier assembly in a production run are reduced.

Design the circuit

From the manufacturer's data sheet for a given dual unit, specifications for the minimum and maximum values of I_{dss} and V_p can usually be obtained. These are the only values needed

Fred Palenschat, Chief Electronic Engineer, Gamma Scientific Inc., San Diego, Calif.

to complete the computations. Often, however, $V_p min$ is not given. In these instances, V_p can be approximated by the following formula:

$$V_p min \approx 1.3\,(I_{dss} min / y_{fs} min)$$

This could have an error of as much as 30%, but it would have only a minor effect on the final result.

The computations from this point on are in a logical sequence to give an orderly procedure to the design of the final circuit. (Known and accepted empirical formulas describing FET action will be used, since they give fairly accurate results. They are indicated by reference numbers in the text.) Figure 3 shows resistor designations and the final circuit configuration.

1. Select an operating current less than or equal to $I_{dss} min$ to ensure that all units in the selected series will be able to supply the required drain current:

$$I_{DL} \leq I_{dss} min$$

2. Compute the gate-source voltage[1] at I_{DL}:

$$V_{GSL} = V_p min\,(1 - \sqrt{I_{DL}/I_{dss} min})$$

3. Compute the total source resistance R_s:

$$R_s = (V_{ss} + V_{GSL})/I_{DL}$$

4. Compute the maximum gate-source operating voltage[2], which is V_{GSH}.

It can be shown that

$R_s = (\sqrt{I_D/I_{dss}} - 1)/(I_D/V_p)$ for a source follower. Combining this equation with results from steps 2 and 3 and observing that maximum values of I_{dss} and V_p are used to compute V_{GSH}:

$$0 = V_{GSH}^2 - V_{GSH} V_p max\,(2 + V_p max/R_s\, I_{dss} max) + V_p^2 max\,(1 - V_{ss}/R_s I_{dss} max)$$

which is of the form:

$$V_{GSH}^2 - BV_{GSH} + C = O$$

$$V_{GSH} = (B - \sqrt{B^2 - 4C})/2$$

5. Solve for the drain current, I_{DH}, which flows with V_{GSH} applied.

$$I_{DH} = (V_{ss} + V_{GSH})/R_s$$

6. The values of R_1 and R_2 must now be computed. Writing the node equations for Fig. 3 under maximum and minimum conditions:

$$-V_{ss} + I_{DL}R_2 = V_{OL}$$

$$V_{GSL} - I_{DL}R_1 = V_{OL}$$

$$-V_{ss} + I_{DH}R_2 = V_{OH}$$

$$V_{GSH} - I_{DH}R_1 = V_{OH}$$

It is also required that:

$V_{OL} = -V_{OH}$ for symmetry.

Combining these equations yields the result:

$$R_2 = R_1(2V_{ss})/(V_{GSL} + V_{GSH})$$

From step 3:

$$R_s = R_1 + R_2$$

R_1 and R_2 can be computed.

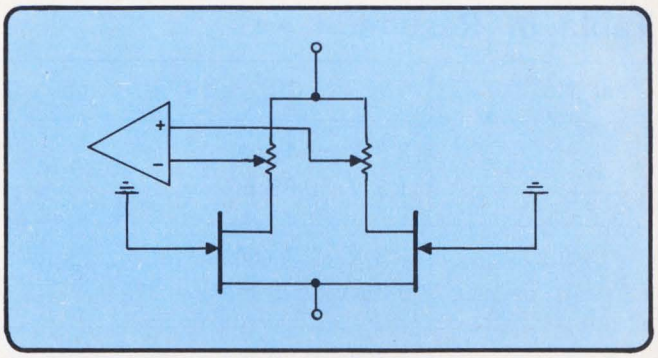
7. Compute the quiescent output voltage ranges V_{OH} and V_{OL} with the values of R_1 and R_2.

From step 6:

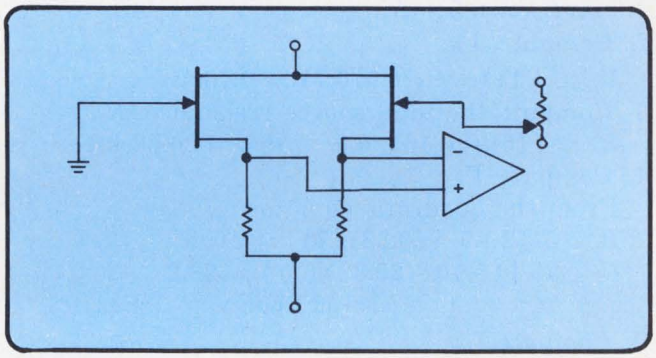
$$V_{OL} = -R_1 I_{DL} + V_{GSL}$$

and $V_{OH} = -R_1 I_{DH} + V_{GSH}$

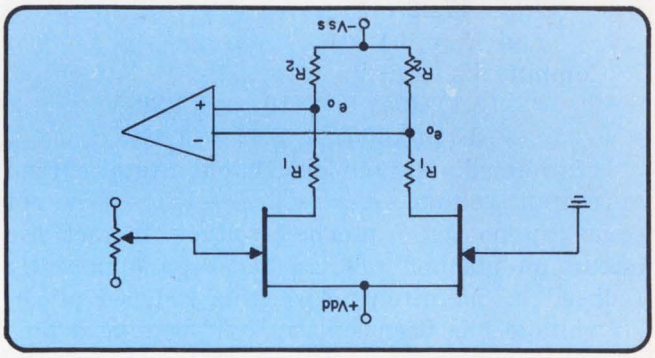
This completes the computational analysis of the circuit.



1. **With potentiometers in source circuit** this dual JFET requires touchy, time-consuming adjustment and the cost of the extra pot. If this circuit is used a pair of discrete JFETs, it would also show poor temperature tracking, and poor I_{dss}, V_p and y_{fs} tracking.



2. **With potentiometer in one gate circuit** the dual JFET cannot reduce common-mode errors due to high V_p. A discrete JFET pair would also exhibit this difficulty.



3. **This recommended circuit** using a dual JFET reduces common-mode errors, exhibits good temperature and parameter tracking, and shows ease of adjustment.

In order to get a feel for the benefits of this design, a simple computation is given, along with the laboratory results.

The manufacturer's specifications for the 2N5199 dual FET, which is used in the example, are as follows:

$V_{GS} max = 5$ V $I_{dss} max = 7$ mA

$V_{GS} min = 1$ V $I_{dss} min = 0.7$ mA

Let $V_{ss} = 10$ V

Table of Results

Unit No.	V_p	I_{dss}	V_{OL} (computed)	V_{OL} (measured)	V_{OH} (computed)	V_{OH} (measured)
1 a	2.3 V	2.1 mA	−0.39 V	−0.44 V	0.37 V	0.36 V
1 b	1.3 V	0.89 mA				
2 a	2.3 V	2.1 mA	−0.68 V	−0.70 V	0.68 V	0.77 V
2 b	0.85 V	0.25 mA				
3 a	1.3 V	0.89 mA	−0.28 V	−0.28 V	0.28 V	0.33 V
3 b	0.85 V	0.25 mA				

1. Select an operating current equal to or less than I_{dss} *min.*
   Let $I_{DL} = 0.5$ mA.
2. Compute V_{GSL}.
   $V_{GSL} = 1(1 - \sqrt{0.5/0.7}) = 0.16$ V
3. Compute the total source resistance, R_s.
   $R_s = (10 + 0.16)/0.5 \times 10^{-3} = 20.32$ kΩ
4. Compute V_{GSH}.
   From the quadratic equation:
   $B = 5\ [2+5/(20.32)\ (7)\ ] = 10.2$
   $C = 25\ [1-10/(20.32)\ (7)\ ] = 23.2$
   $V_{GSH} = 10.2-\sqrt{104-92.8})/2 = 3.44$ V
5. Compute I_{DH}.
   $I_{DH} = (10 + 3.44)/20.32 \times 10^3 = 0.665$ mA
6. Compute R_1 and R_2.
   $R_2 = (2)\ (10)R_1/(3.44 + 0.16) = 5.55R_1$
   $R_2 + R_1 = 20.32$ kΩ
   $R_2 = 17.22$ kΩ
   and $R_1 = 3.1$ kΩ
7. Compute V_{OH} and V_{OL}.
   $V_{OL} = -(3.1)\ (0.5) + 0.16 = -1.39$ V
   $V_{OH} = -(3.1)\ (0.665) + 3.44 = 1.41$ V

It is immediately obvious that the total spread of output voltage, $e_o = |V_{OH} - V_{OL}|$, does not equal the maximum pinchoff voltage. In fact, the maximum pinchoff voltage has been apparently reduced in magnitude. Also, this reduced pinchoff voltage has been spilt in half to give a plus or minus output level, thus further reducing the maximum output common-mode voltage applied to the linear IC by more than 70%.

Experiments verify theory

In the lab, the preceding circuit was built substituting a 3-kΩ resistor for R_1 and an 18-kΩ resistor for R_2. (Standard values were selected as close as possible to the computed values of R_1 and R_2.) With the above values for R_1 and R_2 substituted into the circuit, the quiescent output voltage for three typical units was found to be well within the calculated limits of e_o.

In order to test further the validity of the derived equations, the I_{dss} and V_p parameters of several units were measured, and the units were then paired off to represent the maximum and minimum extremes of an FET type. The values of R_1 and R_2 and V_{OH} and V_{OL} were first computed, and then V_{OL} and V_{OH} were actually measured. The results appear in the table.

It is obvious that the computed and measured values of V_{OL} and V_{OH} agree very closely. It can also be observed that the total output voltage range in each case is much less than the maximum pinchoff voltage, which is in effect an apparent reduction in the maximum pinchoff voltage.

This design procedure can lead to an extremely stable and repeatable system of a dual FET and linear IC that provides the benefits of good temperature tracking, low offset voltages, low common-mode errors, and with a minimum of calibration time. This is accomplished with standard value components and only one additional pot. ■■

References:

1. Dickson Electronics Corp., Application Notes, Vol. 1, No. 2.
2. Dickson Electronics Corp., Application Notes, Vol. 1, No. 5.

Test your retention

Here are questions based on the main points of this article. Their purpose is to help you make sure you have not overlooked any important ideas. You'll find the answers in the article.

1. What are the ill effects of high pinchoff voltage?

2. How can the common-mode voltage be reduced?

3. What advantages do dual JFETs have over discrete JFET pairs?

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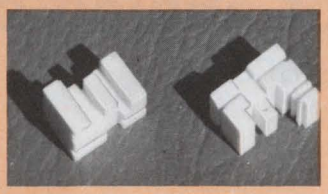
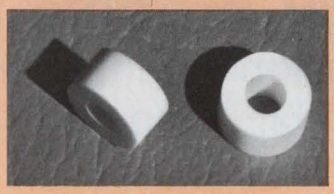
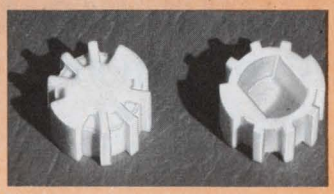


.370 ± .003
Hole .025 ± .002



O. D. .467 $^{+.000}_{-.005}$



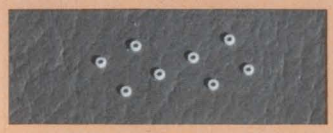
.532 ± .005

Holes .056 ± .003
Holes .016 ± .002

Radii .171 ± .002

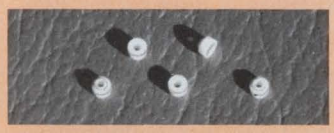
Slot Width .070 ± .002
Holes .034 ± .001

O. D. .379 ± .0025
Holes ± .003



Thickness .0165 ± .0015

Slot Width .064 ± .002
Floor Thickness .050 ± .001



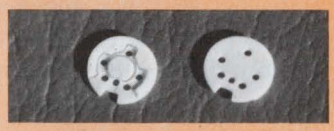
Hole .042 ± .001

O. D. .484 ± .003
Hole .016 ± .002

O. D. .304 ± .003
Holes ± .002

O. D. .369 — .372 ± .0015

O. D. .218 ± .0015
Hole .094 ± .001



Holes ± .002
Thickness ± .002

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Build digital models of analog systems.

A component block program gives analog flexibility to a digital computer.

For the engineer who wants the advantages of analog simulation without the need to learn programing, the Continuous System Modeling Program (CSMP) jumps the language barrier. One version does this by means of computer-typed instructions, punch cards and a console keyboard. Other versions are being offered for use on time sharing terminals. All versions, however, are based on similar concepts although capabilities vary.

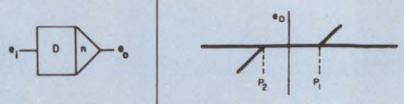
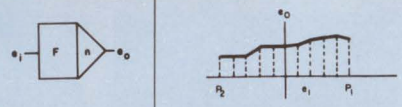
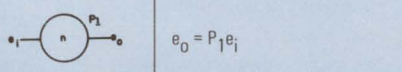
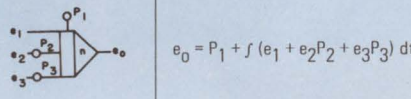
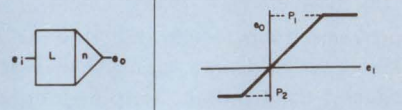
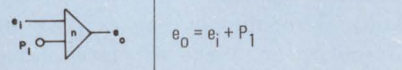
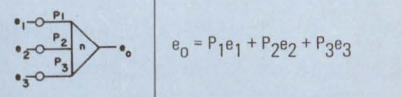
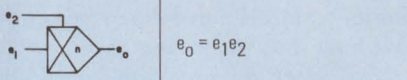
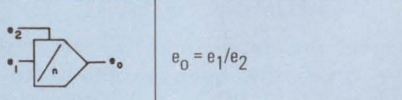
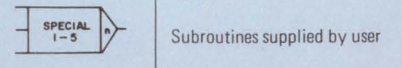
The CSMP package, developed by IBM, contains: (1) a complement of functional elements, or blocks; (2) an input language for transforming the systems block diagram into computer statements; and (3) a technique for conducting a simulation run. No prior computer experience is required—in fact, the system is simpler to use than an analog computer for the same type of problem.

When the system uses a relatively small, fast computer, like the 1130, or a time sharing terminal it is economically feasible for the user to interact in an on-line mode with the simulation. Since the typical simulation run takes only a few minutes, it is practical to experiment with a system under study until its design and performance are satisfactory. "Conversation" with the computer takes place by means of a console typewriter and auxiliary switches.

Digital blocks replace analog

CSMP in conjunction with the IBM 1130 computer makes use of a set of 25 standard simulation elements, or blocks, and five special user-defined elements. The standard elements include such conventional analog devices as summing amplifiers, inverters, integrators, multipliers, relays, potentiometers, absolute value, dead zone, limiters, clippers, zero order hold, time delay and the like.

Figure 1 illustrates a representative group of

Element type	Language symbol	Diagrammatic symbol	Description
Dead space	D		
Function generator	F		
Gain	G		$e_0 = P_1 e_i$
Integrator	I		$e_0 = P_1 + \int (e_1 + e_2 P_2 + e_3 P_3)\, dt$
Limiter	L		
Offset	O		$e_0 = e_i + P_1$
Weighted summer	W		$e_0 = P_1 e_1 + P_2 e_2 + P_3 e_3$
Multiplier	X		$e_0 = e_1 e_2$
Divider	/		$e_0 = e_1 / e_2$
Special	1-5		Subroutines supplied by user

1. **A few of the 1130 CSMP functions** available are shown in this chart of representative elements.

Martin Y. Silberberg, Mgr. Data Acquisition and Control Systems Center, IBM, Palo Alto, Calif., and **Charles A. Luke,** IBM World Trade Corp., New York.

1130 CSMP functional elements and their symbols. Each functional block has up to three possible inputs and a single output. Special blocks can be created by the user by adding the name of the function to the CSMP language and by specifying the operation of the block in FORTRAN. The special blocks are subroutines that require a knowledge of FORTRAN for their development.

The simulation model of a system is developed by first interconnecting on paper, in block diagram fashion, the various functional elements needed to portray the system. After the system block diagram has been developed, it must be translated into the corresponding set of CSMP language statements.

The input language permits specification of the functional blocks and their interconnection, the parameters and initial conditions for each run, and specific run instructions, such as total time simulated, integration intervals, output format (printed or plotted), and the like. The language provides three types of statements:

- Configuration statements, which specify desired functional blocks and their interconnections.
- Parameter statements, which permit selecting numerical constants for those elements that have parameters associated with them. As shown in Fig. 1, some elements—multipliers, dividers, etc.—have inputs but no associated parameters; these require only configuration statements.
- Function generator statements, to define the input/output relationships for function generator elements. Since function generators also have associated parameters, they require all three types of statements.

Keyboard allows user to interact

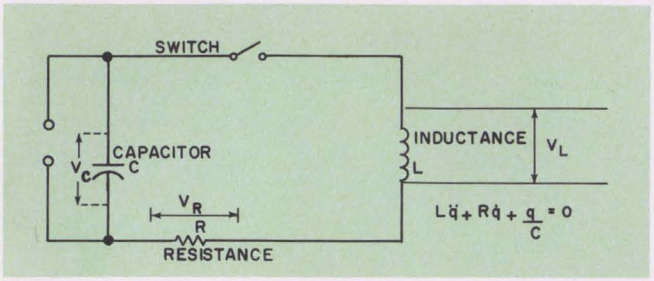
The user enters the program statements either by means of punched cards or directly from the console keyboard. Punched cards, prepared in a standardized format, are usually preferred for initial problem entry; this reserves the console keyboard and switches for on-line modifications of statements and run conditions. A sequential entry procedure need not be followed; block numbers are assigned arbitrarily, and configuration statements are entered in any order. The order of computations to simulate parallel problem functions is determined automatically by a sorting routine. The automatic sorting algorithm eliminates a major headache of previous digital simulations.

During problem entry, the user is guided through the necessary procedures by computer-typed instructions and diagnostics. These instructions tell him to enter the problem data, to select the variables for printer or plotter output, and to specify an appropriate integration interval (one-tenth the period of the highest expected frequency is a good start), total run time, and output intervals. If he has specified an improper configuration, the program generates a "diagnostic message."

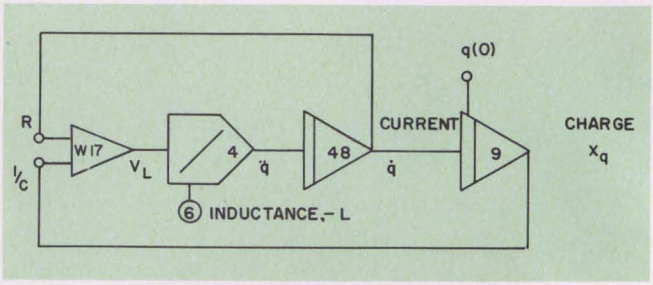
During problem solution the user can, by use of the console keyboard and switch options, experiment with the simulation model as spon-

Table of entry switch options

Interrupt run
Modify configuration
Change initial conditions or parameters
Change function generator intercepts
Change integration specifications
Set print interval
Define print variables
Specify new plot frame
Scale plotter x-axis
Scale plotter y-axis
Suppress instructions
Suppress typing of card input data
Punch updated data deck
Interrogate block outputs
Save status at interrupt point
Restart at previous interrupt point



2. **This elementary R-L-C circuit** illustrates how CSMP can help solve dynamic problems.



3. **Converted into a block diagram** for CSMP analysis, the R-L-C circuit of Fig. 2 appears in this form.

Continuous System Modeling Program
A Digital Analog Simulator Program for the IBM 1130

Instructional comments may be suppressed at any time by turning on switch 10
Turn on switch 1 to enter or modify configuration statements via the keyboard
Turn on switch 2 to enter or modify initial conditions or element parameters via the keyboard
Turn on switch 3 to enter or modify function generator intercepts via the keyboard

Output name	from block number	Type	Input 1 from block	Input 2 from block	Input 3 from block
V_L v	17	Summer	48	9	–
$\ddot{q}$	4	Divider	17	6	
L Inductance	6	Constant			
$\dot{q}$ Current	48	$\int dt$	4		
q Charge	9	$\int dt$	48		

(a)

```
   VERTICAL AXIS  ( -25.0000)  MINIMUM VALUE (  25.00000) MAXIMUM VALUE

TIME      OUTPUT(17)   OUTPUT( 4)   OUTPUT(48)   OUTPUT( 9)   MINIMUM                    MAXIMUM
 0.000    -10.0000       2.0000       0.0000     -10.0000   |----------+               |
 2.000     -2.2647       0.4529       2.4037      -7.0721   |----------+               |
 4.000      2.3760      -0.4752       2.2443      -2.1126   |----------+               |
 6.000      3.2354      -0.6470       1.0161       1.2032   |----------+               |
 8.000      1.9539      -0.3907      -0.0591       2.0722   |----------+               |
10.000      0.3714      -0.0742      -0.5114       1.3944   |----------+               |
12.000     -0.5306       0.1061      -0.4510       0.3714   |----------+               |
14.000     -0.6622       0.1324      -0.1914      -0.2793   |----------+               |
16.000     -0.3800       0.0760       0.0237      -0.4276   |----------+               |
18.000     -0.0574       0.0114       0.1081      -0.2738   |----------+               |
20.000      0.1170      -0.0234       0.0903      -0.0636   |----------+               |
22.000      0.1350      -0.0270       0.0357       0.0635   |----------+               |
24.000      0.0735      -0.0147      -0.0071       0.0879   |----------+               |

TURN ON SWITCH 10 TO SUPPRESS INSTRUCTIONS
SWITCH        OPTION
 1      MODIFY CONFIGURATION
 2      MODIFY PARAMETERS OR INTIAL CONDITIONS
 4      MODIFY INTEGRATION SPECIFICATIONS
 5      MODIFY PRINT INTERVAL
 6      MODIFY PRINT VARIABLES
11      SUPPRESS TYPING OF CARD INPUT DATA
12      PUNCH CORRECTED DATA DECK
13      INTERROGATE BLOCK OUTPUTS
14      SAVE STATUS AT INTERRUPT TIME
15      RESTART AT PREVIOUS INTERRUPT POINT
PRESS START AFTER SELECTING DESIRED OPTION
SWITCHES SET ON HERE     2
```

(b)

4. **The computer printout** of the sample problem shows the configuration and parameter specifications (a) and the "print-plot" output (b). The scale in (b) is automatically adjusted to fit the results.

taneously as he would on an analog computer. He need not follow a prescribed pattern of development and testing. Using the console features, he simply types in modifications in configuration, control variables, or parameters. He may interrupt the run at will to make modifications and then proceed either from the point of interruption or initiate a new run. He can even suppress instructions that are no longer needed, by simply throwing a console switch. The various console switch options are listed in the Table.

This type of direct interaction in a digital simulation run is, of course, the equivalent of changing potentiometer settings and patchboard connections on an analog computer. The digital approach has the added advantage of being self-documenting on the process of modifications and final data. The model's response to modifications can be observed at all times through the printouts at the console printer or, optionally, on the a plotter. All these features add up to easy modeling and a very high degree of operational flexibility.

R-L-C circuit illustrates procedure

The simple second-order oscillating system (Fig. 2) illustrates the operation of the 1130 CSMP system. The system consists of an electrical oscillating system, made up of a capacitor, C; inductor, L; and resistor, R.

Figure 3 shows the block diagram representation of this simple system, with block numbers assigned in an arbitrary manner. The model consists of only four elements—a summing amplifier, divider, and two integrators. The output of the first integrator is the current, i, and the output of the second integrator is the charge, q. These quantities are fed back to the input of the summing amplifier, along with the appropriate parameter constants.

The translation of the block diagram into the corresponding set of 1130 CSMP statements comes next. Simple coding forms assist in preparing the configuration statements for each block, and the associated parameter and function generator statements.

A direct correspondence between the block diagram and the CSMP language statements is evident from Figs. 3 and 4. The statements next are entered either by punched cards or directly, using the console keyboard. The user indicates his choice by means of a sense switch on the console. Fig. 4a shows problem specifications and Fig. 4b the "print-plot" output from the 1130 console printer for the parameters listed. Part of the output is a message indicating the available modification options (sense switches). In this case switch 2 was turned on to modify the parameters and initial conditions.

A larger machine expands capability

System/360 CSMP is based on the most powerful previous continuous-system simulator program the DSL/90[1]. S/360 CSMP combines the block modeling approach of digital-analog simulators, such as the 1130 CSMP, with the algebraic and logical modeling capabilities of conventional digital programing. A knowledge of FORTRAN is not required; however, the program accepts FORTRAN language statements to permit the description of complex nonlinear and time-variant problems.

The input language enables the user to describe the configuration of a physical system, starting either with a system block diagram or directly from the differential equations of the system. Unlike the 1130 CSMP, the program is designed for batch-mode operation on large-scale digital machines (128,000 bytes minimum storage). Interactive operation is economically impractical except on a time-shared system. Various means are therefore provided for automatically sequencing batch runs based on both prescribed data or results of previous runs.

Over all, S/360 CSMP attempts to preserve the simplicity of use and ease of problem description of digital-analog simulators (like the 1130 CSMP), while incorporating greater problem-solving capabilities. It represents a practical compromise between simplicity and flexibility.

The program provides a basic library of 34 functional blocks that includes all the standard functions of analog computers and a complement of special-purpose functions for performing more complex mathematical operations. Figure 5 shows part of the standard complement, including the general form of each language statement and the function it represents. In addition to the functions shown, five switching functions and seven signal sources are available.

Note that the semantic form of the functions differs from the 1130 CSMP blocks, though both are used in the same fashion. For example, to describe a limiting operation on variable X between the paramenters -5 and $+10$, we use the function statement:

Y = LIMIT (−5. , 10. , X)

The basic complement of 34 functions is augmented by FORTRAN library routines that include, for example, logarithms, and exponentials. Simple arithmetic operations are performed by conventional FORTRAN operators (arithmetic statements), rather than by functional blocks.

The user can add any desired special function

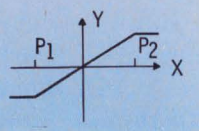
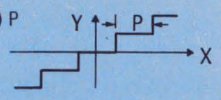
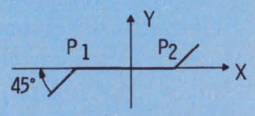
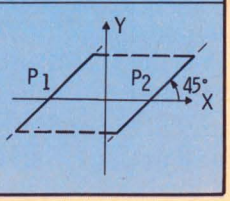
Mathematical Functions

General Form	Function
Y = Intgrl (IC, X) Y (0) = IC Integrator	$Y = \int_0^t X\,dt + IC$ Equivalent laplace transform: $\frac{1}{S}$
Y = Deriv (IC, X) $\dot{X}$ (t = 0) = IC Derivative	$Y = \frac{dX}{dt}$ Equivalent laplace transform: S
Y = Delay (N, P, X) P = Delay time N = Number of points sampled in interval P (Integer) Dead time (Delay)	Y (t) = X (t − P) t≥P Y = 0 t<P Equivalent laplace transform: e^{-PS}
Y = Zhold (X_1, X_2) Zero-order hold	Y = X_2 $X_1>0$ Y = Last output $X_1\leq 0$ Y (0) = 0 Equivalent laplace transform: $\frac{1}{S}(1 - e^{St})$
Y = Impl (IC, P, FOFY) IC = First guess P = Error bound FOFY = Output name of last statement in algebraic loop definition Implicit function	Y = Funct (Y) | Y − Funct (Y) | ≤ P | Y |

System Macros

General Form	Function
Y = Modint (IC, X_1, X_2, X_3) Mode-controlled integrator	$Y = \int_0^t X_3\,dt + IC$ $X_1>0$, any X_2 Y = IC $X_1\leq 0$, $X_2>0$ Y = Last output $X_1\leq 0$, $X_2\leq 0$
Y = Realpl (IC, P, X) Y (0) = IC 1st Order lag (Real pole)	$P\dot{Y} + Y = X$ Equivalent laplace transform: $\frac{1}{PS+1}$
Y = Ledlag (P_1, P_2, X) Lead-lag	$P_2\dot{Y} + Y = P_1\dot{X} + X$ Equivalent laplace transform: $\frac{P_1 S + 1}{P_2 S + 1}$
Y = Cmpxpl (IC_1, IC_2, P_1, P_2, X) Y (0) = IC_1 $\dot{Y}$ (0) = IC_2 2nd Order lag (Complex pole)	$\ddot{Y} + 2P_1P_2\dot{Y} + P_2^2 Y = X$ Equivalent laplace transform: $\frac{1}{S^2 + 2P_1P_2S + P_2^2}$

Function Generators

General Form	Function
Y = Afgen (Funct, X) Arbitrary function generator (Linear interpolation)	Y = Funct (X)
Y = Nlfgen (Funct, X) Arbitrary function generator (Quadratic interpolation)	Y = Funct (X) $X_0 \leq X \leq X_n$
Y = Limit (P_1, P_2, X) Limiter	$Y = P_1$ $X < P_1$ $Y = P_2$ $X > P_2$ Y = X $P_1 \leq X \leq P_2$ 
Y = Qntzr (P, X) Quantizer	Y = kP $(k - 1/2)P < X \leq (k + 1/2)P$ k = 0, ±1, ±2, ±3 ... 
Y = Deadsp (P_1, P_2, X) Dead space	$Y = 0$ $P_1 \leq X \leq P_2$ $Y = X - P_2$ $X > P_2$ $Y = X - P_1$ $X < P_1$ 
Y = Hstrss (IC, P_1, P_2, X) Y (0) = IC Hysteresis loop	$Y = X - P_2$ $(X - X_{n-1}) > 0$ AND $Y_{n-1} \leq (X - P_2)$ $Y = X - P_1$ $(X - X_{n-1}) < 0$ AND $Y_{n-1} \geq (X - P_1)$ Otherwise Y = Last output 

Logic Functions

General Form	Function
Y = AND (X_1, X_2) AND	Y = 1 $X_1>0$, $X_2>0$ Y = 0 Otherwise
Y = NAND (X_1, X_2) Not AND	Y = 0 $X_1>0$, $X_2>0$ Y = 1 Otherwise
Y = IOR (X_1, X_2) Inclusive OR	Y = 0 $X_1\leq 0$, $X_2\leq 0$ Y = 1 Otherwise
Y = NOR (X_1, X_2) Not OR	Y = 1 $X_1\leq 0$, $X_2\leq 0$ Y = 0 Otherwise
Y = EOR (X_1, X_2) Exclusive OR	Y = 1 $X_1\leq 0$, $X_2>0$ Y = 1 $X_1>0$, $X_2\leq 0$ Y = 0 Otherwise
Y = NOT (X) NOT	Y = 1 X≤0 Y = 0 X>0
Y = Equiv (X_1, X_2) Equivalent	Y = 1 $X_1\leq 0$, $X_2\leq 0$ Y = 1 $X_1>0$, $X_2>0$ Y = 0 Otherwise

5. **This chart is a part of the library** of S/360 functional blocks.

to the basic library, either through standard FORTRAN programing, or through a MACRO capability that permits individual functions to be combined into larger functional blocks.

The MACRO capability allows the user to build larger functional blocks from the basic functions available in the library.

For example, an engineer may want to identify a subsection of the system block diagram as a parallel functional entity. Once defined, the MACRO subset can be used any number of times within the simulation program, just like any other library function.

As an example of a user-defined MACRO function, consider a filter simulation study involving several transfer functions with differing parameter values, but all of the form:

$$\frac{Z(s)}{X(s)} = \frac{s^2 + as + b}{s^2 + cs + d}$$

This general functional relationship can be represented by a MACRO function. Assigning some unique name, such a FILTER, to the function, the S/360 CSMP statements defining the MACRO could be as follows:

```
MACRO  OUT = FILTER(A, B, C, D, IN)
       S2Y = IN-C*SY*-D*Y
       SY  = INTGRL(0.0, S2Y)
       Y   = INTGRL(0.0, SY)
       OUT = S2Y+A*SY+B*Y
ENDMAC
```

Here the MACRO and ENDMAC cards are translation control statements that provide the boundaries for the set of statements defining the new MACRO function.

Input language defines operations

The connections between the functional blocks are described by a series of application-oriented input statements. These are of three types: *structure* (configuration) statements, *data* statements, and *control* statements.

Structure statements define the relationships among the functional variables, with the entire set describing the system to be simulated. A translator converts the structure statements into a FORTRAN subroutine, which is then automatically compiled into a program of machine instructions.

Data statements are used to assign the problem's numerical values to all parameters, constants, initial conditions, and table entries.

Control statements specify the choice of available options concerning the translation, execution, and output phases of the program: for example, run time, integration interval, and type of output.

Output options include the printing of variables in standard tabular format, "print-plotting" in graphic form, and the preparation of data for user-written plotting programs.

With a few exceptions, structure statements can be entered in any order and may be intermixed with data and control statements. The correct order of operations is established by automatic sorting of the statements. However, at the user's option, he can specify a sequence in place of automatic sorting.

The user can modify the program.

In addition to the standard functions and sorting features of CSMP, the user may make his own modifications. Subprograms may be written in FORTRAN, or the PROCEDURE function may be used to alter the automatic sorting algorithm. Integration methods may be specified from among such choices as the trapezoidal rule, Simpson's method or the Runge-Kutta method. Integration intervals can be chosen to give the required degree of resolution. The objective is to give the user as much control over the technique as possible.

An important trend in the future will be the use of graphic input/output consoles and digital simulation languages which with wider use of time-shared terminals will make it economically feasible for users to operate in an on-line interactive mode. ■■

References:
1. W. M. Syn and R. N. Linebarger, "DSL/90-a digital simulation program for continuous system modeling," AFIPS Conference Proceedings, Spring Joint Computer Conference 28, 165-187 April, 1966.

Test your retention

Here are questions based on the main points of this article. Their purpose is to help you make sure you have not overlooked any important ideas. You'll find the answers in the article.

1. What programing language is basic to CSMP?

2. What principal underlies the use of CSMP?

3. Under what conditions can user interaction with the program occur conveniently?

4. In what significant way does S/360 CSMP differ from 1130 CSMP?

Equal

Gates

DM8000N (SN7400N)	Quad 2-Input NAND gate
DM8001N (SN7401N)	Quad 2-Input NAND gate (Open Collector)
DM8002N (SN7402N)	Quad 2-Input NOR gate
DM8003N (SN7403N)	Quad 2-Input NAND gate (Open Collector)
DM8004N (SN7404N)	Hex inverter
DM8010N (SN7410N)	Triple 3-Input NAND gate
DM8020N (SN7420N)	Dual 4-Input NAND gate
DM8030N (SN7430N)	Eight-Input NAND gate
DM8040N (SN7440N)	Dual 4-Input buffer
DM8050N (SN7450N)	Expandable Dual 2-Wide, 2-Input AND-OR-INVERT gate
DM8051N (SN7451N)	Dual 2-Wide, 2-Input AND-OR-INVERT gate
DM8053N (SN7453N)	Expandable 4-Wide, 2-Input AND-OR-INVERT gate
DM8054N (SN7454N)	Four-Wide, 2-Input AND-OR-INVERT gate
DM8060N (SN7460N)	Dual 4-Input expander
DM8086N (SN7486N)	Quad Exclusive-OR-gate

Flip Flops

DM8540N (SN7472N)	MASTER-SLAVE J-K flip flop
DM8501N (SN7473N)	Dual J-K MASTER-SLAVE flip flop
DM8500N (SN7476N)	Dual J-K MASTER-SLAVE flip flop
DM8510N (SN7474N)	Dual D flip flop

Counters

DM8530N (SN7490N)	Decade counter
DM8532N (SN7492N)	Divide-by-twelve counter
DM8533N (SN7493N)	Four-bit binary counter
DM8560N (SN74192N)	Up-down decade counter
DM8563N (SN74193N)	Up-down binary counter

Decoders

DM8840N (SN7441AN)	BCD to decimal nixie driver
DM8842N (SN7442N)	BCD to decimal decoder

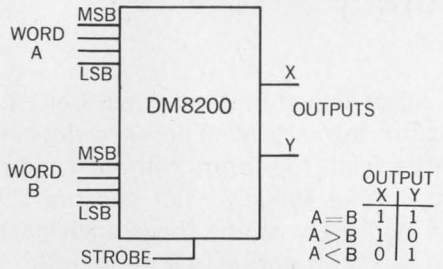
Miscellaneous

DM8550N (SN7475N)	Quad latch

Spec-for-spec. Pin-for-pin. Second source on all popular 74N.

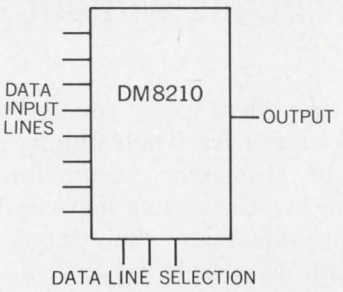
Opportunity

FOUR BIT COMPARATOR

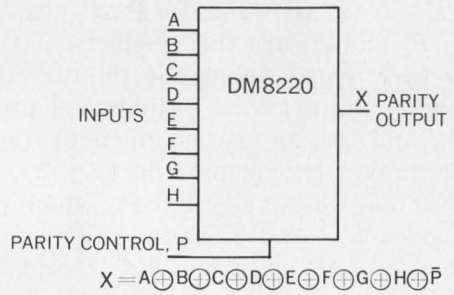


	OUTPUT X	OUTPUT Y
A = B	1	1
A > B	1	0
A < B	0	1

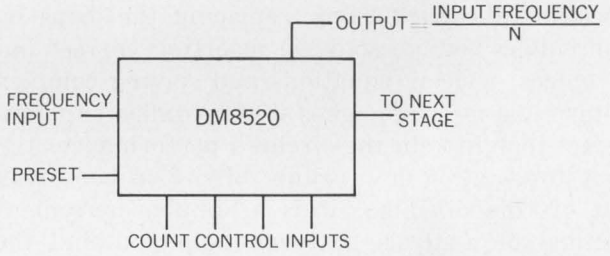
EIGHT CHANNEL MULTIPLEX SWITCH



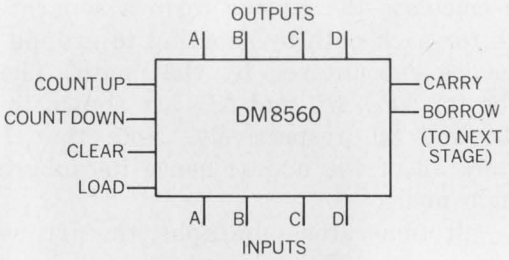
PARITY GENERATOR/CHECKER



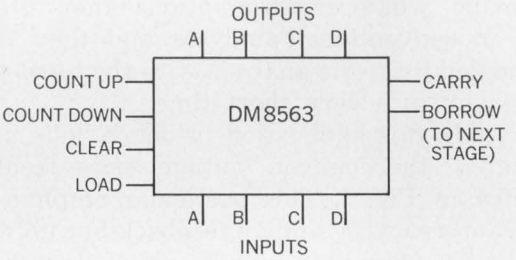
MODULO N FREQUENCY DIVIDER



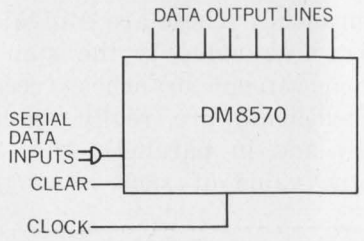
DECADE UP DOWN COUNTER



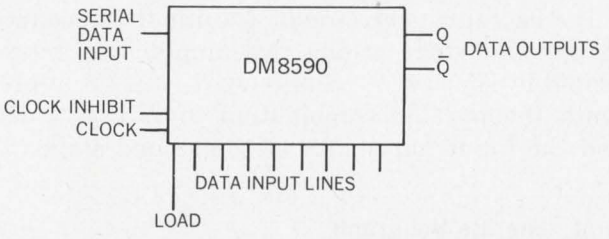
HEXIDECIMAL UP DOWN COUNTER



EIGHT BIT SERIAL IN/PARALLEL OUT REGISTER



EIGHT BIT PARALLEL IN/SERIAL OUT REGISTER



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INFORMATION RETRIEVAL NUMBER 67

Feedback amplifiers are a snap for network topology. Flow-graph methods speed analysis of these complex circuits without sacrificing accuracy.

Feedback amplifiers offer many advantages over ordinary amplifiers. Their gains can be made independent of transistor parameters such as beta, their bandwidths can be increased, they can be made highly linear and their input and ouput impedances can be closely controlled.[1] But they have a major drawback: They are usually difficult to analyze.

Conventional methods of analysis require breaking feedback loops, replacing the loops by current or voltage sources, inserting correct impedances, writing equations and solving complex determinants. This makes it very difficult to gain a real insight into the circuit's performance.

A topological flow graph[2] offers an easy way out of this dilemma. It is a simple, convenient method of analysis that can help you find the incremental gains and impedances of feedback amplifiers in their closed-loop condition. Engineers who are familiar with circuits of this type can make whatever assumptions they usually make in conventional analyses and then carry out the details of the analysis with the topological flow graph in a very short time.

To study this application in detail, let's use it to analyze the common voltage-series feedback amplifier of Fig. 1. This particular amplifier, as well as others with similar feedback but different biasing arrangements, can be studied with the aid of the equivalent circuit of Fig. 2. To maximize the generality of the analysis, the first stage is not considered in detail.

In the equivalent circuit, the input impedance of the first stage of the real amplifier is represented by $R_1 = 1/Y_1$. Similarly $R_3 = 1/Y_3$ represents the parallel combination of R_{C1}, R_{B3}, R_{B4} and the input impedance of the second stage.

First generate the graph

The first step in the analysis is the formulation of the network graph of Fig. 3a. The voltage gain expression consists of a set of numerator terms and a set of denominator terms. Let's look at the numerator terms first. They are dependent upon the paths from the input voltage (node 4) to the output voltage (node 3) not passing through the ground node. There are three such paths: 4 to 2 to 3, 4 to 1 to 3 and 4 to 1 to 2 to 3.

Since there are three paths, the gain expression takes the following form:

$$E_{out}/E_{in} = (P_1\Delta P_1 + P_2\Delta P_2 + P_3\Delta P_3)/\Delta, \quad (1)$$

where P_1, P_2 and P_3 are the products of the admittances (arrowhead values) in the direction of signal flow of the network branches comprising each path, and the Δs are as given by the network determinant expansion rule (Eq. 3).

From Fig. 3a, we can see that P_1, which passes through nodes 4, 2 and 3, has a value of $+g_m{}^2$. P_2, which passes through nodes 4, 1 and 3, has a value of $(Y_1 + g_m)Y_4$, and P_3, which passes through nodes 4, 1, 2, and 3, has a value of $(Y_1 + g_m)\ g_m\ (-g_m)$.

To calculate the Δs, we form a separate subgraph for each path by shorting to ground all of the nodes encountered by that path. The subgraphs for ΔP_1, ΔP_2 and ΔP_3 are shown in Figs. 3b, 3c and 3d, respectively. Note that P_3 encounters all of the nodes; hence its subgraph is a single node.

For all numerator subgraphs, the arrows converging on the ground node are removed because the ground node has been chosen as the reference node for applying the expansion rule. The subgraphs of Figs. 3b and 3c consist entirely of parallel branches. These are equivalent to a single branch whose value is the sum of the values of its constituent branches (recall that the branch coefficients are really admittances and hence they add in parallel). Fig. 3d is a single node; the value of such a subgraph is unity.

In summary, the values of the subgraphs are:

$\Delta P_1 = Y_1 + g_m + Y_2 + Y_4$.

$\Delta P_2 = Y_3$.

$\Delta P_3 = 1$.

The numerator of Eq. 1 is thus:

$$NUM = g_m{}^2\ (Y_2 + Y_4) + (g_m + Y_1)\ Y_3Y_4 \quad (2)$$

In general, as explained in Ref. 2, the numerator subgraphs will be more complex than simple

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parallel branches or single nodes. The subgraphs have to be evaluated by means of the determinant expansion rule. To apply the rule, a reference node is first selected. For the example of Fig. 3, the ground node was chosen. The arrowheads arriving at the reference node are ignored (removed), and the branches leaving the reference node become reference branches. If the coefficients of the reference branches converging on nodes 1, 2, . . . i are called a_1, a_2 . . . a_i, the expansion rule states that the determinant value is given by:

$$\Delta = \Sigma a_i \Delta_i + \Sigma a_i a_j \Delta_{ij} + \Sigma a_i a_j a_k \Delta_{ijk} + \ldots + a_1 a_2 a_3 \ldots \quad (3)$$

where the Δ_{ijk} . . . are the determinants of the subgraphs formed by removing all reference branches as well as arrowheads pointing towards the subscripted nodes. The node obtained by this process becomes a new reference node for reapplication of the rule, if necessary, to any remaining subgraphs. The process can thus be iterated until it is complete.

Evaluate the denominator

The rule of Eq. 3 is also used to evaluate the denominator determinant in the same manner. To apply the rule, all independent current sources must be open circuited and all independent voltage sources must be short-circuited. When this is done to the graph of Fig. 3a, the graph of Fig. 4a results.

Selecting node 3 as the reference node, we see that there are only two reference branches with non-zero values. From Eq. 3, the denominator determinant for Eq. 1 is found to be:

$$\Delta = Y_4\Delta_1 + Y_L\Delta_5 + Y_4Y_L\Delta_{1,5}. \quad (4)$$

The subgraphs Δ_5, Δ_1 and $\Delta_{1,5}$ are shown in Figs. 4b, 4c and 4d, respectively. Evaluating them with Eq. 3, we get:

$$\Delta_5 = Y_3(Y_1 + Y_2 + g_m).$$
$$\Delta_1 = Y_3(Y_1 + Y_2) + g_m(Y_3 + g_m)$$
$$\Delta_{1,5} = Y_3.$$

These values can be used to find the denominator of Eq. 1. When combined with the numerator (Eq. 2), the result is:

$$E_{out}/E_{in} = [(g_m^2(Y_2+Y_4) + (Y_1 + g_m)Y_4Y_3]/$$
$$[Y_4Y_3(Y_1+Y_2) + g_mY_4(Y_3+g_m)$$
$$+ Y_LY_3(Y_1+Y_2+g_m) + Y_LY_4Y_3]. \quad (5)$$

Eq. 5 is the exact voltage-gain expression for the circuit of Fig. 2. To develop some insight into the operation of the circuit, some simplifying approximations can be made. For transistors at room temperature,[3] the gain is approximately:

$$g_m = |I_c|/26 \text{ mV}.$$

When I_c is on the order of a milliampere, the g_m terms will be much greater than any of the others. Thus we can get an excellent approximation of Eq. 5 by retaining only the terms in g_m^2. This yields:

$$E_{out}/E_{in} = (Y_2+Y_4)/Y_4 = (R_2+R_1)/R_2.$$

Note that by using sufficiently high transconductances and resistances, the gain can be made independent of everything except R_2 and R_1, which can be specified very accurately.

Calculate the output impedance

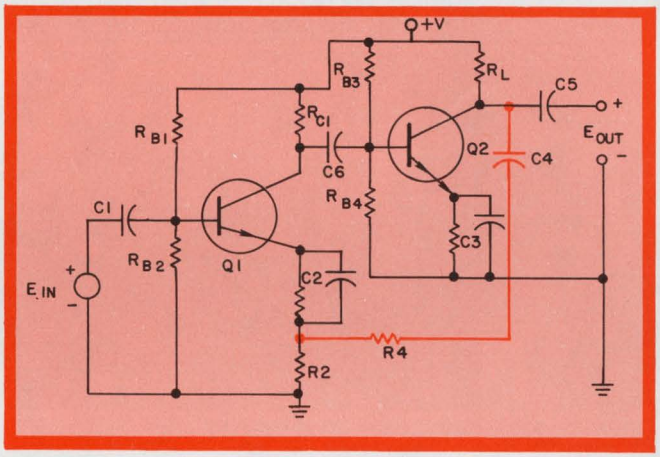
Next, let's calculate the output impedance of the feedback amplifier. This is defined (Fig. 2) as the voltage response at the output (node 3) to a unit current excitation applied at that point. Thus $Z_{out} = E_3/I$. The graph for this calculation is shown in Fig. 5a. This is the same graph as Fig. 3a, with node 4 shorted to ground (node 5). This is done because the output impedance has been defined with zero volts at the input.

Since we are looking for E_3, we note that

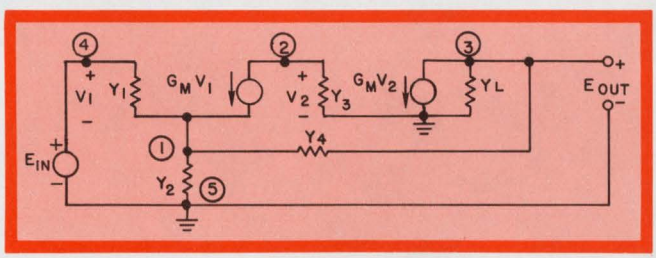
$$Z_{out} = \Delta_{3s}/\Delta, \quad (6)$$

where Δ_{3s} (Fig. 5b) is the network determinant of Fig. 3a with node 3 shorted to ground. (This comes about because Eq. 6 is a special case of Eq. 1, with only one path, P_1, of unit value. Δ_{3s} is formed by shorting to ground all of the nodes that P_1 passes through.)

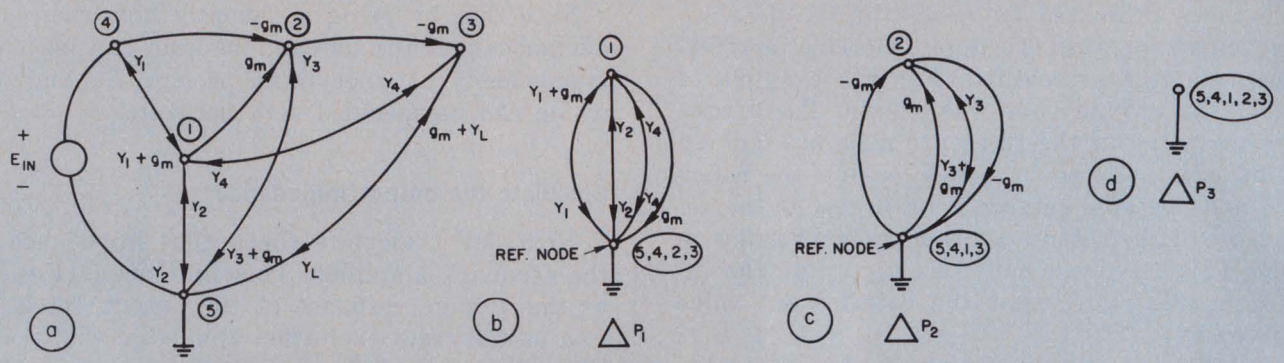
Using node 5 as the reference node, we get: $\Delta_{3s} = Y_3(Y_1+g_m+Y_2+Y_4)$. The denominator of



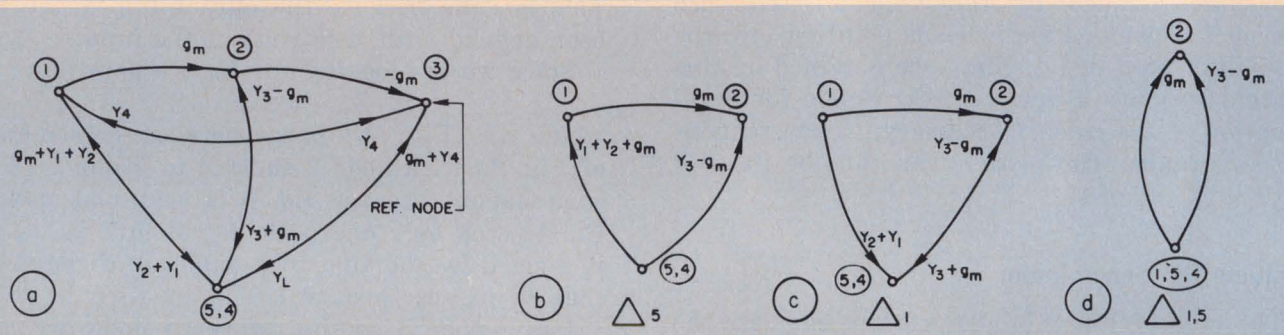
1. **Extremely stable gain,** high input impedance and low output impedance characterize this voltage-series feedback amplifier. It's called a voltage-series type because a portion of the output is fed back (via R_1 and R_2) in series with the input. When properly designed, the amplifier's gain is $(R_2+R_1)/R_2$.



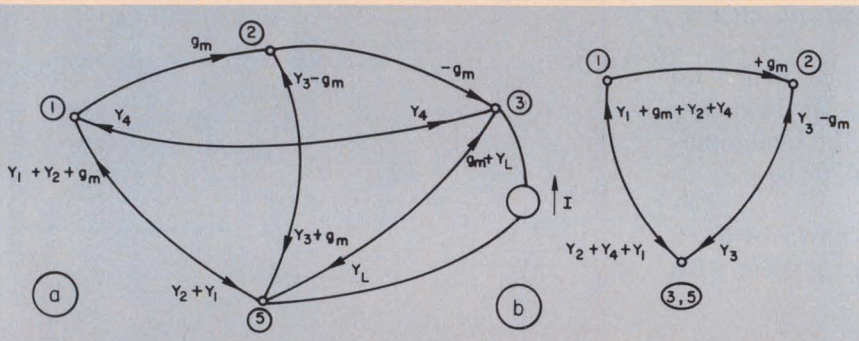
2. **This equivalent circuit** of the amplifier of Fig. 1 can be applied to other amplifiers with similar feedback and different biasing arrangements.



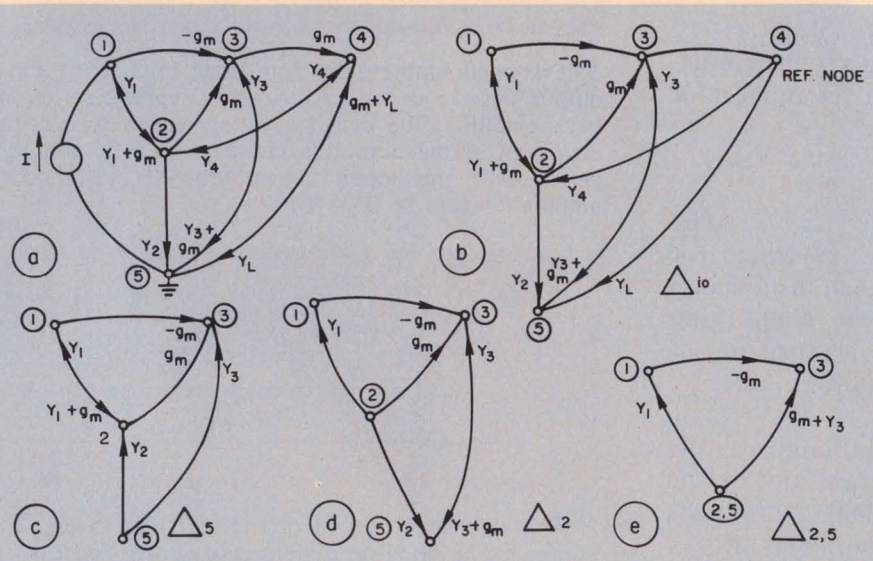
3. **Generating the network graph is the first step** in the analysis (a). The subgraphs for ΔP_1 (b), ΔP_2 (c) and ΔP_3 (d) are also shown. Note that subgraph ΔP_3 is only a single node. This has a value of unity.



4. **To evaluate the denominator,** open-circuit all of the independent current sources and short-circuit all of the independent voltage sources. When this is done to the graph of Fig. 3a, the result is that shown in "a." The subgraphs Δ_5 (b), Δ_1 (c), and $\Delta_{1,5}$ (d) are also shown.



5. **The output impedance is found** from the graph of Fig. 3a by shorting node 4 to ground (a). Subgraph Δ_{3s} (b) is also derived from Fig. 3a, but by grounding node 3.



6. **The input impedance is found** by using the graph (a) to calculate the voltage at node 1. To evaluate Δ_{1o}, the current source is open-circuited (b). The subgraphs Δ_5 (c), Δ_2 (d) and $\Delta_{2,5}$ (e) are also shown.

Eq. 6 is the same as that of Eq. 5 because they both came from identical graphs. The output impedance is therefore given by:

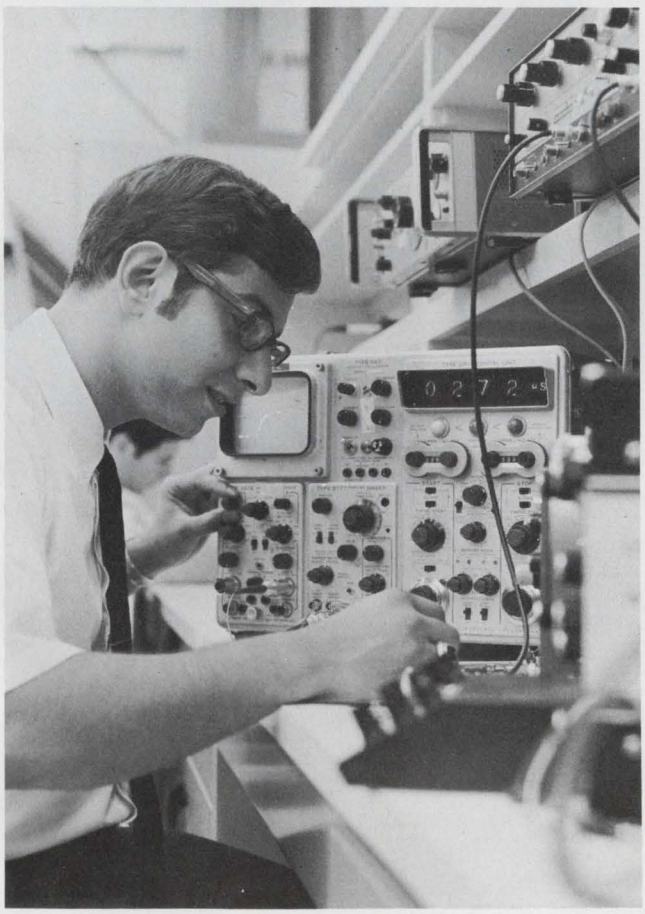
$$Z_{out} = Y_3(Y_1+g_m+Y_2+Y_4)/[Y_4Y_3(Y_1+Y_2) + Y_4g_m(Y_3+g_m) + Y_LY_4Y_3+Y_LY_3(Y_1+Y_2+g_m)].$$

Again, to make some practical sense out of this expression, the same simplifying assumptions can be made as were made in the gain case, yielding $Z_{out} = R_4/g_mR_3$. If the load and bias resistors are large compared with the input impedance of the next stage, then $R_3 \cong (\beta+1)r_e$ where $r_e = 26\ \text{mV}/I_E$, β is the common-emitter current gain and I_E is the emitter bias current.

Since $g_m = \beta/(\beta+1)r_e$, the expression Z_{out} reduces to $Z_{out} = R_4/\beta$, which can be made quite low since β is often 50 or higher.

What about input impedance?

We can conclude this analysis by finding the input impedance of the feedback amplifier with the same topological methods. The impedance is defined as the voltage response at node 4 to a unit current input. The pertinent graph is shown in Fig. 6a, and the impedance can be seen to be given by $Z_{in} = \Delta_{is}/\Delta_{io}$, where Δ_{is} is the determinant of Fig. 6a when node 1 is shorted to ground and Δ_{io} is the determinant of Fig. 6a when the current source is open-circuited. Δ_{is} is the same determinant evaluated in the denominator of Eq. 5.



Author DeFalco checks the performance of an amplifier for comparison with topological analysis results.

To evaluate Δ_{io}, we open-circuit the current source and choose node 4 as the reference node. The resulting flow graph is shown in Fig. 6b. There are only two non-zero reference branches; therefore $\Delta_{io} = Y_L\Delta_5 + Y_4\Delta_2 + Y_LY_4\Delta_{2,5}$. The Δ_5, Δ_2 and $\Delta_{2,5}$ subgraphs are shown in Figs. 6c, 6d and 6e, respectively. From these we find that $\Delta_5 = Y_1Y_2Y_3$, $\Delta_2 = Y_1Y_2Y_3$ and $\Delta_{2,5} = Y_1Y_3$. Thus $Y_{io} = Y_LY_1Y_2Y_3 + Y_4Y_1Y_2Y_3 + Y_4Y_LY_1Y_3$.

Finally we get:

$$Z_{in} = [Y_3(Y_4+Y_L)(Y_1+Y_3+g_m) + g_m^2\ Y_4+Y_LY_4Y_3]/[Y_1Y_2Y_3Y_4 + Y_1Y_3Y_4Y_L + Y_1Y_2Y_3Y_L].$$

If we make the same assumptions as before about the relative magnitudes of the various terms and multiply both numerator and denominator by $R_1R_2R_3R_4R_L$, we get:

$$Z_{in} \cong g_m^2\ R_1R_2R_3R_L/[R_L+R_4+R_2].$$

If $R_L >> R_4+R_2$, $Z_{in} \cong g_m^2\ R_1R_2R_3$.

Now, since R_1 and R_3 are transistor input impedances, $R_1 \cong R_3 \cong (\beta+1)r_e$. And since $g_m = \beta/(\beta+1)r_e$, then $Z_{in} \cong \beta^2R_2$.

It should be noted that in some designs the approximations used above may not be satisfied and the exact expressions will have to be employed. In any event, the topological method allows the job to be done in the shortest possible time. ■■

References:

1. Thornton, Searle, et al, *Multistage Transistor Circuits* SEEC, Vol. 5, Chap. 3, John Wiley.
2. John DeFalco, "Speed Network Analysis with Topology," *Electronic Design* 17, April 1, 1969, p. 56.
3. Searle, Boothroyd, et al, *Elementary Circuit Properties of Transistors* SEEC, Vol. 3, p. 99, John Wiley, 1964.

Test your retention

Here are questions based on the main points of this article. Their purpose is to help you make sure you have not overlooked any important ideas. You'll find the answers in the article.

1. If a subgraph turns out to be a single node, what is its value?

2. What is a voltage-series feedback amplifier.

3. How are parallel branches in a graph combined?

4. What is the general rule for expanding a determinant graph?

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Cut binary-to-BCD conversion costs.

Reduce your IC package count with a nonsequential circuit using full adders and TTL gates.

A static n-bit binary-to-BCD converter design can easily require $10n$ IC packages, for n less than 16. Sequential n-bit "add and shift converters" reduce this requirement to about $1.2n$, but at a sacrifice of speed. A better way to cut the IC package count and the cost, without loss of conversion speed, is with a nonsequential technique that uses full adders.

With this technique, equations for each decade of the BCD number are developed from the general expressions for binary numbers, and are implemented in a straight-forward step-by-step manner. The circuits used are exclusively MSI full adders and 1-, 2-, 3-, and 4-input TTL gates. Each binary input bit is represented by its equivalent BCD bits, and these are summed in weighted full adders. The nonsequential operation results in very low decode delays—as low as 800 ns for a 16-bit binary input (Table 1).

Examine the binary-to-BCD conversion

The binary-to-BCD conversion circuit decodes the equivalent BCD number in the same way a designer would perform it in longhand. The general equation for a binary number is

$$a_m(2^{m-1}) + a_{m-1}(2^{m-2}) + \ldots + a_4(2^3) + a_3(2^2) + a_2(2^1) + a_1(2^0), \quad (1)$$

where a is either a 1 or a 0. The equation also can be written in more expanded form as

$$a_m(2^{m-1}) + a_{m-1}(2^{m-2}) + \ldots + a_8(128) + a_7(64) + a_6(32) + a_5(16) + a_4(8) + a_3(4) + a_2(2) + a_1(1). \quad (2)$$

Suppose the decimal equivalent of this binary number can be at most a five-digit number $vwxyz$; then,

$$vwxyz = a_m(2^{m-1}) + a_{m-1}(2^{m-2}) + \ldots + a_8(128) + a_7(64) + a_6(32) + a_5(16) + a_4(8) + a_3(4) + a_2(2) + a_1(1), \quad (3)$$

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where z is the units digit, y is the tens digit, and so on. Equation 3 can be expanded to

$$\begin{aligned} vwxyz = {} & a_m(10{,}000\,v_m + 1{,}000\,w_m + 100\,x_m + 10\,y_m + z_m) \\ & + a_{m-1}(10{,}000\,v_{m-1} + 1{,}000\,w_{m-1} + 100\,x_{m-1} + 10\,y_{m-1} + z_{m-1}) \\ & + \ldots + a_8(100(1) + 10(2) + 8) + a_7(10(6) + 4) + a_6(10(3) + 2) \\ & + a_5(10(1) + 6) + a_4(8) + a_3(4) + a_2(2) + a_1(1) \end{aligned} \quad (4)$$

A special rule in the nonsequential technique pertains to the unit-digit terms z_5, z_9, z_{13}, z_{17}, in Eq. 4: these quantities should be equal to 16 for m greater than 6. (The reason for this will be made evident later.)

For m equal to 5 or 6, z_5 should be 6. In both cases, the corresponding y-terms, y_5, y_9, y_{13}, y_{17}, . . . should be adjusted to make the corresponding a-terms equal in Eqs. 3 and 4. For example, if $m = 8$, the a_5 term is Eq. 4 would be $a_5(16)$, where $y_5 = 0$ and $z_5 = 16$. However, if $m = 6$, then the a_5 term of Eq. 4 would be written in the form $a_5\,(10(1) + 6)$, where $y_5 = 1$ and $z_5 = 6$.

By grouping the z-terms, y-terms, x-terms, etc., Eq. 4 can be rewritten, then, as

$$\begin{aligned} vwxyz = {} & 10{,}000(a_m v_m + a_{m-1}v_{m-1} + \ldots + a_{15}(1)) \\ & + 1{,}000(a_m w_m + a_{m-1}w_{m-1} + \ldots + a_{11}(1)) \\ & + 100(a_m x_m + a_{m-1}x_{m-1} + \ldots + a_8(1)) \\ & + 10)a_m y_m + a_{m-1}y_{m-1} + \ldots + a_6(3)) \\ & + (a_m z_m + a_{m-1}z_{m-1} + \ldots + a_5(16) + a_4(8) \\ & + a_3(4) + a_2(2) + a_1(1)) \end{aligned} \quad (5)$$

Equation 5 can be divided into five separate equations, the first of which is

$$z = a_m z_m + a_{m-1}z_{m-1} + \ldots + a_5(16) + a_4(8) + a_3(4) + a_2(2) + a_1(1) - p \quad (6)$$

where p equals the highest multiple of 10 contained

in the sum

$$a_m z_m + a_{m-1} z_{m-1} + \ldots + a_5(16) + a_4(8) + a_3(4) + a_2(2) + a_1(1) \quad (7)$$

If the sum of the terms in Eq. 7 were, for example, equal to 23, the value of p in Eq. 6 would be 20 and that of z would be 3.

The second equation obtained from Eq. 5 is

$$y = a_m y_m + a_{m-1} y_{m-1} + \ldots + a_7(6) + a_6(3) + \frac{p}{10} - q \quad (8)$$

In this equation, q is equal to the highest multiple of 10 in

$$a_m y_m + a_{m-1} y_{m-1} + \ldots + a_7(6) + a_6(3) + \frac{p}{10} \quad (9)$$

Similarly, the remaining three equations are

$$x = a_m x_m + a_{m-1} x_{m-1} + \ldots + a_8(1) + \frac{q}{10} - r, \quad (10)$$

$$w = a_m w_m + a_{m-1} w_{m-1} + \ldots + a_{11}(1) + \frac{r}{10} - s, \quad (11)$$

and

$$v = a_m v_m + a_{m-1} v_{m-1} + \ldots + a_{15}(1) + \frac{s}{10}, \quad (12)$$

where r is the highest multiple of 10 in

$$a_m x_m + a_{m-1} x_{m-1} + \ldots + a_8(1) + \frac{q}{10} \quad (13)$$

and s is the highest multiple of 10 in

$$a_m w_m + a_{m-1} w_{m-1} + \ldots + a_{11}(1) + \frac{r}{10}. \quad (14)$$

Equations 6, 8, 10, 11, and 12 correspond to addition of columns of decimal numbers. Eq. 6 represents the addition of all units digits in the column, where $p/10$ is the number carried to the tens column and z is the units digit of the sum being formed. Equation 8 adds the number from the units column and all the digits in the tens column; here $q/10$ is the digit carried to the hundreds column and y is the tens digit of the sum. The remaining equations define the equivalent digits by addition for any m-bit binary number,

$$a_m a_{m-1} a_{m-2} \ldots a_4 a_3 a_2 a_1 .$$

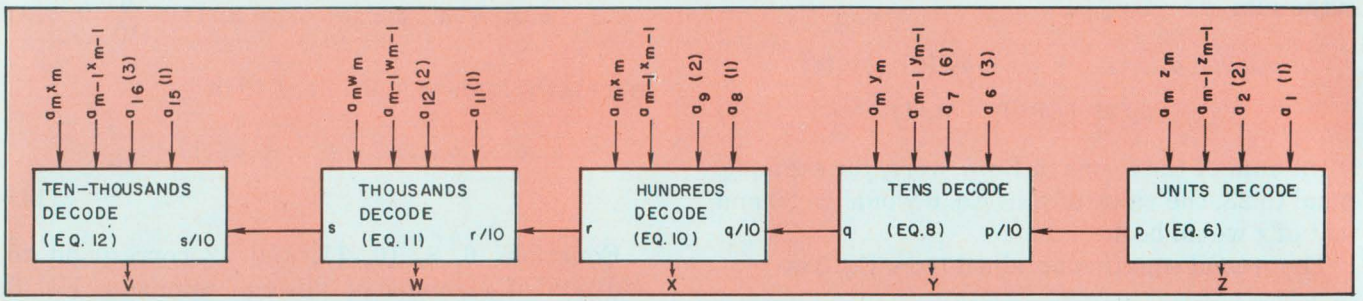
Note that, if $m = 6$, v and w will both be 0, and the number of equations used to describe the decimal equivalent digits of a binary number is dependent on the maximum number of bits in the binary number.

A block diagram of the binary-to-BCD converter defined by Eqs. 6, 8, 10, 11, and 12 is shown in Fig. 1. A logic circuit for each equation can be developed using inverters, 2- and 3-input gates, and full adders. The conversion is performed in three steps:

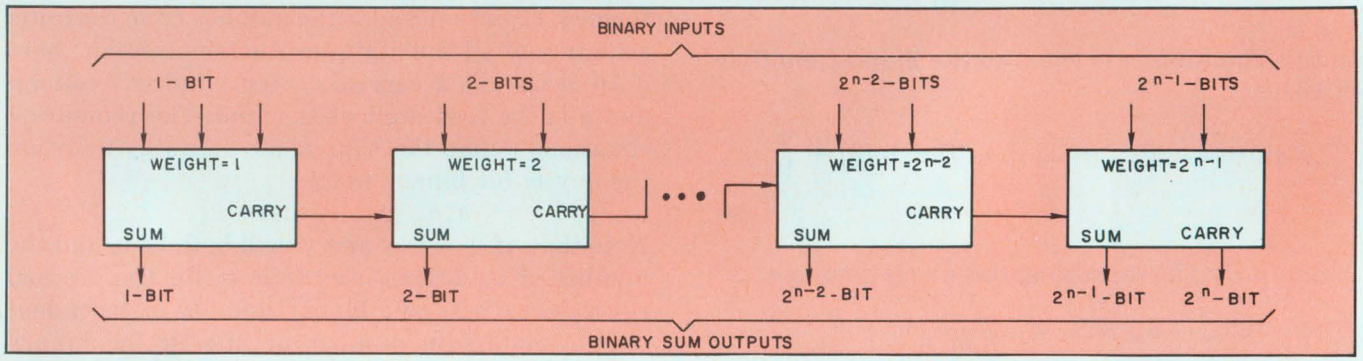
- The input binary bits are received in the proper weighted full adders, and their binary sum is obtained.
- The sum is reduced to a binary number of maximum value 29; carried numbers are produced to compensate for the difference between this number and the sum from Step 1.

Table 1. Number of modules versus decode time

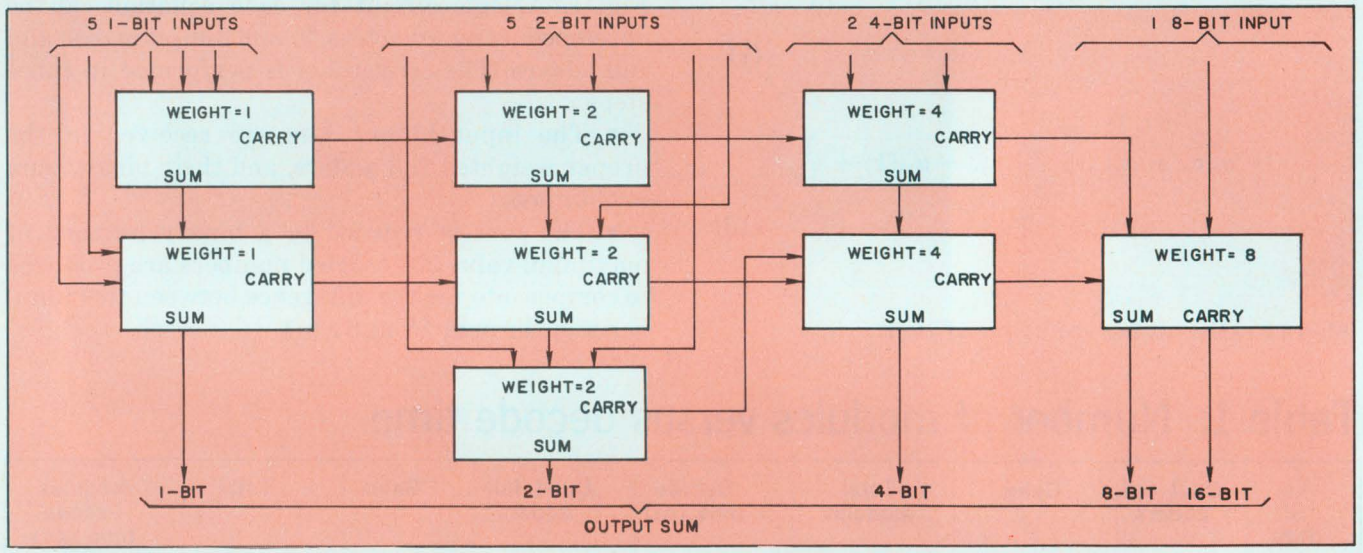
No. of Bits (n)	Dual full adders	Gates	Total modules	Decode time (ns)	Quad full-adders	Gates	Total	modules Decode time (ns)
4	2	1	3	60	1	1	2	40
6	4	3	7	100	3	3	6	65
8	11	4	15	190	8	4	12	130
10	14	5	19	250	10	5	15	180
12	22	6	28	420	15	6	21	350
14	27	7	34	500	19	7	26	420
16	44	10	54	800	28	10	38	600
18	53	11	64	1,000	35	11	46	830
20	65	11	76	1,200	43	11	54	1,000
22	75	11	86	1,380	51	11	62	1,080
24	88	13	101	1,500	59	13	72	1,200



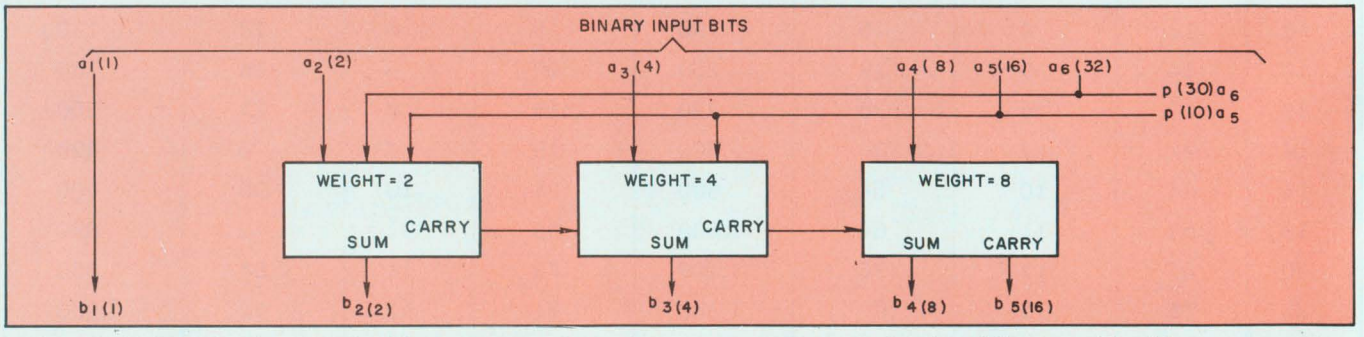
1. **The binary-to-BCD decode circuit** is defined in block form by the basic conversion equations. A logic circuit can be developed for each block using only inverters, TTL gates and full adders.



2. **The standard binary n-bit adder** is built from full-adder circuits. Although it offers a limited number of input lines, it can be modified to handle more inputs, if desired, simply by ganging adders.



3. **Adders are ganged by using the sum and carry outputs** of all full adders as inputs to other adders or as outputs of the circuit. This technique ensures that no information has been lost in the circuitry.



4. **The reducing circuit cuts the binary output** down to a maximum value of 29, and generates carry outputs to compensate for the difference. The binary output is a multiple of 10 less than the binary inputs.

■ Some multiple of 10 is subtracted from the reduced number from Step 2 to obtain more carried digits and the final BCD bits.

Weight and sum the input bits

A standard n-bit binary adder using full-adder circuits is shown in Fig. 2. For the receiving circuit in the binary-to-BCD converter, n will be typically 5 or less. Notice that this standard design, with the limited number of input lines it offers, requires modification if it is to handle more inputs of similar weight.

The added capability can be obtained by ganging adders, as shown in Fig. 3. Both the sum and the carry outputs of all the full adders must be used as inputs to other adders, or as outputs of the circuit, to ensure that all information entered into the circuit is contained on the five output lines (and that no information or bits have been lost in the circuit).

The matrix of Table 2 aids in calculation of the number of full adders of each weight required in a receiving circuit, given the number of inputs of each weight. For example, the binary adder circuit in Fig. 3 requires five input lines of weight 1, and there are no carries from other full adders, so the number of full adders of weight 1 required (determined from the intersection of row 5 and column 0 in Table 2) is 2.

The two full adders handling the five weight 1 inputs produce carries of weight 2, which must be used as inputs to full adders of weight 2. Since there are also five inputs of weight 2 to the circuit, the number of full adders of weight 2 required (from the intersection of row 5 and column 2 in Table 2) is 3. Similarly, the need for two full adders of weight 4 and one of weight 8 can be determined from the matrix.

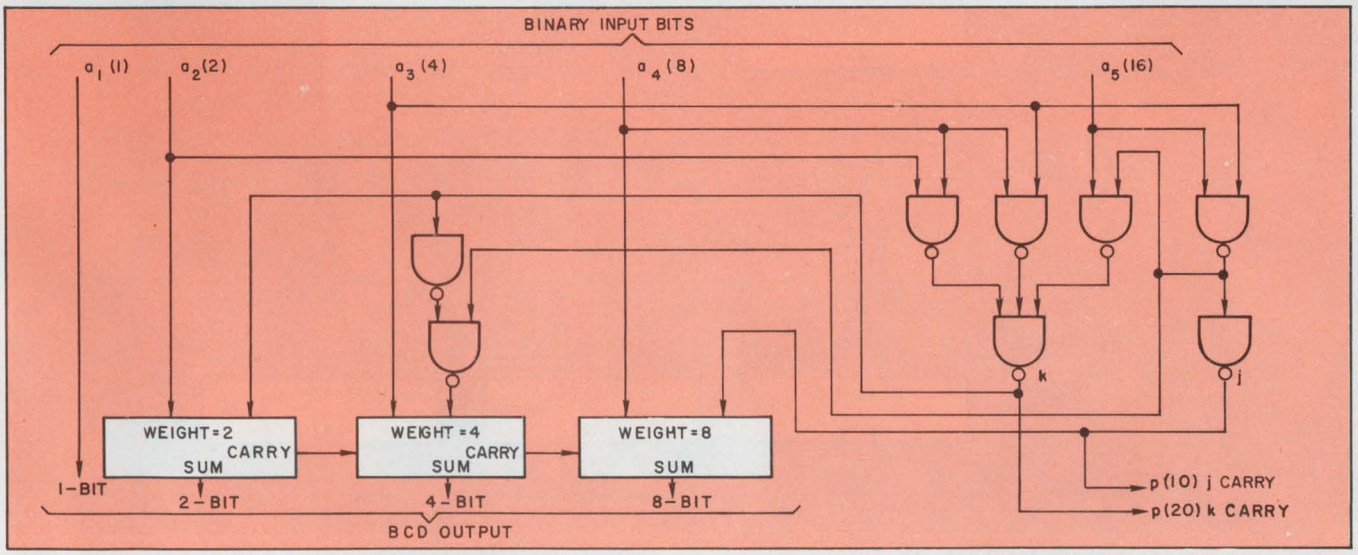
Using Table 2 and the procedure described, a receiving circuit can be designed with any combi-

Table 2. Number of Y-weight adders required

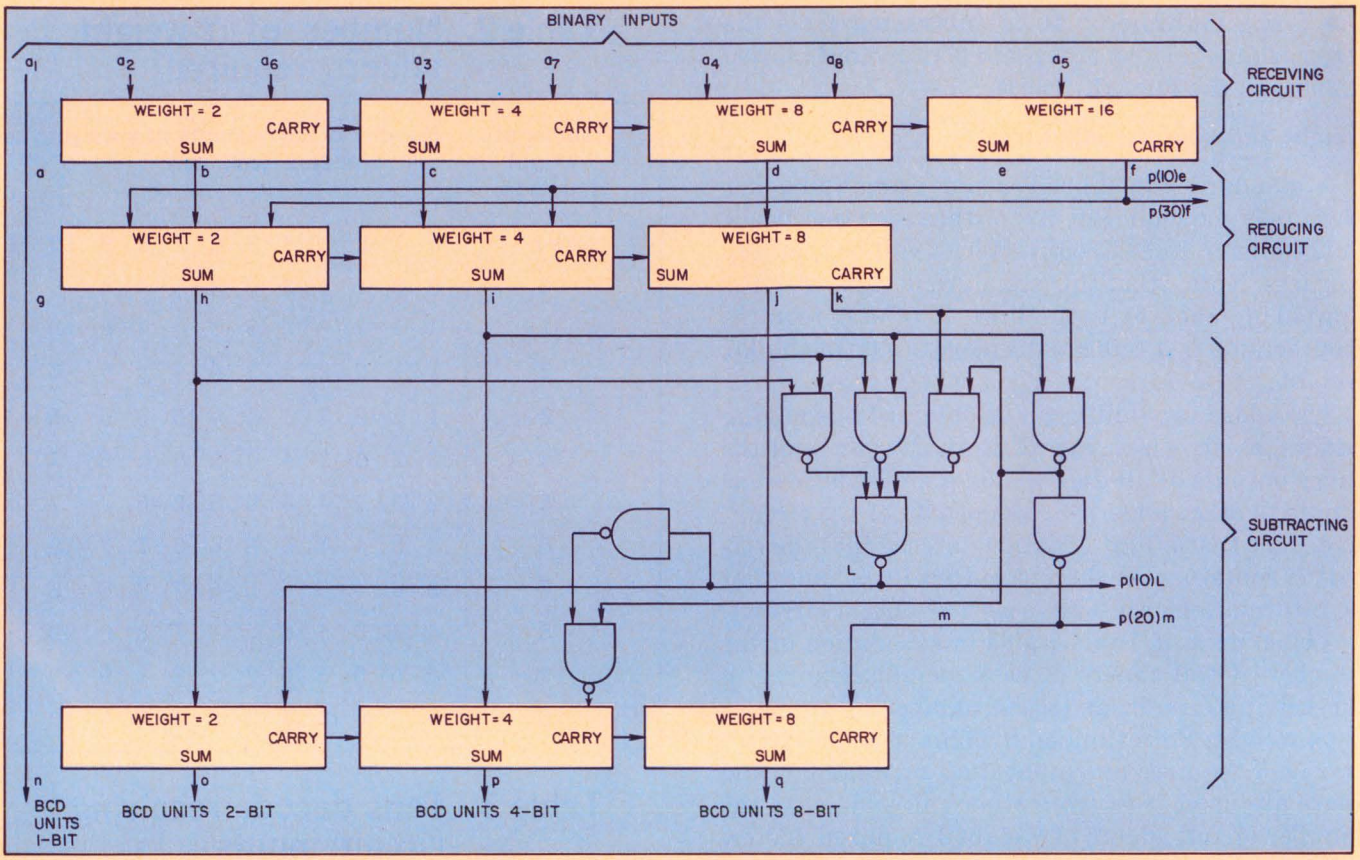
Number of y-weight inputs to circuit (row no.)	Number of carry inputs to y-weight adders (col. no.)										
	0	1	2	3	4	5	6	7	8	9	10
0	0	0	1	1	2	2	3	3	4	4	5
1	1	1	1	2	2	3	3	4	4	5	5
2	1	1	2	2	3	3	4	4	5	5	6
3	1	2	2	3	3	4	4	5	5	6	6
4	2	2	3	3	4	4	5	5	6	6	7
5	2	3	3	4	4	5	5	6	6	7	7
6	3	3	4	4	5	5	6	6	7	7	8
7	3	4	4	5	5	6	6	7	7	8	8
8	4	4	5	5	6	6	7	7	8	8	9
9	4	5	5	6	6	7	7	8	8	9	9
10	5	5	6	6	7	7	8	8	9	9	10

Table 3. Tens decode receiving circuit inputs

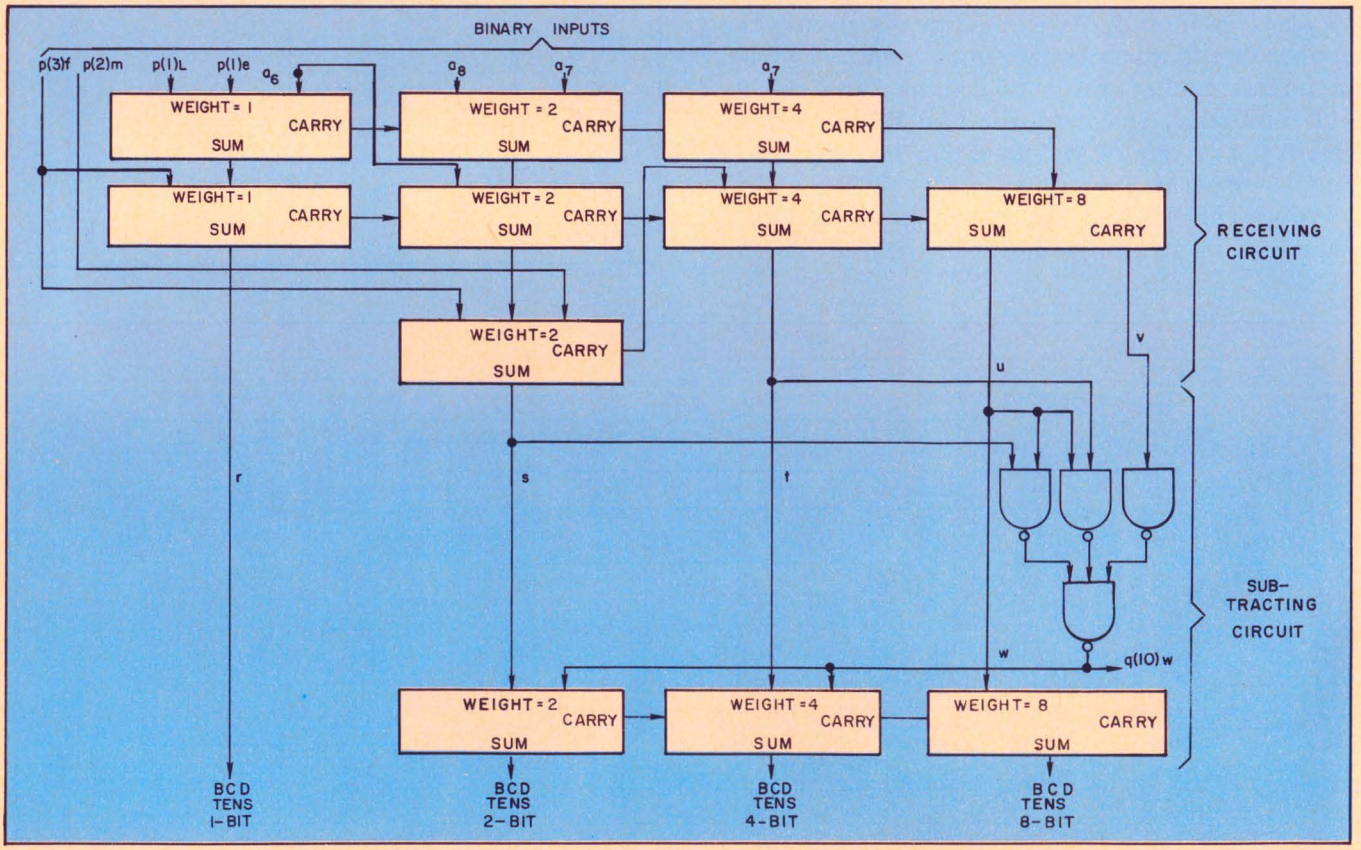
Inputs	Placed into full-adders of weight:			
	1	2	4	8
$a_8(2)$		x		
$a_7(6)$		x	x	
$a_6(3)$	x	x		
p(3)f	x	x		
p(2)m		x		
p(1)1	x			
p(1)e	x			



5. **The subtracting circuit receives 5-bit binary numbers,** with decimal value from 0 to 29, and generates four-bit binary numbers from 0 to 9 and a carry of weight 0, 10, or 20.



6. **In the units decade decode circuit,** the "a" inputs to the first row of full adders (the receiving circuit) represent the input binary bits. They are weighted according to their coefficients in Eq. 23 and are fed to the reducing circuit, a second row of full adders. The subtracting circuit receives the 5-bit output of the reducer, and produces the BCD output. It subtracts from the input number the highest multiple of 10 in it.



7. **The tens decode circuit** does not require a reducing circuit, since the maximum value of the 5-bit binary number from the receiving circuit is less than 23. The subtracting logic is similar to that of the units decode.

nation of inputs. The output lines of such a circuit will contain a binary number equal to the sum of the weights of the binary input bits.

Reduce sum to 29, generate carry

The reducing circuit for an n-bit binary number, where n is equal to or less than 6, is shown in Fig. 4. The $a_5(16)$ input is routed into the weighted adders of values 2 and 4, and is also used as a carry of value 10. If this input is a 1, 6 will be added to the other full adder inputs, and 10 will be carried to the next higher decade decode circuit, thus accounting for the full value of input weight 16. Similarly, the $a_6(32)$ input is routed into the full adder of weight 2 and is also used as a carry of weight 30.

The outputs of this circuit in terms of inputs are

$$a_1(1) + a_2(2) + a_3(4) + a_4(8) + a_5(6) + a_6(2) + p(30)a_6 + p(10)a_5 \quad (16)$$

where $p(30)a_6$ and $p(10)a_5$ are carries of 30 and 10, and the sum of the remaining terms is on lines b_1 through b_5. The sum is either equal to, or a multiple of, 10 less than the input on lines a_1 through a_6. For n greater than 6, full adders again must be ganged to receive all the inputs.

In essence, then, the receiving and reducing circuits receive the set of inputs defined by Eqs. 6, 8, 10, 11, or 12, and produce a binary number from 0 to 29 and a set of carry bits. The binary output is a multiple of 10 less than the binary input.

Subtract multiple of 10 for final bits

The output of the reducing circuit must be reduced again to a binary number between 0 and 9, the final BCD bits for a given decade. The subtracting circuit receives a 5-bit binary number with a decimal value from 0 to 29, and produces a 4-bit binary number from 0 to 9 (either 20 less than the input number, 10 less, or equal to it). It also produces a carry of weight 10, 20, or no carry, equal to the difference between the input and output binary numbers. In other words, the circuit subtracts the highest multiple of 10 in the input number from the input number, using the two's complement method.

To subtract binary numbers, say A from B, the binary complement of A, plus 1, is added to B and the highest-valued 1-bit of the result is dropped. Thus, if the circuit is to subtract 10 (binary 1010), the complement of 10 (binary 0101), plus 1 (binary 0110), is added to the input number. The number in the last set of parentheses is a binary 6. To subtract 20 (binary 10100), the complement of 20 (binary 01011), plus 1 (binary 1100) is added to the input number, the last binary number being 12. If the input binary number is between 20 and 29, a binary 12 is added by the subtraction circuit, and the 32-weighted bit of the result is dropped. This, in effect, subtracts 20 from the input number. If the input number is between 10 and 19, 6 is added and the 16-bit of the result is dropped; this subtracts 10 from the input. If the input is less than 10, nothing is added to or subtracted from it.

Subtract by two's complement method

A subtracting circuit, capable of receiving binary numbers from 0 to 29, is shown in Fig. 5. Here, the NAND circuitry decides whether the input binary number is between 0 and 9, 10 and 19, or 20 and 29. Depending on the bracket into which the input number falls, a binary 0, 6, or 12 is added to the input number, and the 16- or 32-bit of the result is dropped. The manipulation, according to the two's complement substraction method, produces a binary number from 0 to 9, which is a multiple of 10 less than the input number. The two carry lines are used as inputs to the next higher decade decode circuit. The outputs of the circuit of Fig. 5 are described by

$$a_1(1) + a_2(2) + a_3(4) + a_4(8) + a_5(16) - j(10) - k(20) + p(10)j + p(20)k, \quad (17)$$

where

$$j = (a_5.k) + (a_3.a_4) + (a_2.a_4) \quad (18)$$

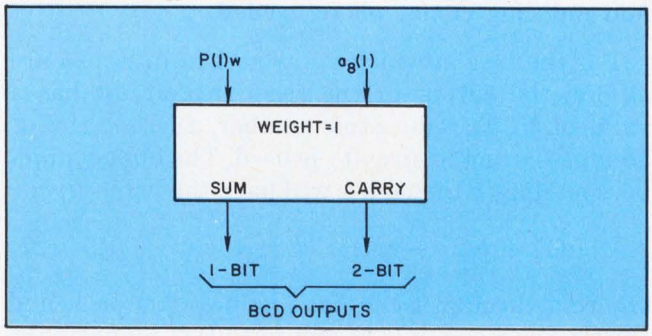
and

$$k = a_3.a_5. \quad (19)$$

The two p terms in Eq. 17 are the carry terms, and the sum of the remaining terms is present in binary form on the four outputs of the illustrated circuit. Equation 17 clearly states that the sum of the outputs always will equal the input binary number. Subtraction circuits can be designed to receive inputs as high as 11 or 29.

Let's build an 8-bit converter

For an 8-bit binary-to-BCD decoder, Eq. 2 becomes



8. **The hundreds decode circuit** is simply one full adder, which accepts one binary input and the carry term from the tens decode circuit.

$$a_8(128) + a_7(64) + a_6(32) + a_5(16) + a_4(8) + a_3(4) + a_2(2) + a_1(1). \quad (20)$$

Since an 8-bit binary number can have a maximum decimal value of 225, Eq. 20 can be set equal to 3-digit decimal number xyz, and

$$xyz = a_8(100) + a_8(20) + a_7(60) + a_6(30) + a_8(8) + a_7(4) + a_6(2) + a_5(16) + a_4(8) + a_3(4) + a_2(2) + a_1(1) \quad (21)$$

$$= 100\,(a_8(1)) + 10\,(a_8(2) + a_7(6) + a_6(3)) + a_8(8) + a_7(4) + a_6(2) + a_5(16) + a_4(8) + a_3(4) + a_2(2) + a_1(1) \quad (22)$$

Then

$$z = a_8(8) + a_7(4) + a_6(2) + a_5(16) + a_4(8) + a_3(4) + a_2(2) + a_1(1) - P, \quad (23)$$

$$y = a_8(2) + a_7(6) + a_6(3) + \frac{p}{10} - q, \quad (24)$$

and

$$x = a_8(1) + \frac{q}{10}. \quad (25)$$

The three decade decode circuits are based on Eqs. 23, 24, and 25. To obtain the units decade decode circuit, Eq. 23 can be implemented in logic as shown in Fig. 6. In the first row of full adders, the a inputs represent the binary bits defined in Eq. 21 and are placed into weighted adders according to their coefficients in Eq. 23. The outputs of these adders (lines a through f) contain a 6-bit binary number equal to the sum

$$a_8(8) + a_7(4) + a_6(2) + a_5(16) + a_4(8) + a_3(4) + a_2(2) + a_1(1). \quad (26)$$

In this case, the receiving circuit is only one row of full adders. The a_1 binary input bit is always equal to the 1-bit output of the units BCD decode (this is recognized easily because a_1 is the only odd bit in both number codes).

Add reducing circuit where needed

For the case in which a_1 through a_8 in Eq. 26 are all 1's, the output of the receiving circuit has a value of 45. To reduce this number, a second row of adders (reducing circuit) is used. The binary numbers on lines g through k will have the value

$$a(1) + b(2) + c(4) + d(8) + e(6) + f(2) \quad (27)$$

where a through f can have values of 0 or 1, and the two carries $(p(1)e)$ and $(p(30)f)$ make up the difference between the numbers represented by Eqs. 26 and 27. The maximum value of Eq. 27 is 23, the reducing circuit having already performed its function.

The remainder of the circuit in Fig. 6 receives the 5-bit output of the reducing circuit. It produces a binary number from 0 to 9 on lines n through q, which is a multiple of 10 less than the number on lines g through k. The entire circuit in Fig. 6 subtracts from the input number the highest multiple of 10 in that number.

The tens decade decode circuit is derived from Eq. 24. From this equation, and the p-carry of the circuit in Fig. 6, the inputs to the tens decode circuit are $a_8(2)$, $a_7(6)$, $a_6(3)$, $p(3)f$, $p(1)e$, $p(1)1$, and $p(2)m$. Table 3 lists these inputs with the weights of the full adders in their respective receiving circuits. Four inputs of weight 1 are required. From Table 2, two full adders of weight 1 are required to handle these inputs. Since two carries of weight 2 are produced by these adders and five inputs of weight 2 are shown in Table 3, the intersection of row 5 and column 2 in Table 2 shows the number of full adders of weight 2 needed in this circuit is three. Similarly, the number of full adders of weight 4 (determined from row 1 and column 5) is 3, and of weight 8 (row 0 and column 2) is 1.

The tens decode circuit is shown in Fig. 7. Lines r, s, t, u, and v form a 5-bit binary number that equals the sum of the inputs in Eq. 28. The maximum value of this number is 18. Since this is less than 23, a reducing circuit (the second step) is not required. The remainder of the circuit is subtracting logic similar to that used in the units decode.

From Eq. 25, it can be seen that the hundreds decade decode circuit is simply one full adder (Fig. 8). The only inputs to this circuit are the $a_8(1)$ term (Eq. 25) and the carry term from the tens decode circuit. ■■

Test your retention

Here are questions based on the main points of this article. Their purpose is to help you make sure you have not overlooked any important ideas. You'll find the answers in the article.

1. What are the three steps in the conversion process in the circuit described by the author?

2. How can the converter be easily modified to accommodate more input bits?

3. What convenient method is used to perform subtraction?

4. Why does the author expect it to be obvious that the a_1 binary bit will always be equal to the 1-bit output of the units BCD output in an 8-binary-bit converter?

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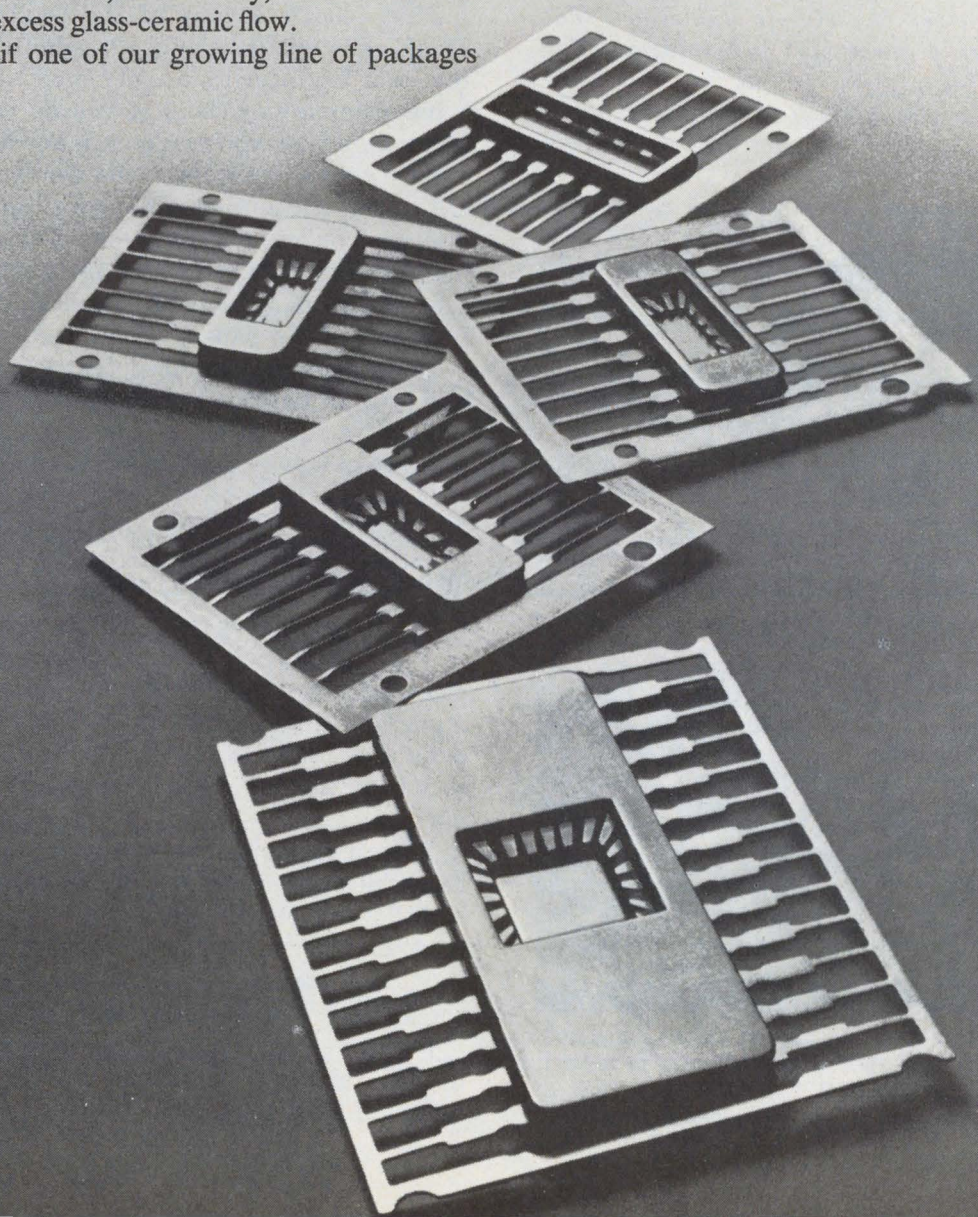


Preparing a technical paper? Check these steps designed to guide you in the written and oral presentation of your material.

It isn't always the engineer who designs the product who gets credit for it; sometimes it's the first one who talks about it. And one of the best ways to "talk" about an engineering concept is through the presentation of a paper at a technical meeting.

The check list on the opposite page is not intended to be earthshaking in content. As you can see, most of the points provided are dictated by common sense. But the difference between making a good presentation and making a poor one usually depends on whether or not the writer follows to the letter the simple guidelines that almost guarantee a successful presentation. The check list is there for you to cut out and refer to the next time you present a technical paper and want to refresh your memory on the points of proper oral and written presentation.

Roger D'Aprix, Manager, Employee Communications, Xerox Corp., Rochester, N.Y. The author has written two other articles for ELECTRONIC DESIGN: "How to get word to the top," and "Join the experts—Publish!"

The do-it-yourself paper

If you have at your disposal a company group charged to assist with technical papers and articles, rely heavily on its services. If your employer does not offer such a service, preparing the paper yourself may test your ingenuity, but you'll be able to do the job if you follow these helpful suggestions.

First—locate a copy of the "call" for papers. These calls are generally distributed to the professional engineering society membership and to a few company officials. If you do not fall under either category, you can obtain the data from the society that's sponsoring the forum.

The call will inform you about the meeting and instruct you on how to submit your paper. Normally, you will be requested to send in a title and a brief summary of your proposal, which will be screened by the papers committee.

If the summary is accepted, you will then be asked to prepare two versions of the paper—one for oral presentation at the actual meeting and the other for publication in the symposium transactions.

Model paper is 'camera-ready'

In some cases no transactions are printed, but you would do well to prepare a typed copy for reproduction since you will generally receive numerous requests for copies. Further, your company may want to distribute the finished manuscript to certain customers or other interested parties.

When you submit your paper to the symposium for publication, it is essential that the typed pages and illustrations should be "camera ready"; that is, your paper must be clean and free from error. It will be photographed and incorporated into a complete record of all the papers presented.

For your convenience, here are two check lists to help guide you in the oral and written presentation of your material:

Checklist

Written presentation

The copy

- Keep the message simple, concise and readable. Test your paper's readability on your co-workers.
- Get your company's approval before presenting your paper.
- Supply a bibliography for anyone who wants to dig deeper into your background and experience, or check your research.

The art work

- Submit glossy photos of original art work. No art work will be returned by the symposium.
- Blue-pencil your name and figure number on the back of all illustrations in case they become separated from your paper.
- Mark "top" on each picture in case there's some question about its position.

The mailing

- Pack your paper with cardboard to prevent mutilation in the mail.
- Send it via registered mail and make a few copies to protect yourself against possible loss.
- Make a list of the names of people who should see your paper.

Oral Presentation

The preparation

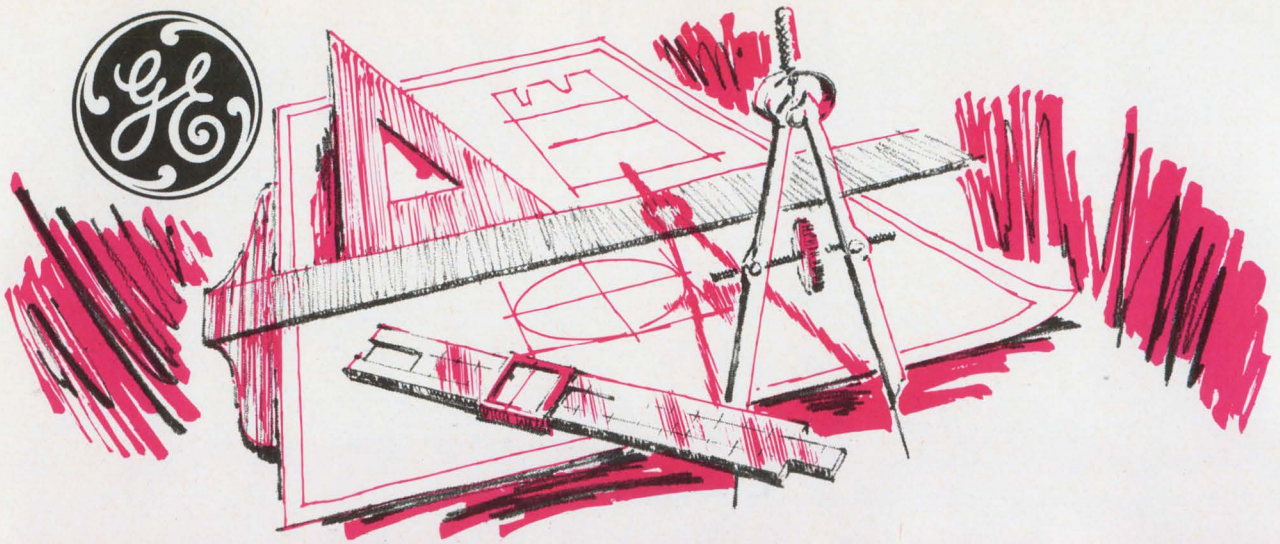
- Determine what points you can develop in 20 to 30 minutes.
- Give conclusions with just enough information to validate your logic. Your audience cannot absorb more information than that.
- When you cannot express a concept clearly in words, plan to use slides.

The visual aids

- Use the 3-1/2 × 4-inch slide. It is large enough to be seen in a large meeting hall.
- Use film negative slides (white lines on a black background) for a line drawing.
- Color slides will enhance your presentation, if they are used judiciously. For best results get advice from someone who knows how to present color slides.

The delivery

- Above all, relax. Remember that you are the expert. You are among friends who will squirm in embarrassment only if you give a bad performance.
- Use notes rather than reading your paper. A well-done speech requires a certain amount of acting ability to infuse naturalness and enthusiasm into the words.
- Give your talk at least two "dry runs." Use slides, lectern, and a small audience. This rehearsal will provide you with the opportunity to smooth the rough spots in content and delivery; it's also a chance to anticipate questions from the audience.



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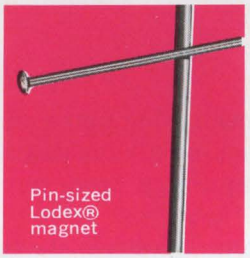

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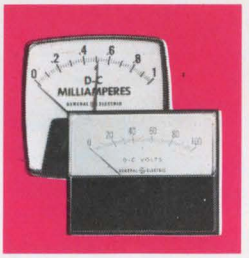

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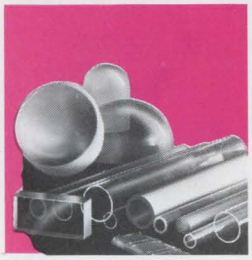

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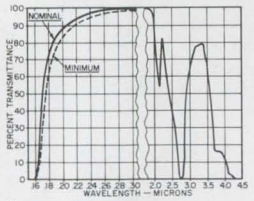

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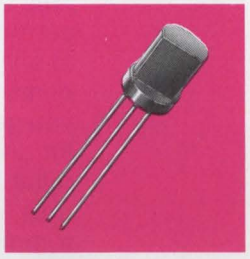

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Voltage	10-40W
Peak Current (10 sec pulse width, 1% duty cycle)	1A
Operating Temp. Range	—15C to +125C
Temp. Coefficient of rated voltage	.03%/°C typ.

Housed in the standard epoxy TO-98 package, GE's IVR is a low-cost means to stabilizing voltage for solid-state circuits. Applications are found in auto radios, TV ripple filters and as a reference amplifier for high-power regulation. The IVR can also be used where other voltage regulation methods have been too costly for high-volume use.

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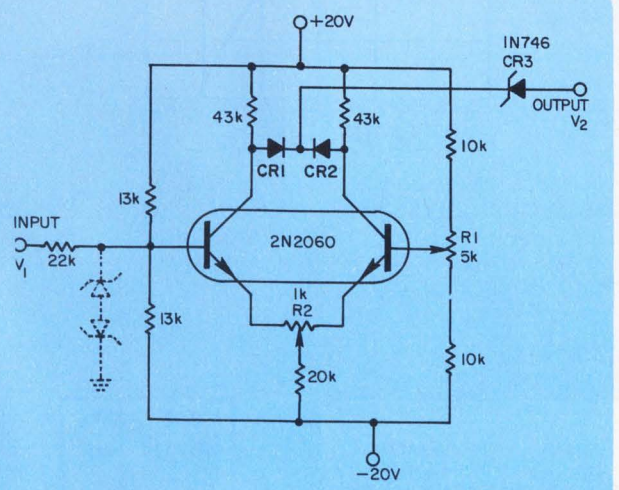
INFORMATION RETRIEVAL NUMBER 70

Dual level detector uses one active device

Most techniques for monitoring the excursions of a voltage signal employ two Schmitt trigger circuits. One detects excursions above an upper limit level; the other detects excursions below a lower level. The circuit shown in the figure can do the same, using only one active device instead of the four needed to build two Schmitt triggers. The only proviso is that the upper and lower limits must be symmetrically spaced about the center reference level.

The active device is the MIL-approved type 2N2060 dual transistor. The input voltage, V_1, is connected to the base of a differential amplifier for comparison with a reference voltage. The reference is set by *R1*.

When V_1 is at the desired level, the amplifier is balanced. If V_1 deviates from the reference level, one of the collectors will go positive and the steering diodes, *CR1* and *CR2*, will apply a positive voltage to the zener diode, *CR3*. When the deviation is large enough, *CR3* will break down, providing an output signal, V_2. Thus the zener breakdown voltage determines the allowable deviation from the reference level.



By using a zener diode to set the (symmetrical) upper and lower excursion limits, this single circuit can do the work of two Schmitt triggers.

R2 is used to balance the two transistor currents when the base voltages are equal.

The circuit showed less than a 3 per cent change in threshold level over the temperature range of 30°F to 140°F. For low-quantity production or in situations with relaxed temperature requirements, the 2N2060 can be replaced with a matched set of less expensive transistors.

The circuit can also be used to compare the absolute values of two variable voltages by using the reference base as an input and adding zener diodes as shown in dotted lines to restrict operation to the linear region of the differential amplifier.

B. A. Rogers, Senior Engineer, Bendix Corp., North Hollywood, Calif.

VOTE FOR 311

Ultralinear ramp generator uses UJT to drive Darlington

An inexpensive variable-frequency ramp generator can be built with three transistors and one UJT.

The generator consists of a constant current source, *Q1*, a charging capacitor; C_1; and a unijunction transistor switch. The output circuit uses *Q2* and *Q3* in a Darlington configuration.

Q1, used in the common-base configuration, acts as a constant-current source. The zener, *Z*, and diode,*D*, are used to hold the emitter current fixed. If diode *D* is of the same material as *Q1*, it will provide temperature compensation, because the voltages across the diode and across the emitter-base junction of *Q1* will vary similarly. This means that the zener voltage of *Z* will always appear across the 6-kΩ resistor, and hence the emitter current will be very nearly constant. The zener will also compensate for any drift in the power-supply voltage.

The constant current delivered by *Q1* linearly charges capacitor C_1 to the triggering level of

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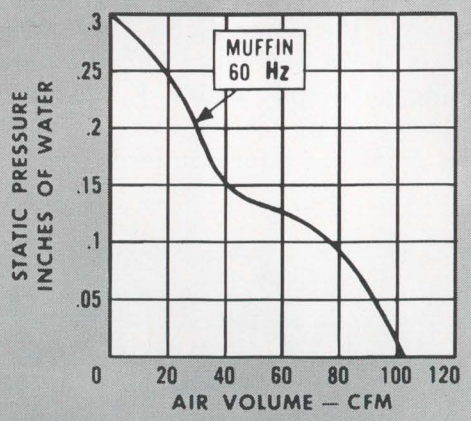

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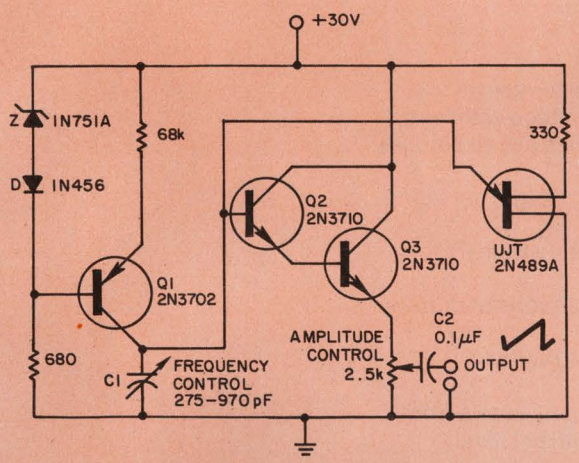


Firing time of the UJT is determined by C_1 and the circuit output is taken from the Darlington.

the UJT. At this point, C_1 discharges through the UJT in one microsecond. Varying C_1 adjusts the frequency of the sawtooth wave from 5 to 200 kHz. The charging capacitor is applied to the output terminals through a Darlington amplifier. The very high input impedance of the Darlington circuit does not load *Q1*, and hence will not affect the linearity.

Amplitude of the output signal is determined by potentiometer *R*, and can be varied from zero to 10 volts. The linearity for frequencies between 5 and 10 kHz is within 0.1%; between 10 and 50 kHz it is within 1.0%. Power dissipation of the circuit is 1.2 watts.

Godfried T. Toussaint, University of Tulsa, Tulsa, Okla.

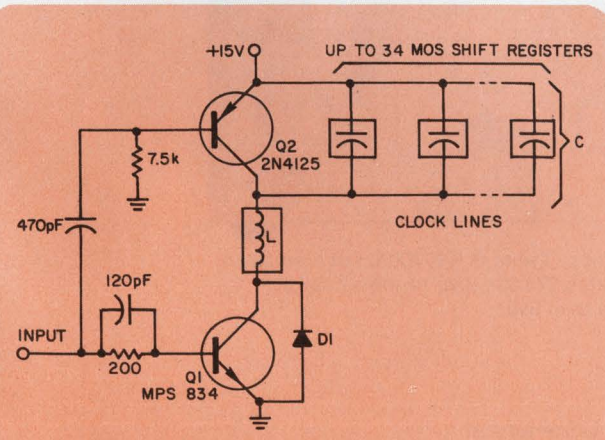
VOTE FOR 312

Drive high-C loads, like MOS registers, by resonating them

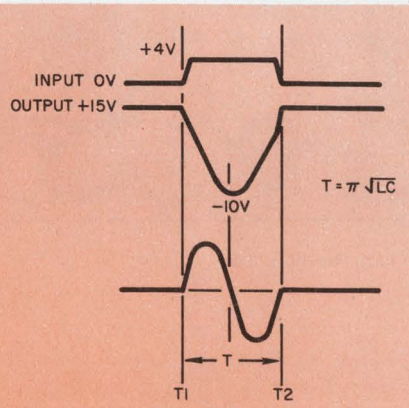
System designers are finding more and more uses for MOS shift registers in data handling applications. Frequently large numbers of registers are connected in series and used as serial delay lines. One of the problems involved is the generation of the register clock pulses.

A typical MOS register may require clock pulses of 0.5 μs duration with peak amplitudes of up to 26 V. The clock-line impedance is primarily capacitive. With clock-lines of, say, 30 registers connected in parallel, total load capacitances in the neighborhood of 2700 pF can be expected. Peak currents of up to 350 mA will be encountered when generating pulses with rise times of, say, 200 ns. If the output buffer of the clock driver is a complementary emitter-follower, as is usually the case, excessive power dissipation will result because the transistors will always operate within their linear regions.

The clock driver circuit shown (Fig. 1), actually takes advantage of the load capacitance by combining it with an inductor and a switch to form a series-resonant tank circuit. The switch is closed long enough to allow one half-sinusoid



1. **A resonant circuit is formed** by the load capacitance, C, and the series inductor, L.



2. **Transistor Q1 carries the current** during the first half of the resonant cycle. Then diode D1 takes over.

smooth

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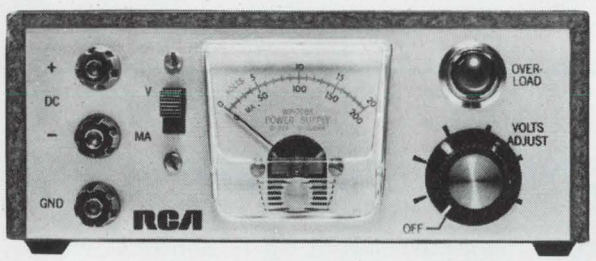
All four power supplies have built-in electronic short-circuit protection—and a front panel overload-indicator that signals approach to maximum rated current level.



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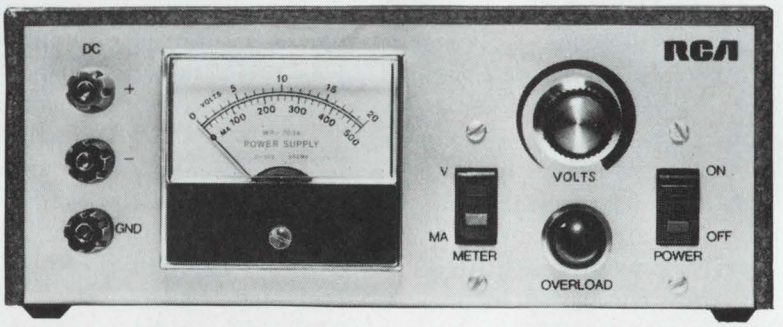

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INFORMATION RETRIEVAL NUMBER 72

to be induced across the load; then it is opened and another switch across the load is closed to terminate the half-sinusoid and prevent further oscillation.

A positive input pulse at time *T1* (Fig. 2), turns on *Q1* and turns off *Q2*. Current flows first down through the load, the inductor and *Q1*, then reverses through the diode *D1*. At time, *T2* the trailing edge of the input pulse turns off *Q1* and turns *Q2* back on, thereby terminating the output pulse and clamping the output to +15 V. The input pulse width must be adjusted to $T = \pi(LC)^{1/2}$, the resonant half-period of the tank circuit.

The circuit losses prevent the peak voltage amplitude across the load from reaching twice B+ (30V), the theoretical value for an ideal circuit.

The transistors used may be inexpensive epoxy devices since they operate simply as switches and do not conduct large currents during their transition periods.

With the components shown and $L = 6.8\ \mu H$, thirty-four 256-bit registers have been operated at 620 kHz. The maximum rep rate may be increased at the expense of a lighter load: Eight 128-bit registers were operated reliably at 4 MHz with $L = 1.0\ \mu H$.

R. O. Brink, Design Engineer, Philco-Ford Corp., Palo Alto, Calif. Now with Novar Corp., Mountain View, Calif.

VOTE FOR 313

Transient inrush current is limited by series transistor

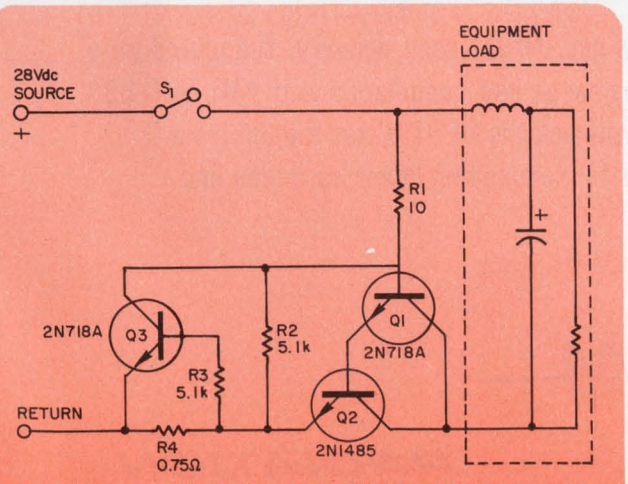
It is often necessary when operating equipment from a dc source to limit the inrush current when power is applied. Transient limitation may be required to protect the source, turn-on relay contacts, or the equipment load itself. If the equipment contains large input capacitor filtering on the power line, the starting transient can reach many amperes when power is initially applied. The circuit shown here can be used to limit the maximum current to any arbitrary value greater than the steady-state current drain, yet the steady-state power loss is relatively small.

This circuit has been used with loads requiring up to 0.5 amp steady-state current. With component values as shown, the maximum current is approximately 1 amp.

When *S1* is closed, *Q1* and *Q2* conduct due to base current supplied through *R1*, thus completing the return path for current in the load. However, if the current is sufficient to produce a voltage of about 0.75 volt across *R4*, then *Q3* will conduct and rob base current from *Q1*. This causes the effective resistance of *Q1* and *Q2* to rise to that value, which will maintain the total current at 1 amp. After the initial charging period is over, the steady-state current drops to a value where *Q3* no longer conducts and *Q1* and *Q2* approach saturation. The full supply voltage now appears across the load except for a small drop across *Q2* and *Q4*.

Al Fisher, Senior Electronics Engineer, Leach Corp., Azusa, Calif.

VOTE FOR 314



Inrush current level is controlled by series transistor in return line.

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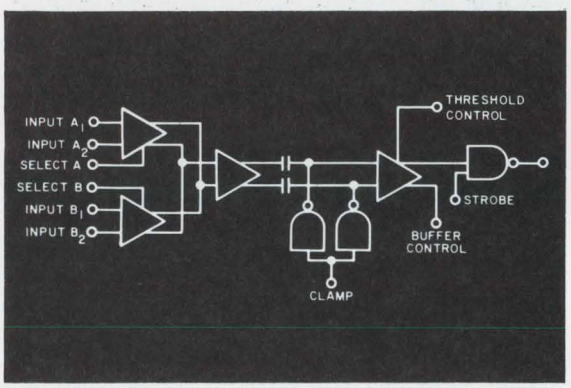

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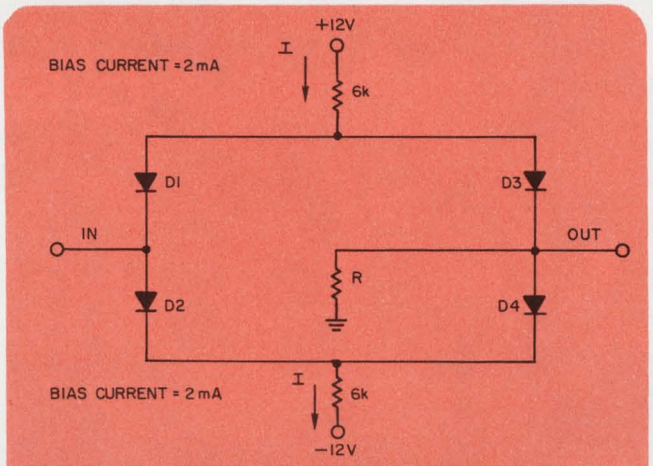
INFORMATION RETRIEVAL NUMBER 73

Diode bridge makes adjustable low-level limiter

A four-diode bridge can be used to make a low-level limiter. Two opposite polarity bias current sources are connected in series with the bridge to supply equal currents. With small signals applied, the bias currents keep the diodes forward biased, and the output waveshape is the same as the input since the diodes do not introduce significant distortion. When large signals are applied, either *D1* and *D3* or *D2* and *D4* become reverse biased depending on polarity of the signal. The bias current is then forced to flow through either *D2* or *D3*, respectively, and *R*. The output voltage in these cases is limited to an amplitude of *IR* or *2IR* peak to peak.

If R=50 Ω and the bias resistors are set to 6 kΩ, the bias current is virtually constant. With the bias voltages set to +12 and −12 volts, the bias currents, *I*, are 2 mA in each branch. Under these conditions, the limiting level is $2 \times 50 \times 2 \times 10^{-3} = 0.2$ V peak to peak. Note that with no signal the bridge is balanced, and the output is zero.

If fast diodes are used, recovery time is no problem. The effect of diode capacitance is minimized by the high quiescent current, 1.0 mA per diode. Under these conditions no significant distortion below the limiting level will occur from dc to about 1 MHz. The limiting level is independent of temperature. The circuit has relatively low output and high input impedances.



Diode bridge acts as a limiter with limiting level chosen by selecting load resistance, R, and bias current, I.

Goubeau Bernard, Design Engineer, Tours, France

VOTE FOR 315

Integrated-circuit hi-peaker shapes frequency response

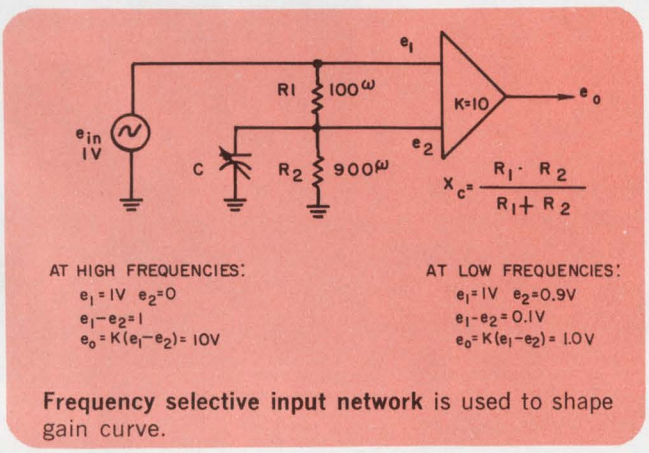
In the field of video amplifiers for television cameras the designer often has need for a hi-peaker circuit. Over a specified frequency range, the circuit must provide a flat response below the inflection point, and a 6-dB/octave rise in gain for frequencies above the inflection point.

Three commonly used methods to achieve this type of operation are:

- Frequency-selective attenuator (equalizers).
- Frequency-selective emitter degeneration.
- Frequency-selective over-all negative feedback.

The use of an integrated-circuit differential amplifier as a hi-peaker is illustrated. While in some respects it has the "feel" of a frequency-selective negative feedback circuit, it can never become unstable since there is no actual output to input feedback. Instead, the high common-mode rejection characteristic of a good differential-input integrated-circuit video amplifier is utilized.

Assume that the differential gain of the IC is 10, and that resistors R_1 and R_2 are chosen so that 0.9 of the input signal appears across R_2 and 0.1 of it appears across R_1. The amplifier



Frequency selective input network is used to shape gain curve.

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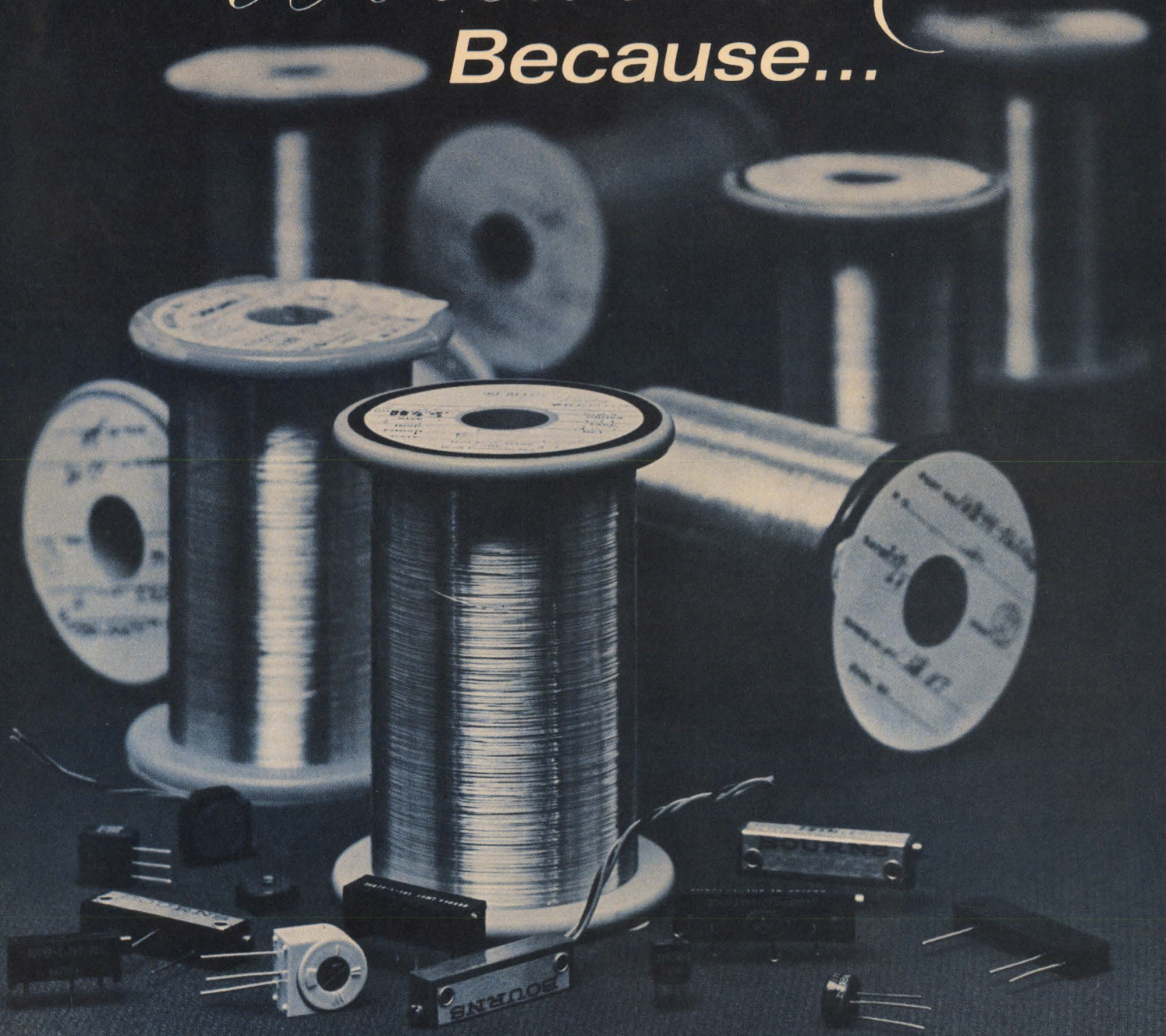

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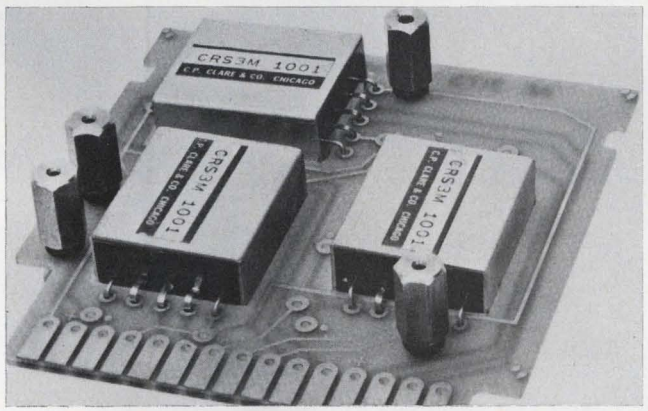
output will be 0.1 × 10 or unity at low frequencies. At high frequencies the total input signal will appear across R_1 and the output will be 1 × 10 or 10 times. Assuming a zero-source impedance, the inflection point will occur at the frequency where $X_c = R_1R_2/(R_1+R_2)$.

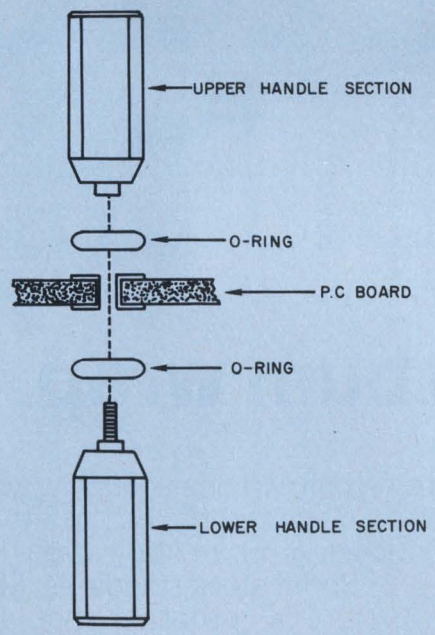
By selecting an IC with the proper gain and choosing R_1, R_2, and C correctly, the designer has control over the low-frequency gain, the inflection frequency, and the maximum gain at high frequencies. Typical ICs that lend themselves to this application are RCA's CA-3001, CA-3040 and Motorola's MC1510G, with a gain of about 10, 30 and 100, respectively.

John O. Schroeder, Member Technical Staff, RCA Laboratories, Princeton, N. J.

VOTE FOR 316

Fixtures mask selected areas during PC board encapsulating





Simple PC board land-masking fixtures use O-rings to mask against the encapsulent (photo). Four such fixtures are used on this PC assembly during encapsulation.

It is often necessary to coat PC board assemblies with encapsulant before final wiring is done. In such cases, there are a number of areas on the board that must be protected, or masked, from the encapsulating material to permit subsequent soldering of lead wires. Masked areas are also often necessary to permit electrical tests subsequent to encapsulation and prior to soldering of lead wires.

Inexpensive fixtures, constructed as shown in A, are handy for this purpose. They use O-rings to mask against the encapsulant, and have shoulders on each handle section to provide electrical contact with the PC board. Although the fixtures work best with brush coating, they may also be used with dip and spray coatings. A 00-90 screw is used to feed through the circuit-board hole.

Fred W. Kear, Design Engineer, Sparton Southwest, Inc., Albuquerque, N. Mex.

VOTE FOR 317

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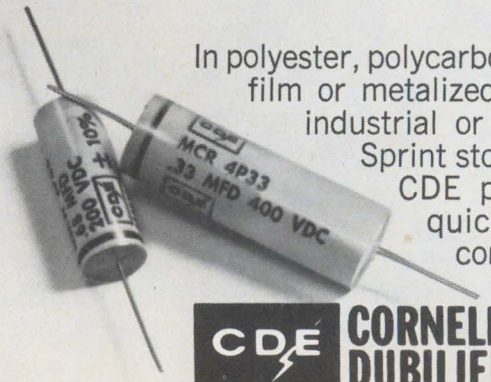

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Narrow-band rejection filter uses twin-T

In the course of low-frequency amplifier design, it is often necessary to have a narrow-band rejection filter. At vlf, inductors are excessively large, and this suggests the use of an RC filter. The twin-T has theoretically infinite rejection at its null frequency; however, it is unsuitable for narrow-band work since its bandwidth is four times its center frequency. Since the RC passive filter doesn't meet the specifications, the use of an active filter is indicated.

By placing the twin-T in the forward loop there is no transmission at the null frequency.

If the twin-T has a transfer function of

$$H(s) = (s^2 + \omega_o^2)/(s^2 + B_w s + \omega_o^2)$$

the over-all system has a transfer function of

$$\frac{E_o(s)}{E_i(s)} = \frac{k}{k+1} \cdot \frac{s^2 + \omega_o^2}{s^2 + \frac{B_w s}{k+1} + \omega_o^2}$$

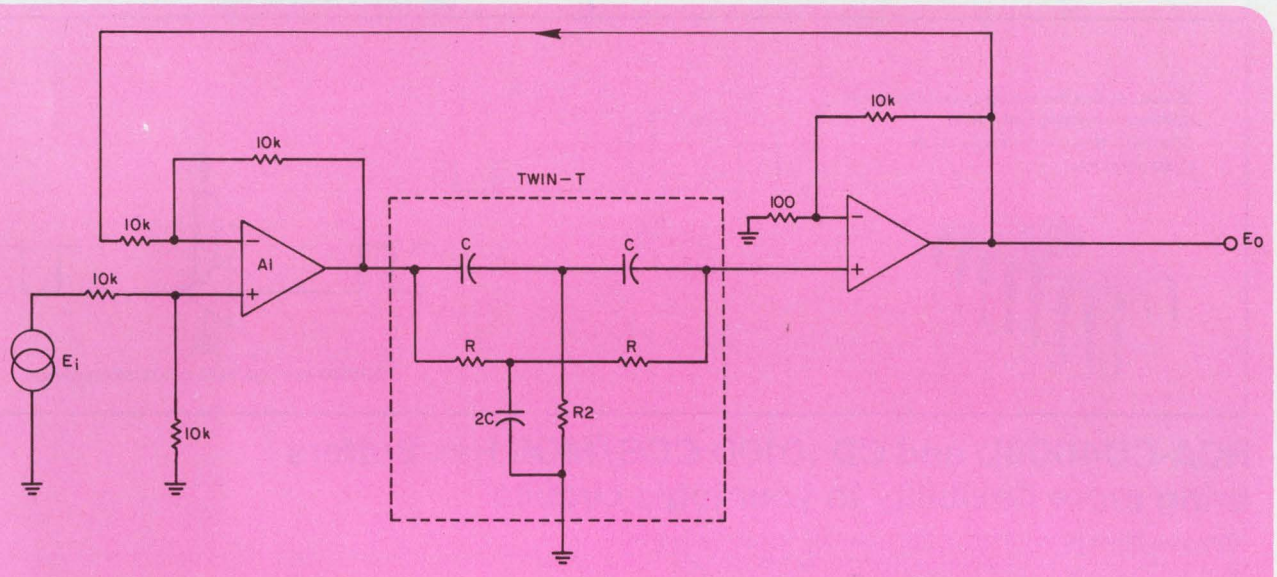
where k = amplifier gain, ω_o = filter center frequency in radians and B_w = filter bandwidth of $H(s)$. It can be seen that the passive network bandwidth has been narrowed by the factor $k + 1$.

The circuit uses two IC amplifiers. Amplifier 1 is simply a subtractor, and amplifier 2 supplies gain with no inversion. This circuit at its null frequency has rejection greater than 40 dB and bandwidth of 0.04 ω_o with a gain of 100 in A2.

The circuit has the advantage of driving the twin-T from a low impedance and terminating it in a high impedance.

Jerome Lyman, Electronics Engineer, Servo Corp. of America, Hicksville, N. Y.

VOTE FOR 318



Narrow-band amplifier using twin-T requires two operational amplifiers.

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Ronald C. Chauvin, Associate Electronics System Engineer, LTV Electrosystems, Inc., Greenville, Texas. His Idea "Get emitter-follower action without input/output level shift" has been voted the Most Valuable of Issue award.

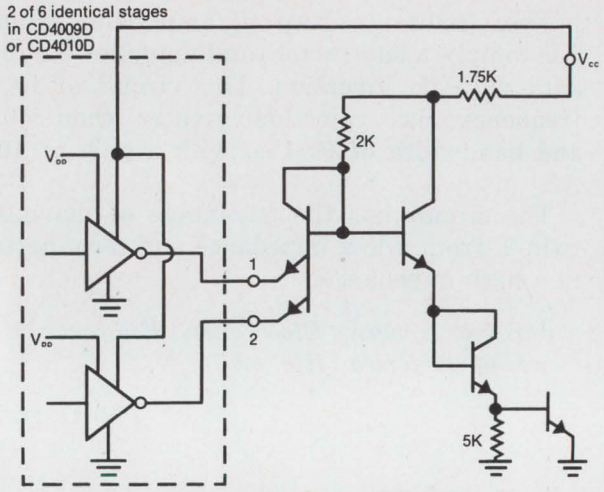
Vote for the Best Idea in this Issue.

IFD Winner for June 7, 1969

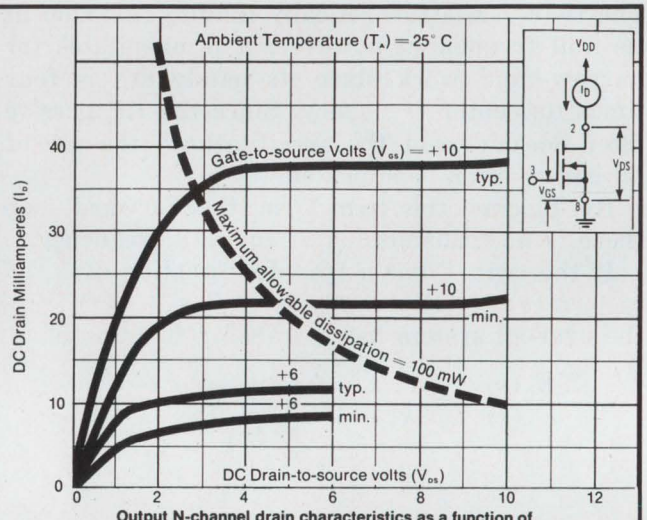
Frederick W. Brown, Design Engineer, Communications Research, Idyllwild, Calif. His Idea "Rf current probe is immune to interfering magnetic fields" has been voted the Most Valuable of Issue Award.

Vote for the Best Idea in this Issue.

Use COS/MOS more ways in more places

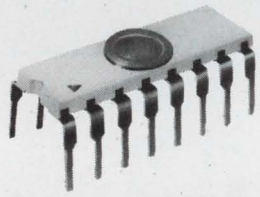


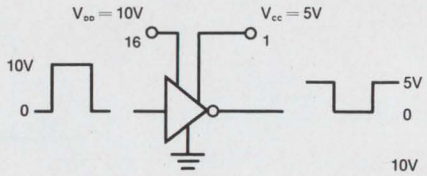
COS/MOS (CD4009D) to DTL (CD2302) Driver



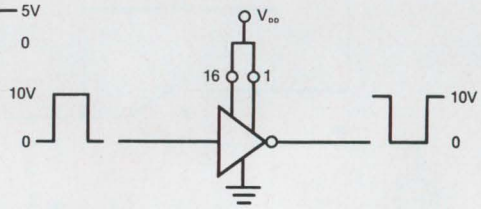
Output N-channel drain characteristics as a function of gate-to-source voltage in CD4009D and CD4010D Hex Buffers

16-lead DIC Hex Buffer/Logic-Level Converters
CD4009D — Inverting Type $7.00
CD4010D — Non-inverting Type $7.00
(1,000 unit prices)





CD4009D as a Logic-Level Converter/Inverter



CD4009D as a COS/MOS to COS/MOS Inverter

RCA-CD4009D and CD4010D COS/MOS Hex Buffers bring more flexibility to your logic circuits

Now you have many more opportunities to take advantage of the known capabilities of COS/MOS—RCA's COmplementary Symmetry MOS digital integrated circuits. Use the new CD4009D (inverting) and CD4010D (non-inverting) hex buffers for:

- greater driving capability, and wider current flexibility in COS/MOS systems
- greater latitude for interfacing COS/MOS with DTL and/or TTL devices.

A most important feature of these new hex buffers in such applications is their low "1" and "0" output impedances which result in excellent dynamic noise margins.

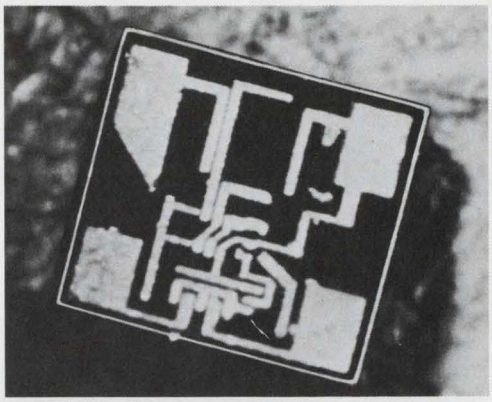
For more information on the COS/MOS Hex Buffers and the rest of RCA's growing line of COS/MOS Integrated Circuits, get in touch with your local RCA Representative or your RCA Distributor. For specific technical information, write RCA Electronic Components, Commercial Engineering, Sec. ICG-10-1, Harrison N.J. 07029.

RCA Integrated Circuits

INFORMATION RETRIEVAL NUMBER 76

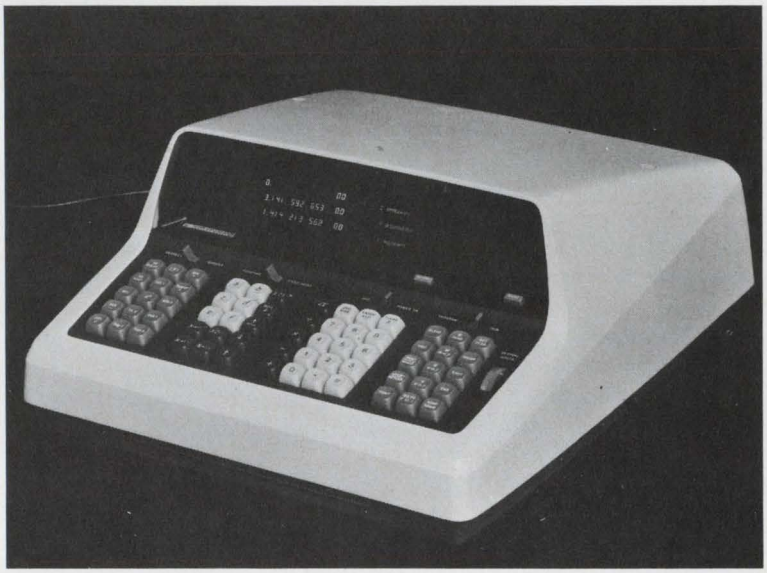
Products

Six-digit clock improves display versatility with interchangeable light-emitting-film panels, p. 158.



On-chip Hall generator digitizes its dual 10-mA output, p. 138.

Split-screen storage CRT provides two readout display modes, p. 152.

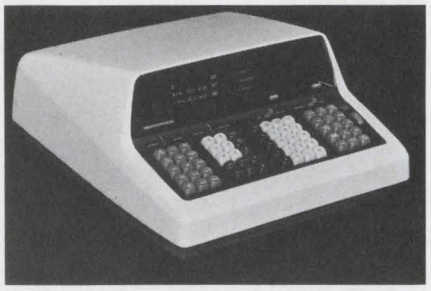


Multi-function desktop calculator, which offers subroutine capability, stores 392 program steps, p. 130.

Also in this section:

Digital TV system converts gray shades into spectrum of colors, p. 130.
Low-cost plastic npn/pnp pairs can handle up to 25 W at 4 A, p. 140.
Helium-neon laser delivers two nearly collinear 1-mW outputs, p. 166.
Evaluation Samples, p. 192 . . . **Design Aids,** p. 194 . . . **Annual Reports,** p. 196.
Application Notes, p. 198 . . . **New Literature,** p. 200.

Versatile desktop calculator accepts 392 program steps



Hewlett-Packard, 1501 Page Mill Rd., Palo Alto, Calif. Phone: (415) 326-7000. P&A: $4400; 10 days.

Part of a fully expandable computing system, a new desktop calculator, which features subroutine capability, can accept up to 392 program steps with its 32 data registers. The model 9100B calculator also provides a dual display for simplified program editing.

Like its predecessor, the 9100A, the new 9100B can perform calculations ranging from simple addition and subtraction to highly sophisticated scientific computations. Prime features for engineering users include finding logarithmic, trigonometric and mathematical functions with a single key stroke.

The subroutine capability permits instant access to subroutines and return from any point in a program. Up to five subroutines may be nested. The calculator remembers up to five return addresses at one time.

An additional feature of the new calculator is a dual display that simplifies program editing. When looking at a program one step at a time, the operator can see the present address and instruction code as well as the next address and instruction code to be executed. This allows the operator to make changes without stepping through the entire program.

The 9100B calculator can be considered as the star member of a fully expandable computing system with peripherals and a large program library that offers a wide variety of practical problem solutions.

The system can accept data via the calculator keyboard, from punched tape, cards, teletypewriters, or from instruments in real time. Results can be displayed on the calculator, on graphs, printed lists, pages, tapes, or on a large-screen CRT.

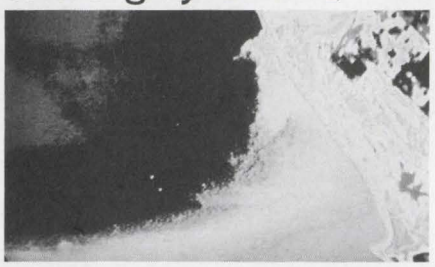
Peripherals are available to tailor the calculator's input and output to suit the user's specific needs. Since the system can expand as required, it practically eliminates the danger of becoming obsolete.

All elements of the system are fully compatible. They simply plug-in. Available accessories include a printer for $975 and an X-Y plotter for $2475.

CIRCLE NO. 250

Sophisticated calculator with 32 data registers is part of a fully expandable computing system that includes a complete line of peripherals.

Digital TV system colors gray shades

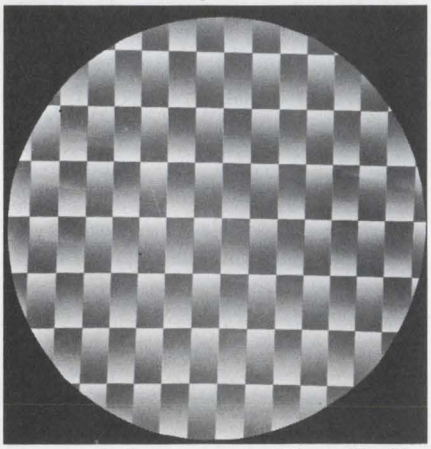


Spatial Data Systems, 132 Aero Camino, Goleta, Calif. Phone: (805) 968-3594.

Offering a new approach to image enhancement and quantitative analysis of scientific pictures and photographs, Datacolor digital color television systems convert the shades of gray in an image or scene into a wide spectrum of colors. Typically, twenty or more shades of gray may be resolved. Simple controls provide continuous adjustment of the color display so that any part of the gray scale may be analyzed in detail.

CIRCLE NO. 297

Image display terminal shows 10^6-point array



Dicomed Corp., 4600 W. 77th St., Minneapolis, Minn. Phone: (612) 920-8980.

Designed to reconstruct digitally derived images from digital computers, digitizers, and other image processing equipment, a new image display terminal provides immediate viewing and long-term storage in one tabletop-size device. The new display utilizes an 8-in.-dia storage CRT that is capable of presenting an array of over one million points, each having an intensity range of 64 levels.

CIRCLE NO. 251

From near the banks of Loch Walden we bring you a GRrrrand new product, the 1192 - a wee bonnie counter that'll make your pocketbook smile. But don't let its size or price fool you; it's a real performer. For instance, it measures frequency (from dc to 32 MHz), period (single and multiple), time interval, frequency ratio, and, of course, it counts. Units of measurement and decimal point are automatically displayed. As little as 10 mV will trigger its input (up to 25 MHz), and you can control trigger threshold and attenuation. You get better than average stability with its internal crystal oscillator.

The 1192 can be ordered with 5, 6, or 7 digits, with or without BCD output, and for bench or rack use. A new companion scaler, the 1157-B, extends the upper frequency limit to 500 MHz. This unit mounts side by side with the 1192 in a common cabinet to form the 1192-Z.

Prices* for the 1192 range from $575 for the 5-digit bench model without data output to $845 for a 7-digit rack model with data output. Add the scaler for another $850. That gives you a 500-MHz counter for as low as $1425. How's that for a bonnie bargain? If you order two or more, the unit cost is even less with GR's quantity-discount plan. Discounts range from 3% for 2-4 units to 20% for 100 units.

For free literature (postpaid) or an all-expense-paid demonstration, write or call General Radio Company, West Concord, Massachusetts 01781; telephone 617 369-4400. In Europe (except Scotland), write Postfach 124, CH 8034 Zurich 34, Switzerland. In Scotland, write General Radio Company (U.K.) Limited, Bourne End, Buckinghamshire, England, for special attention.

*Prices apply only in the USA.

GENERAL RADIO

Wee Bonnie Counter

Pushbutton terminals fit all telephones

Metroprocessing Corp. of America, 64 Prospect St., White Plains, N.Y. Phone: (914) 949-0890. P&A: $200; first quarter, 1970.

Two new Fone-Tone Spartan portable Touch-Tone computer terminals are said to work with any telephone handset manufactured in the United States since 1940. The FT-1248 provides a built-in inductively coupled amplifier and speaker, allowing several people at a time to hear the voice responses from a computer.

CIRCLE NO. 252

Acoustic coupler kit converts Teletypes

Omnitech Corp., sub. of Nytronics Corp., 903 N. 2nd St., Phoenix, Ariz. Phone: (602) 258-8246. Availability: stock.

Able to change Teletype machines into acoustic data terminals, a new fully asynchronous coupler kit converts audio tones from standard voice-quality telephone lines to error-free digital signals. The model 701C kit allows any model 33 Teletype to operate with a standard office-type telephone. Either full-duplex or half-duplex operation is possible.

CIRCLE NO. 253

20 from the tide

From the tide of 5,364 SCRs now available,* TI has selected 20 that meet 80% of low-level circuit requirements.

They're part of TI's preferred semiconductor line, selected after months of computer demand analysis to save you time and money in specifying discrete components.

TI's preferred 20 SCRs are popular, proven and readily available from TI distributor and factory stocks. Volume production assures you the most competitive prices.

Applications are many and varied in consumer and industrial equipment such as light flashers, ignition systems, appliance and stereo/TV controls. In military systems they can perform relaying, squib firing, fuzing and readout-tube driving functions.

If one of TI's preferred 20 SCRs doesn't fit your specific requirements, remember TI makes 111 standard and over a thousand special SCR types from which to choose.

TI Preferred SCRs

Type	Avg. Fwd. Current I_D (A)	Fwd. & Rev. Voltage BV_F/BV_R (V)	Gate Current to Fire I_{GT} (μA)	Type	Avg. Fwd. Current I_D (A)	Fwd. & Rev. Voltage BV_F/BV_R (V)	Gate Current to Fire I_{GT} (μA)
TIC44	.600	30	200	2N3007	.350	100	200
TIC45	.600	60	200	2N3008	.350	200	200
TIC46	.600	100	200	2N3555	1.6	30	20
TIC47	.600	200	200	2N3556	1.6	60	20
2N3001	.350	30	20	2N3557	1.6	100	20
2N3002	.350	60	20	2N3558	1.6	200	20
2N3003	.350	100	20	2N3559	1.6	30	200
2N3004	.350	200	20	2N3560	1.6	60	200
2N3005	.350	30	200	2N3561	1.6	100	200
2N3006	.350	60	200	2N3562	1.6	200	200

Write for TI's brand new 1970 *Preferred Semiconductors and Components* catalog: Texas Instruments Incorporated, PO Box 5012, MS 308, Dallas, Texas 75222. Or just circle reader service card number 117.

*1969 Worldwide figure from D.A.T.A., Inc., publishers of *Electronic Data*.

TEXAS INSTRUMENTS
INCORPORATED

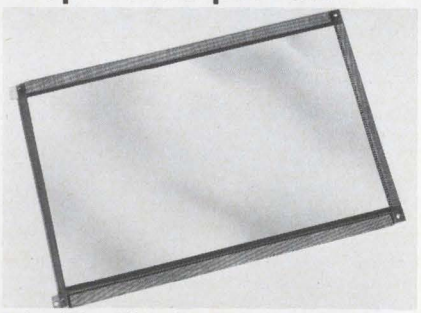
Xerographic duplicator reduces and copies

Xerox Corp., Xerox Square, Rochester, N.Y. Phone: (716) 546-4500. Price: from $600/month.

Providing four functions in a single package, a new xerographic duplicator can automatically reduce, duplicate, copy and collate. Called a reduction duplicator, model 7000 can often cut report size and file space by 75%, knock engineering drawings down to handling size and produce same-size copies at the rate of one a second. It reproduces from documents as large as 14 by 18 in.

CIRCLE NO. 254

Plated-wire memory drops cost per bit

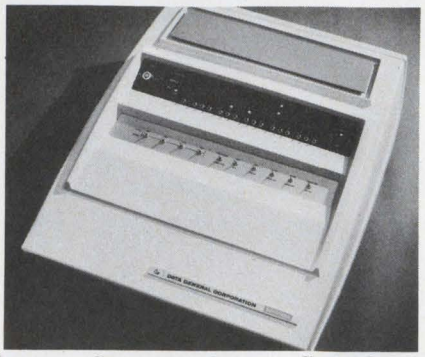


Flexible Circuits Memory Products Div., Val Industrial Park, Warrington, Pa. Phone: (215) 343-2300. Price: 1/4¢ per bit.

Offering switching times of less than 20 ns, a new plated-wire memory plane contains over 165,000 bits at a cost of less than 1/4¢ per bit. The assembly consists of two tunnel structures (one on each side of a printed circuit board) on a 0.25-in. pitch and two single-turn word straps on 0.05-in. centers. It provides low power consumption as well as nondestructive readout.

CIRCLE NO. 255

Fast mini-computer adds in 300 ns

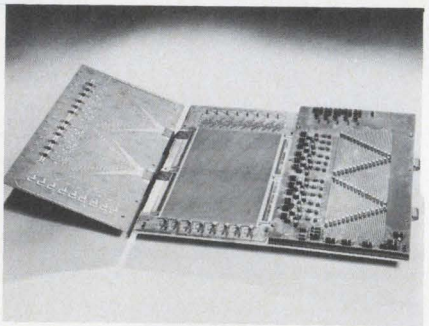


Data General Corp., Southboro, Mass. Phone: (617) 485-9100. Price: $12,000.

Claimed to be the fastest of all the mini-computers, a new small-scale general-purpose computer has an add time of only 800 ns using conventional core memory, and an add time of 300 ns using read-only memory, which is interchangeable with core. Called the Supernova, the new unit offers a basic organization of 4096 words with 16-bit core memory, expandable to 32,768 words.

CIRCLE NO. 256

Memory systems cycle in 125 ns

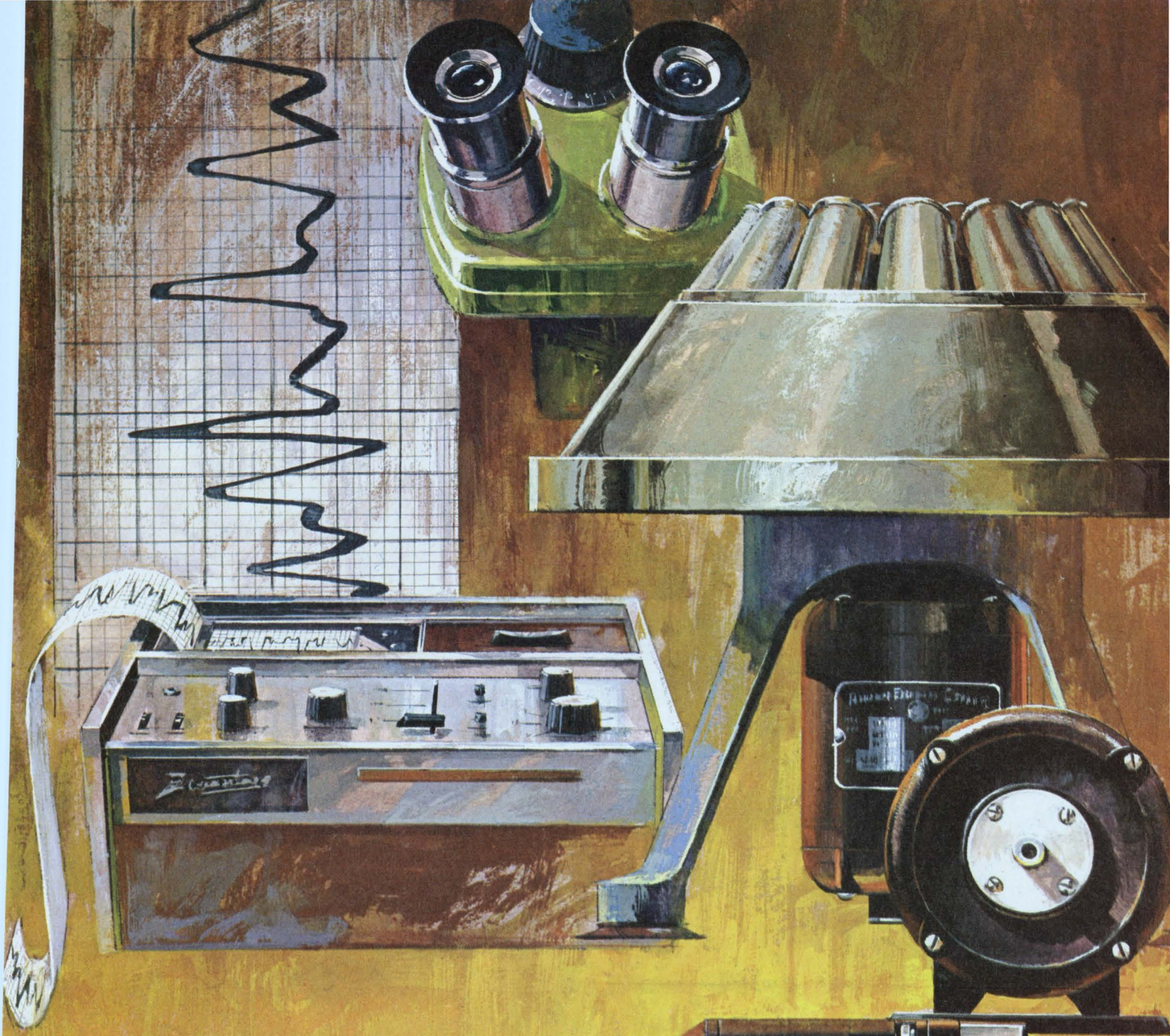


Precision Magnetics, Inc., 525 Park Ave., Minneapolis, Minn. Phone: (612) 339-1489. Availability: 60 to 90 days.

Two new compatible high-speed computer memory systems, the Celeritas 125 (read/write) and the Celeritas 125R (read-only) offer read cycle times of only 125 ns. Word lengths can be as large as 150 bits for the read/write system and up to 96 bits for the read-only system. Both memories are random-access units that use magnetic wire elements.

CIRCLE NO. 257

INFORMATION RETRIEVAL NUMBER 80 ►



Bodine helps keep medical equipment strong hearted...

Bodine fractional horsepower drives. Small. Quiet. A complete line designed to keep medical equipment and apparatus powered precisely, reliably, for a long, long time. Motors built with all the integrity you've designed into your product—that deliver as specified with fewer callbacks and service problems. If this is the kind of power you're looking for, you'll find no better source.

Over 3,500 standard specifications to choose from. Bodine also builds custom and special fhp motors to design requirements. Our engineers will be happy to help you pinpoint the right one for your specific application need. Mechanical organ, heart recorder, test unit, pumps—whatever your product, specify Bodine fhp drives. The power behind the leading products for some 63 years. Write for bulletin. Bodine Electric Company, 2500 W. Bradley Place, Chicago, Illinois 60618.

Bodine Motors Wear Out—It Just Takes Longer

BODINE MOTORS/CONTROLS

Ask about Bodine SCR motor speed controls

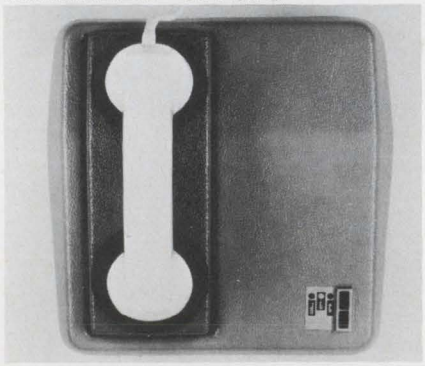
Fast data modem works 2400 bits/s

RFL Industries, Inc., Boonton, N.J. Phone: (201) 334-3100.

Model 3952 high-speed modem can transmit and receive serial binary data over voice bandwidth at a synchronous rate of 2400 bits per second. The new unit is designed for use with all present-day transmission equipment, including conventional and dedicated telephone lines, power lines, microwave and radio. It is compatible with all features and options of Western Electric 201B data sets.

CIRCLE NO. 258

Portable modems minimize errors



Digital Techniques Corp., 4921 Leafdale Blvd., Royal Oak, Mich.

A new series of portable acoustic data sets allow error-free coupling of remote terminals with computers via conventional telephone handsets. The DTC 2000 series features a linear frequency discriminator, automatic gain control, multiple tuned receiver circuits, a high-stability transmitter oscillator and low second-order harmonic distortion transmitter output. Typical applications include time-sharing systems and data centers.

CIRCLE NO. 259

S/D D/S converters by CLIFTON

Excellent means — "first class, of great worth, eminently good." Definite qualities of our ADverter S/D, D/S converters. But we should add one other feature: *not expensive!* (Model SD12A1, $795 qty. 1-9.)

In fact, their low cost, combined with such other features as: reliable, all solid state circuitry, easily interchangeable encapsulated sub-modules, no calibration or adjustments, multi-channel capability, wide variety of options, make them superior in many ways to brush encoders.

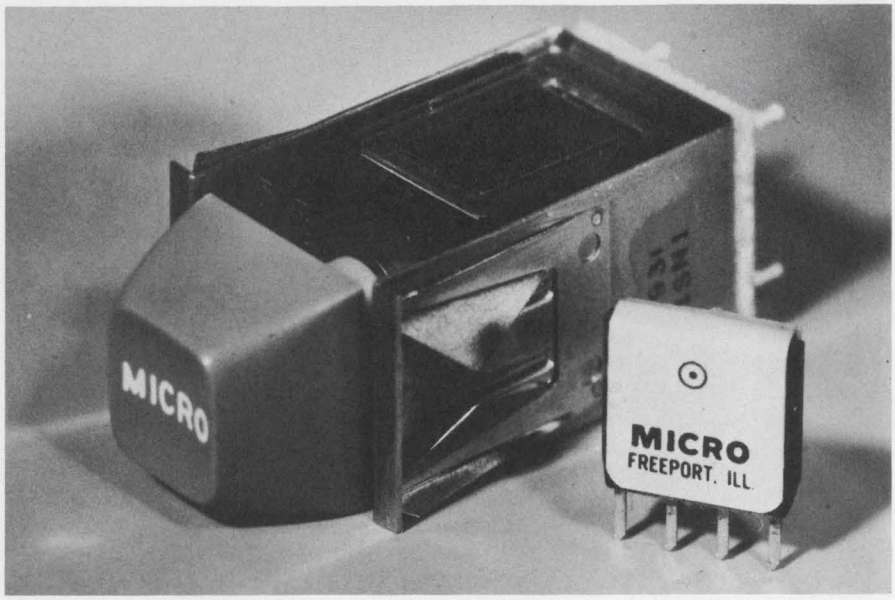
Athough designed especially for the process control and machine tool fields, this system can easily be modified for military applications.

So take advantage of our application engineering know-how which is yours for the asking. Call our DITRAN division in Burlington, Mass. (617) 272-6210, or your local Clifton sales office. When you consider Litton, Clifton, Ditran quality, you couldn't do better!

CLIFTON
DIVISION OF LITTON INDUSTRIES

Pearls by J. E. Caldwell Co., Philadelphia—$5,600

INFORMATION RETRIEVAL NUMBER 82



Hall-effect amplifier chip switches dual load to 10 mA

MicroSwitch Div., Honeywell Inc., Freeport, Ill. Phone: (815) 232-1122. P&A: $4; stock.

Actuated not by physical contact, but by a permanent magnet, a new solid-state switch combines a Hall element with an amplifier and switching circuitry in a single integrated circuit. Labeled the 1SS1, the new chip has two completely digital outputs, either fully on or fully off, for absolute compatibility with digital integrated circuits.

Since the 1SS1 has no moving parts, it can be operated at very fast operating speeds for long periods of time. The absence of physical contact means no mechanical wear and freedom from friction.

In addition, there is no contact bounce on make or break actions. This means that buffering is not required between the switching function and the electronic circuitry.

The 1SS1 internally generates a Hall voltage that is dependent on the proximity of an external magnet. This on-chip Hall generator supplies its neighboring trigger circuit, which, in turn, converts the signal to two digital outputs.

Magnetic flux used to actuate the 1SS1 must pass through the chip, perpendicular to the substrate face. At 25°C, actuation flux can range from 300 to 750 gauss; minimum deactuation flux is 100 gauss.

With a nominal supply voltage of 5 V dc, load current can range from 1 to 10 mA for each output, and can be as high as 20 mA with the outputs paralleled. Loads are connected between the output terminals and the minus lead of the supply.

When operated, the new Hall-effect IC has a minimum output voltage of 3.15 V dc at the load currents mentioned above. When released, it provides a maximum output voltage of 0.25 V dc with a load of 25 kΩ or less.

Over the full output current range, output switching time remains the same. Risetime is 0.5 μs maximum and fall time is 10 μs maximum.

Also available is a new solid-state pushbutton switch that incorporates the 1SS1 Hall-effect chip. Model 1SN offers a choice of momentary (1SN1 for $4) or alternate (1SN3 for $5) switching action. It comes complete with snap-in mounting hardware. Its output is bounce free and does not require buffering.

CIRCLE NO. 260

Try shaking it after you've buttoned up your big, heavy, complex equipment. Miles of densely packed wiring and a myriad of interconnected subassemblies. It passes all functional tests at the plant, but often flunks out after handling, transportation or in service use. "Off the air" due to things like bits of wire, unused screws and washers floating around. Loose connections and cut through insulation from poor wire routing also do a pretty good job.

With Ogden's new, inexpensive ROTOCON vibrator, it's easy to find goofs at the subassembly level. This mechanical, complex wave vibrator eliminates lots of expensive disassembly, rework and reassembly. It's also great for finding simple design errors in R&D or prototypes before you swing into expensive-to-change production.

Some ROTOCON models vibrate assemblies up to 220 lbs. Gently, without degrading reliability. Readings are repeatable too. All frequencies are present from 50 Hz to at least 2000 Hz. For as little as $2600. Most mechanical vibrators operate at 60 Hz tops and electrodynamic vibrators start at $10,000.

Wheel it between production areas. Really simple operation. No test parameter decisions, no special operator training. More dollars saved. Lots of time too.

Sound like a great shake? Our new color brochure gives you all of the details. Or call any of our environmental test labs listed.

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(212) 478-2010

Monterey Park, California
(213) 289-4425

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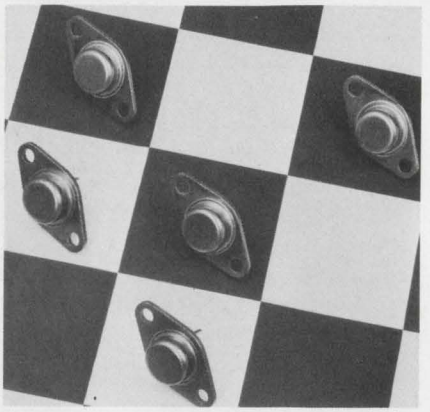
(714) 879-6110

SHAKE WELL BEFORE USING!

INFORMATION RETRIEVAL NUMBER 84

Plastic $1 complements handle 25 W at 4 A



Fairchild Semiconductor, 313 Fairchild Drive, Mountain View, Calif. Phone: (415) 962-5011. P&A: $1.20 to $3; stock.

Offering 25-W power capability in a plastic package, a new line of complementary power transistors cost as little as $1.20 each in single-unit quantities. Packaged in TO-66 metal cans, these pnp and npn devices can handle peak collector currents as high as 4 A.

Type 2N3054 is a npn transistor that costs only $1.20 for one to 99 units and 80¢ for 100 to 999 units. Its maximum collector-base voltage is 90 V, while maximum collector-emitter voltage is 55 V. Base current can be as large as 2 A.

Npn types 2N4910, 2N4911 and 2N4912 have price tags of $1.55, $1.80 and $2.10, respectively. They have maximum collector-base and collector-emitter voltages of 40, 60 or 80 V. Peak collector current is 1 A.

Their pnp complements are types 2N4898, 2N4899 and 2N4900. Prices for these are $1.95, $2.60 and $2.90, respectively.

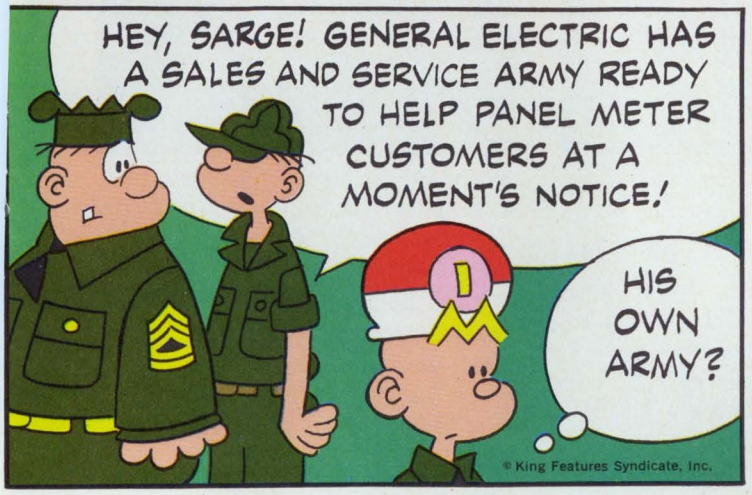
Another npn power transistor is type 2N3441. For a cost of $2.70, it offers a maximum collector-base of voltage of 160 V and a maximum collector-emitter voltage of 140 V. Collector current can be 3 A.

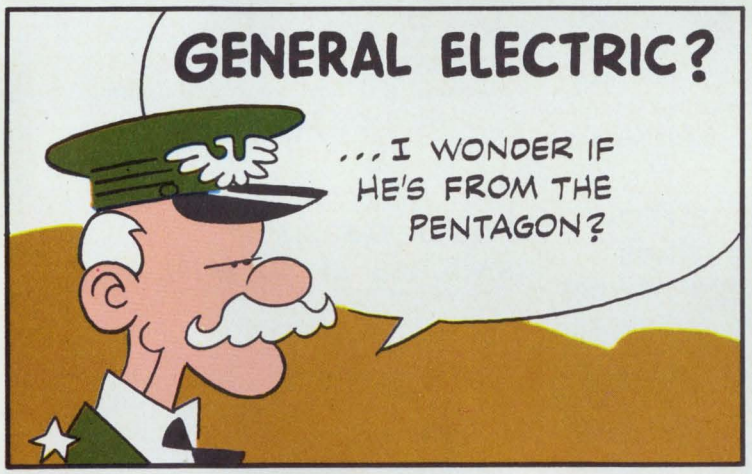
Types 2N3740 and 2N3741 are 25-W pnp transistors selling for $2.70 and $3, respectively. They can carry a peak collector current of 4 A, with a maximum collector-base voltage of −60 V (2N3740) or −80 V (2N3741).

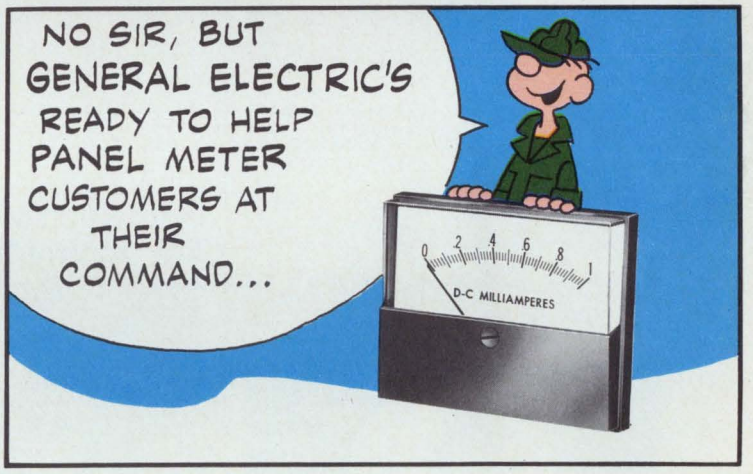
CIRCLE NO. 261

TAKE IT FROM BEETLE BAILEY:

FOR PANEL METERS, COUNT ON GENERAL ELECTRIC'S SALES AND SERVICE ARMY!







Horizon Line® panel meter

The Big Look® meter relay

Edgewise panel meter

Edgewise panel meter

The Big Look time meter

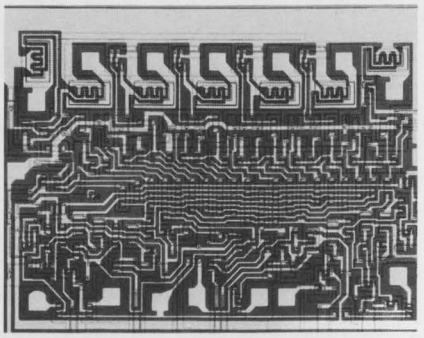
. . . just give the order. General Electric's Sales and Service Army is prepared to combat any panel meter problem with an arsenal of powerful, up-to-date weapons—**a full line of quality panel meters and meter relays, expert application assistance, fast service** across the country, and **on-time delivery** from a nation-wide network of sales offices and distributors.

Why fight it? Surrender all your panel meter problems to General Electric's Sales and Service Army. Contact your GE Electronic Components Sales Office or your dependable General Electric panel meter distributor. 592-34

GENERAL ELECTRIC

INFORMATION RETRIEVAL NUMBER 85

MSI decoder/driver displays numeral 1

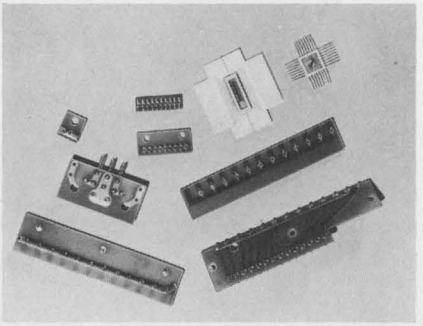


Fairchild Semiconductor, 313 Fairchild Drive, Mountain View, Calif. Phone: (415) 962-3563. Price: $14 to $30.80.

Able to directly drive a seven-segment numerical display, a new MSI digital decoder/driver features a display position for the numeral one. Called the MSI 9317, this integrated circuit can convert four inputs in 8-4-2-1 BCD format. To guard against false inputs, incoming code configurations in excess of binary nine cause the outputs to be disabled.

CIRCLE NO. 262

Optoelectronic arrays are monolithic chips

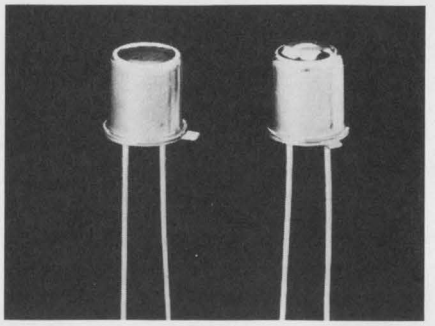


Motorola Semiconductor Products Inc., P. O. Box 20924, Phoenix, Ariz. Phone: (602) 273-6900.

Monolithic arrays of photodetectors are now available for use in light-sensing applications in both digital and analog circuits since their electrical output is proportional to the light level. A typical array contains 31 photodiodes arranged in a line on 0.005-in. centers (200 photodiodes per inch). Each photodiode active area is rectangular with dimensions of 0.005 by 0.0045 in.

CIRCLE NO. 263

Photodiode detectors sense 0.4 to 1.1 microns

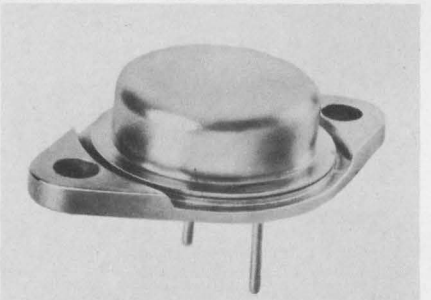


Monsanto Electronic Special Products, 10131 Budd Rd., Cupertino, Calif. Phone: (408) 257-2140. P&A: $6.25; stock.

Two new general-purpose photodiode detectors, the MD1 and MD2, have a response range from 0.4 to 1.1 microns with a maximum sensitivity at a wavelength of 0.9 microns. At this wavelength, the MD1, which has built-in optics, provides a minimum sensitivity of 1.5 μA/mW/cm^2. At the same wavelength, the MD2 with its conventional flat lens has a minimum sensitivity of 3 μA/mW/cm^2.

CIRCLE NO. 264

Power transistor switches at 30 MHz



Westinghouse Electric Corp. Semiconductor Div., P.O. Box 868, Pittsburgh, Pa. Phone: (412) 255-3693. Price: $45.75 typical.

A new high-voltage epitaxial transistor for high-current industrial applications features a typical operating speed of 30 MHz at voltages as high as 375 V with peak currents to 30 A. Type 1843 is designed for use in power supplies, voltage regulators, dc-to-dc inverters, linear amplifiers, dc-to-ac converters and control circiutry.

CIRCLE NO. 265

No other multimeter gives you all this

and no one but Cimron can make a claim like that stick

Here's the first and only 4-digit instrument that you can take with you and hook up for full multimeter performance anywhere. Cimron, the Customer Concern Company, puts your needs first. That's why this new Cimron 6453 is just one more the competition will have to catch up with.

You get the most advanced MSI and IC construction plus a thin film attenuator . . . which, by the way, eliminates 75% of the normal calibration requirements. Single plane Digivac readout tubes result in the lowest power consumption of any digital multimeter, and make full-day battery operation possible. The same amplifier used in the most costly instruments provides an input impedance ten times greater than any meter in its class.

The basic instrument gives you 5 ranges of DC voltage measurement with 5th digit overrange, autoranging in all functions, autopolarity, and pushbutton selection. Add remote control, AC, resistance, print output and the 8-hour battery pack options, and you have full remote programming capability anywhere. And it's computer compatible. The 6453 . . . just 8 pounds and 3½″ × 8″ × 12″, sells for only $1,125. A full multimeter is less than $1,600. *Call us for a demonstration.* Phone (714) 276-3200 or write Cimron, Dept. D-114, 1152 Morena Blvd., San Diego, Cal. 92110.

CIMRON
first name in measurement

LSi
LEAR SIEGLER, INC. / *CIMRON DIVISION*

INFORMATION RETRIEVAL NUMBER 88

Monolithic regulator supplies 100-mA load

RCA/Electronic Components, 415 S. Fifth St., Harrison, N.J. Phone: (201) 485-3900. Price: $2.95.

Packaged in an eight-lead TO-5 metal can, the CA3055 monolithic voltage regulator delivers a load current of 100 mA with a line and load regulation of 0.025%. Its input voltage range goes from 7.5 to 40 V, while output voltage varies from 1.8 to 34 V. Typical output resistance is 0.075 Ω and reference voltage and output voltage temperature coefficient is 0.0025%.

CIRCLE NO. 266

Plastic 39¢ SCRs can take 300 V

Transitron Electronic Corp., 168 Albion St., Wakefield, Mass. Phone: (617) 245-4500. Price: 39¢ to $1.08.

Supplied in a TO-92 plastic package, a new line of low-cost SCRs offer blocking voltage ratings from 15 to 300 V at currents as high as 0.8 A rms. Available in quantity, these new devices have 1000-lot prices ranging from 39¢ to 90¢ for the RTJ02 series, and 45¢ to $1.08 for the RTJ05 series. Triggering sensitivities are as low as 20 μA.

CIRCLE NO. 267

Plastic 800-mA SCR handles up to 200 V

General Electric Co., Semiconductor Products Dept., 1 River Rd., Schenectady, N.Y. Phone: (315) 456-2396. P&A: 33¢ to 48¢; stock.

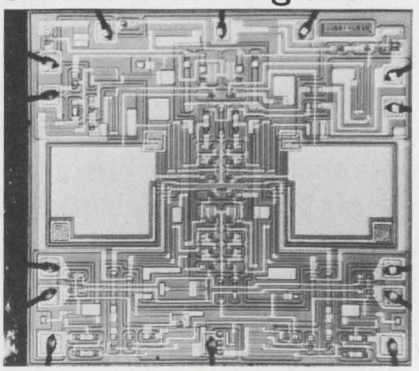
Rated at 800 mA up to 200 V, a new plastic SCR in a TO-18 package features a maximum sensitivity of 200 μA and a surge capability of 8 A. In addition, model C103 has a low forward blocking current of 1 μA. Typical applications include computer and military markets, and control circuits in the appliance, industrial and toy markets.

CIRCLE NO. 268

INFORMATION RETRIEVAL NUMBER 90 ►


They're new, Molex edge connectors.
For printed circuit boards. Terminals crimped
to wires automatically. We have straight-in and
right-angle types. With and without mounting ears.
It's another giant step by Molex in helping create
high-speed, low-cost devices that simplify circuitry.
Reliable? You bet. The connector has bifurcated
terminals that provide solid contacts. Yet you can
slip the connector on and off many times without
damaging printed circuits. And it's not
a preloaded unit. Carries only contacts
required. From nine to twenty-two.
If you want to save assembly time, steps and money,
take a close look at this new Molex edge connector.
For free samples, write or you can make connections
by calling (312) 969-4550.
molex
M155A
MOLEX PRODUCTS
COMPANY
Downers Grove, Ill. 60615

Hardened amplifier senses 1-mV signals

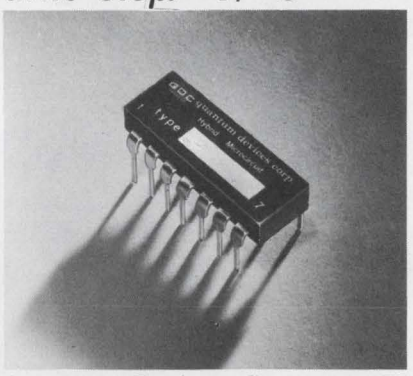


Radiation Inc., Microelectronics Div., sub. of Harris-Intertype Corp., P.O. Box 37, Melbourne, Fla. Phone: (305) 727-4000. P&A: $85; stock.

. A new radiation-hardened dual-channel plated-wire sense amplifier offers a 1-mV signal sensitivity in a high-noise environment and an access time of 10 ns. Model RA-2540R is a monolithic integrated circuit that performs the functions of a hardened differential amplifier and a hardened voltage comparator.

CIRCLE NO. 269

Hybrid amplifiers drift 0.5μ V/°C

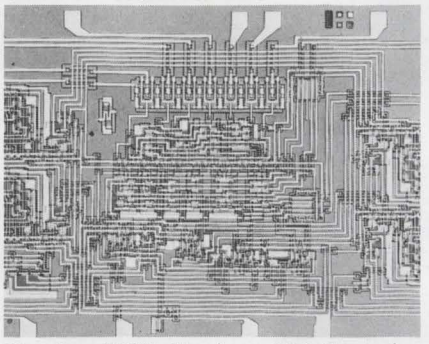


Quantum Devices Corp., 15 W. Main St., Bergenfield, N.J. P&A: $72; stock.

Operating over the temperature range of −25 to +75°C with only a ±5°C change in their substrate, a new line of hybrid operational amplifiers limit offset voltage drift to less than 0.5 μV/°C. These microcircuits are internally frequency compensated and short-circuit protected on both input and output stages. Voltage offset is trimmable with an external potentiometer.

CIRCLE NO. 270

MOS counters drive numerics

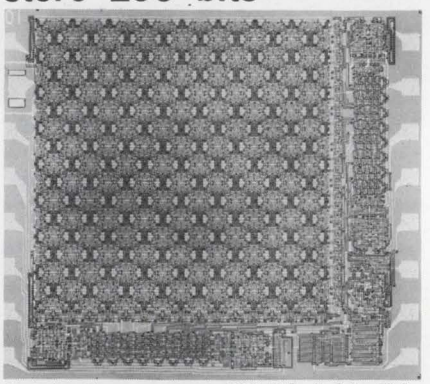


Hughes MOS Devices, 500 Superior Ave., Newport Beach, Calif.

Designed for use with seven-bar electroluminescent numeric indicators, two new universal MOS counters consist of an up-down presettable counter, storage register, a seven-segment decoder, and driver transistors—all on a single chip. Model HCTR0117 uses negative true logic for the set inputs and BCD outputs and has a count frequency of 250 kHz. Model HCTR-0107 uses positive true logic and offers a count frequency of 1 MHz.

CIRCLE NO. 271

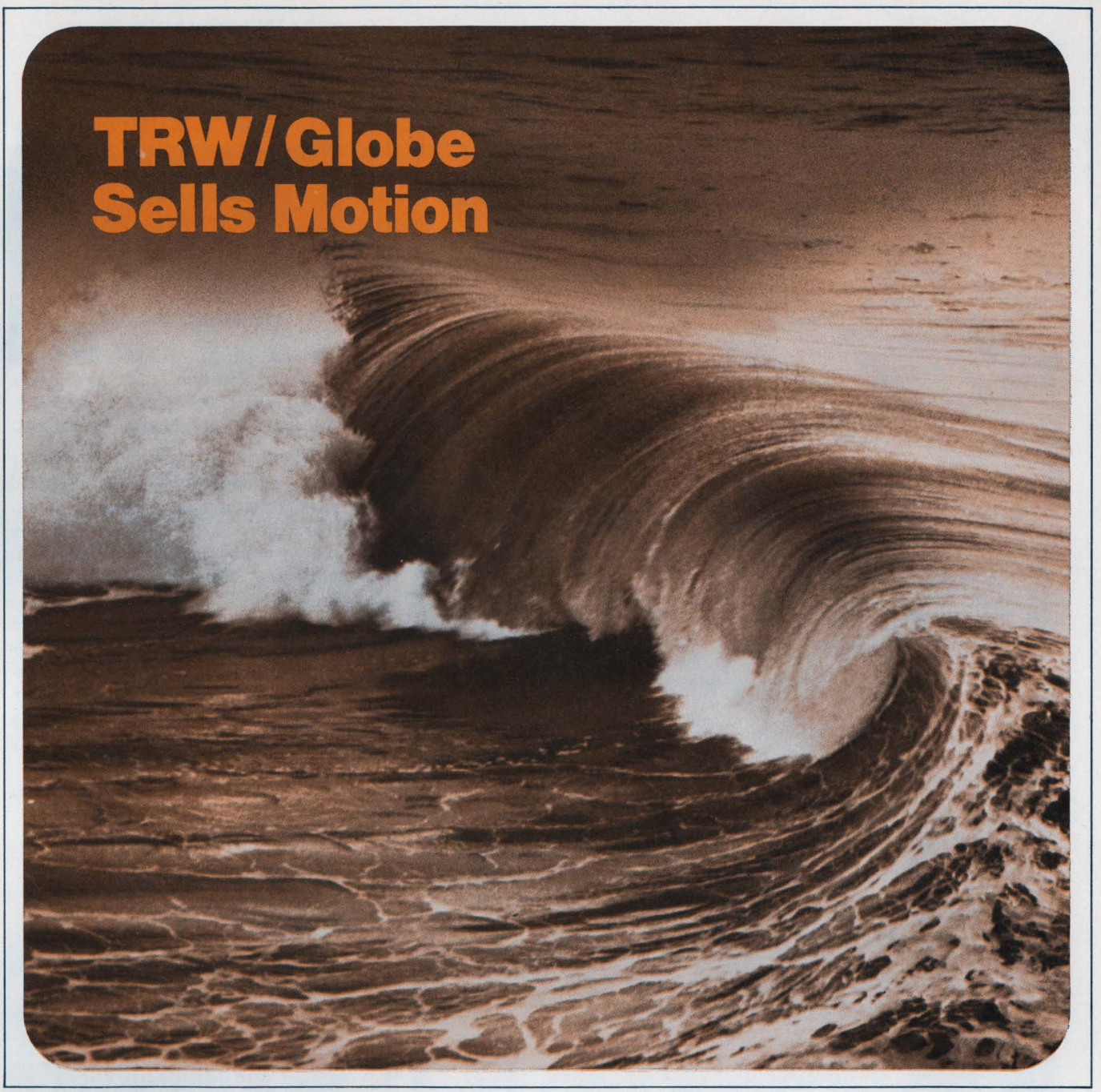
Decoded memories store 256 bits



Intel Corp., 365 Middlefield Rd., Mountain View, Calif. Phone: (415) 969-1670. P&A: $150 or $187.50; stock to 30 days.

Using large-scale integration, two new static random-access memories can store 256 bits plus all decoding circuitry on a single silicon chip. Maximum access time is 1.5 μs for model 1101 and 1 μs for model 11011. Power dissipation is only 50 μW per bit on standby and 2 mW per bit during access. Both units come in 16-lead dual-in-line packages.

CIRCLE NO. 272



Application #1: Pumping Fluids and Gases

Most pumps have a problem with leakage around the motor coupling. So they put in a dynamic seal. But seals wear out and have to be replaced. They also put an added load on the motor.

Globe found a solution. Do away with mechanical coupling between motor and impeller. Use magnetic coupling. No dynamic seal is necessary. No leakage; no seal wear; no unnecessary load on the motor. Result: less power needed; less weight; lower cost; longer maintenance-free performance.

This wasn't a sudden discovery. Globe has been designing and building pumps on this principle since 1963.

The Globe Industries Division of TRW INC. is in the business of solving problems in motion. Any kind of motion; rotary or linear; rapid or slow; air, liquid or mechanical linkage.

If you have a problem in motion, let Globe's motor system engineers find your optimum answer. Contact Globe Industries Division of TRW INC., 2275 Stanley Ave., Dayton, Ohio 45404. Phone (513) 222-3741.

TRW®

INFORMATION RETRIEVAL NUMBER 92

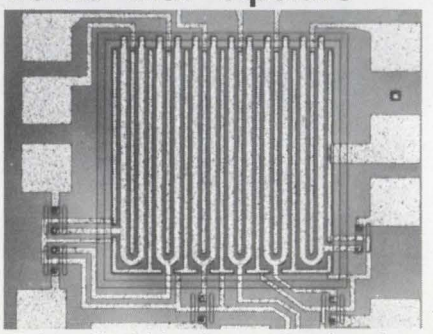
Infrared LEDs put out 5.5 mW

General Electric Co., Miniature Lamp Dept., Dept. 381, Nela Park, Cleveland, Ohio. Phone: (216) 266-2400.

Two new high-power infrared solid-state lamps are now available: the SSL-34 peaks at 900 nm and produces 0.7 mW at 100 mA, while the SSL-35 peaks at 940 nm and delivers 5.5 mW at the same power input. Key to their high power output is a piggyback lens construction. An inner plastic lens covers the gallium-arsenide chip and is, in turn, itself topped by a molded glass lens that hermetically seals the unit.

CIRCLE NO. 273

MOS shift regulator works with bipolars



Union Carbide Corp., Semiconductor Dept., P. O. Box 23017, 8888 Balboa Ave., San Diego, Calif. Phone: (714) 279-4500. Availability: stock.

Eliminating most interfacing requirements, a new MOS dual 25-bit dynamic shift register is a fully bipolar compatible device with inputs that can be driven by DTL or TTL. The output of model SRD-25 (UC7330) can drive either DTL or TTL. Other features include low-voltage power supplies of −10 and −16 V and a power dissipation of 0.4 mW/bit at 1 MHz.

CIRCLE NO. 274

INFORMATION RETRIEVAL NUMBER 94 ►

To sweep 5 to 1500 MHz
• you don't switch ranges
• or change plug-ins
• or use a second instrument

YOU JUST SWEEP

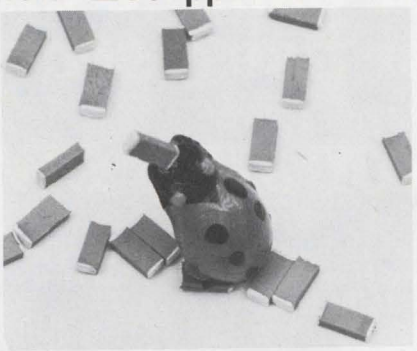
The 3305 plug-in oscillator lets you operate over this entire range, using either end point *or* center frequency calibration, at widths as narrow as 200 kHz, as wide as 1495 MHz.

The 3305, in fact, makes the Telonic 2003 Sweep Generator "every man's" instrument while still permitting total flexibility if your requirements change. All functions of the instrument are on plug-in units — there are 7 oscillators including a new one covering audio frequencies, 6 different attenuators, fixed and variable markers, detectors, and other plug-ins regulating sweep rate and display processing. Complete 2003 Sweep/Signal Generator Systems start as low as $1396.00. Price will depend on plug-ins selected.

Catalog 80A contains a comprehensive description of the 2003 and specs on all plug-ins. Send for a copy.

TELONIC INSTRUMENTS™
A Division of Telonic Industries, Inc.
60 N. First Avenue
Beech Grove, Indiana 46107
Tel: 317 787-3231 · TWX 810 341-3202

Chip capacitors hold ±30 ppm

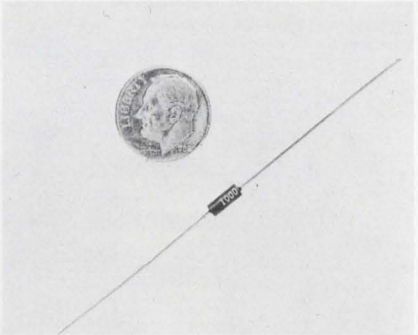


American Technical Ceramics, 1 Norden Lane, Huntington Station, N.Y. Phone: (516) 271-9600. P&A: 20¢ to $1.11; stock to 3 wks.

Measuring 50 by 110 mils, a new line of porcelain chip capacitors exhibit a temperature coefficient of 0 ±30 ppm over the range of −55 to +125°C. Series 700 NPO units are available with capacitance values from 0.1 to 1500 pF at 50 Vdcw and tolerances of 5, 10 or 20%. They are silver metalized devices that are available with presoldered terminations for reflow mounting.

CIRCLE NO. 275

Shielded inductors fit in 0.002 in.^{3}

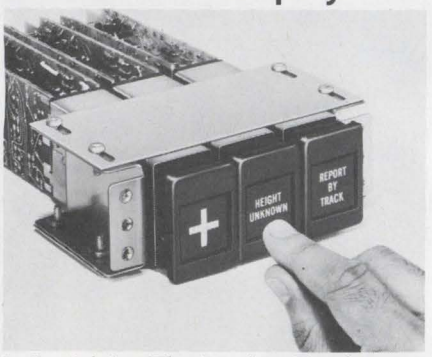


Lenox-Fugle Electronics, Inc., 100 Sylvania Place, South Plainfield, N.J. Phone: (201) 756-1164. Availability: stock.

Occupying a volume of only 0.002 cubic inches, a new line of shielded rf inductors measures 0.1 in. in diameter by 0.25 in. long. Red Shield units offer inductances from 0.1 to 1000 μH ±10% with power ratings of 0.25 W. They also have a high Q and low distributed capacity. Their envelope is made of non-flammable epoxy.

CIRCLE NO. 276

Pushbutton switches control and display

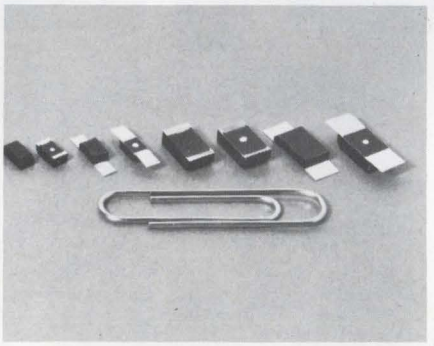


Industrial Electronic Engineers, Inc., 7720 Lemona Ave., Van Nuys, Calif. Phone: (213) 787-0311. P&A: $55 to $66; 8 wks.

Using an optical system to project variable legend information onto their pushbutton screen, a new family of switches permits the control of multiple functions from one switch position. Messages are simply changed by switching from one internal incandescent lamp to another. Each Cue-Switch offers up to 24 different messages or instructions.

CIRCLE NO. 277

Rectangular capacitors measure 70-mils thick



Sprague Electric Co., 347 Marshall St., North Adams, Mass. Phone: (413) 664-4411.

Designed for use on hybrid substrates and printed wiring boards, a new line of rectangular solid-tantalum capacitors feature profiles as low as 70 mils. These Domino 193D capacitors encompass values from 0.1 to 47 μF over the voltage range of 3 to 35 V. Units are available in lead or leadless styles for mounting by dip-soldering, welding or other conventional techniques.

CIRCLE NO. 278

INFORMATION RETRIEVAL NUMBER 96 ►

The Friden 1150 Digital Printer: fast, reliable– and inexpensive.

The Friden* 1150 Digital Printer has a printing speed of 50 characters a second.

Because it has fewer moving parts than ordinary medium-speed printers, it is easier to maintain. This means less downtime for your OEM product. The unit contains a single 20-character print wheel and a synchronized print hammer. Both are driven across the tape from right to left at a uniform speed.

The hammer's short impact time ensures quality printing from the continuously rotating wheel. Your output looks good and is easy to read. And we have even eliminated ribbons with a disposable ink roller.

Logic requirements are simple, making it easy for you to integrate the 1150 into your OEM product.

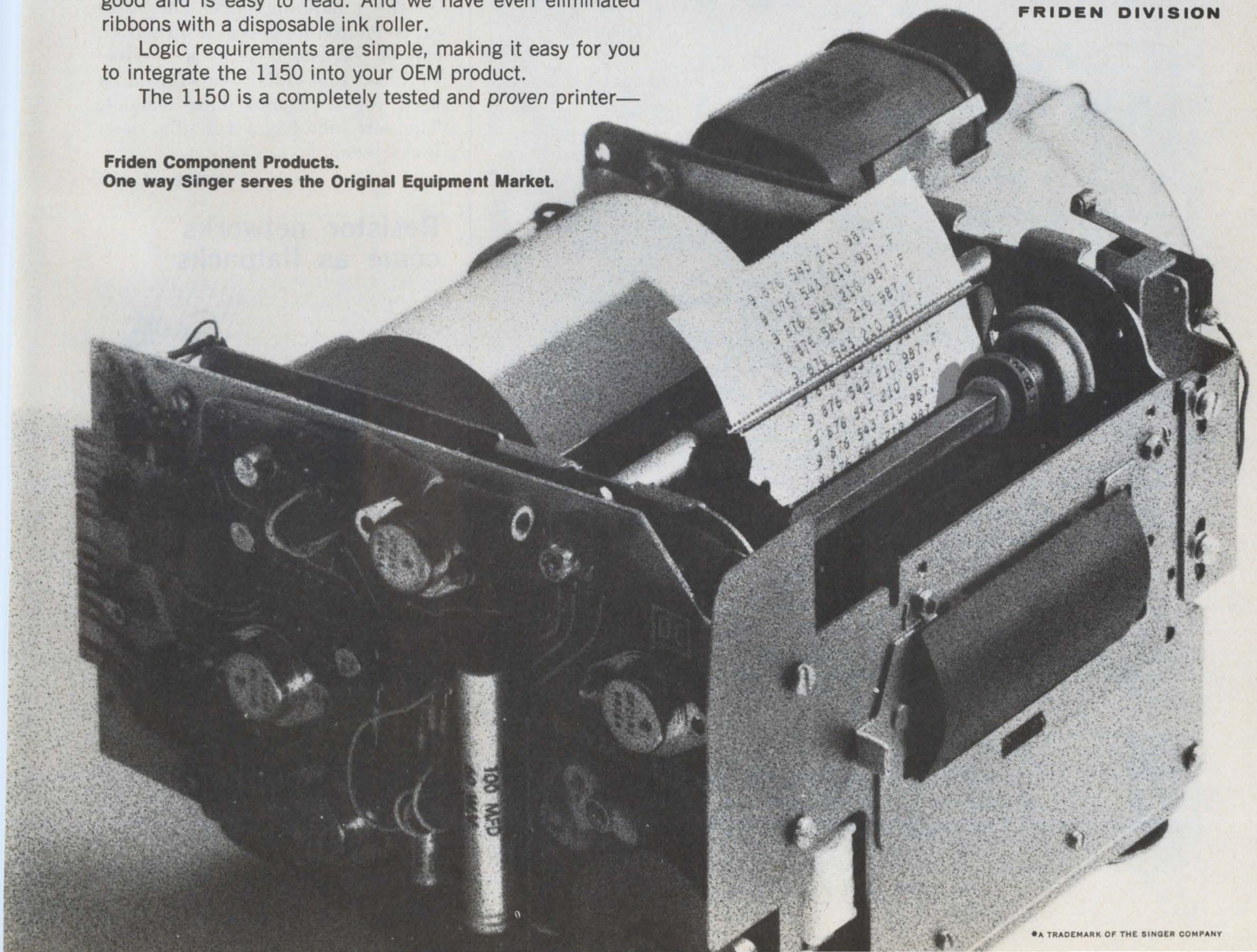
The 1150 is a completely tested and *proven* printer—a vital component of Friden electronic printing calculators for nearly two years. And Singer's Friden Division provides maintenance backup throughout the world.

With its low initial cost and desirable operating features, the 1150 gives you a price/performance ratio that is unique among OEM printers.

We'd like you to have complete specifications. Just write Friden Division (Component Products), The Singer Company, San Leandro, California 94577. Ask for Specification 1001.

SINGER
FRIDEN DIVISION

Friden Component Products.
One way Singer serves the Original Equipment Market.



*A TRADEMARK OF THE SINGER COMPANY

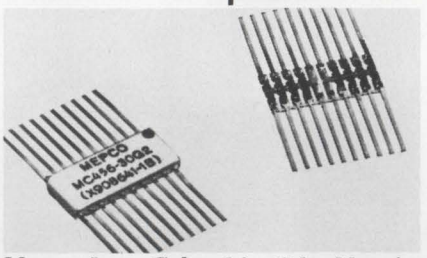
Split-screen CRT doubles readout

Westinghouse Electric Corp., P.O. Box 868, Pittsburgh, Pa. Phone: (412) 255-3693.

With its split-screen dual-mode construction, a new display storage tube permits stored information to be displayed on part of its screen while data is continuously readout on the remaining part. The ratio of nonstored-to-stored information can be varied; it is even possible to have the entire viewing area used for nonstored data readout. The new tube has a 4-in.-dia viewing screen.

CIRCLE NO. 279

Resistor networks come as flatpacks



Mepco Inc., Columbia Rd., Morristown, N.J. Phone: (201) 539-2000. Availability: stock.

Ceramic sandwich resistor flatpacks are now available in three sizes—1/4 by 1/4, 1/4 by 3/8, and 1/4 by 1/2 in. The smallest of these thick-film networks weighs 0.25 g and carries up to nine resistors; the next is only 0.3 g and can contain up to 12 resistors, the largest weighs 0.5 g and handles up to 19 resistors. Maximum voltage is 50 V and power dissipation ranges from 0.5 to 1 W.

CIRCLE NO. 280

INFORMATION RETRIEVAL NUMBER 98 ►

When you buy a low-cost electronic counter from us, you get a unique bonus. Us.

With 55 service offices in the United States and Canada and 86 offices worldwide, we're always close by if you need help. And we give the same complete, dependable back-up to customers who spend a few hundred dollars for a counter as we do to those who spend a few thousand. That's a good thing to keep in mind when you're looking for an inexpensive way to solve your counting problems. And when you add the price and service to the performance you can expect from these counters, you know you're onto a real bargain.

For instance the Hewlett-Packard 5321A counts frequencies up to 10 MHz, has a 100 mV sensitivity and 1 MΩ/30 pF input impedance, 4-digit readout with display storage, zero blanking for easier, faster reading. All this is $425.

The more versatile and more accurate Hewlett-Packard 5321B gives you BCD recorder output, 5-digit readout, frequency ratio and pulse duration measurement, additional gate times and a quartz crystal time base. Yet the price is just $775.

The Hewlett-Packard 5221A/B Counters are the same in everything but shape. They're higher, narrower and not as long as the 5321A/B.

If you need greater capability, the Hewlett-Packard 5216A will provide it for $985. This counter will totalize, measure frequency, period, multiple period averages, ratio, multiple ratios and pulse duration. It has a 7-digit readout, gate times of 0.01 to 10 seconds, 10 millivolt sensitivity, BCD recorder output, and a maximum count rate of 12.5 MHz.

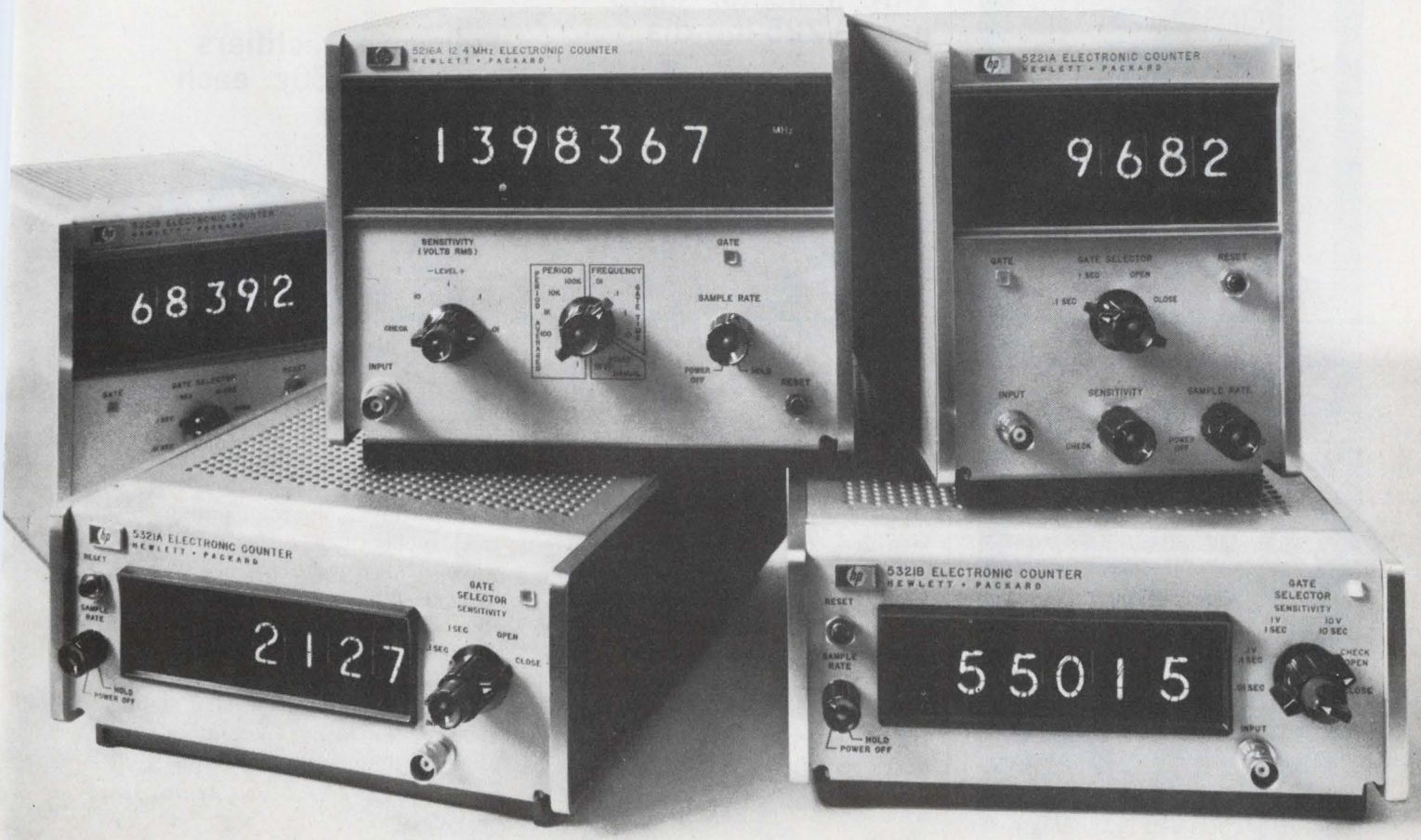
So when you need a low-cost counter, talk to the people who can deliver the goods *and* whatever service you need, whenever you need it. Call your local Hewlett-Packard field engineer for all the details. Or write to Hewlett-Packard, Palo Alto, California 94304; Europe: 1217 Meyrin-Geneva, Switzerland.

HEWLETT hp PACKARD

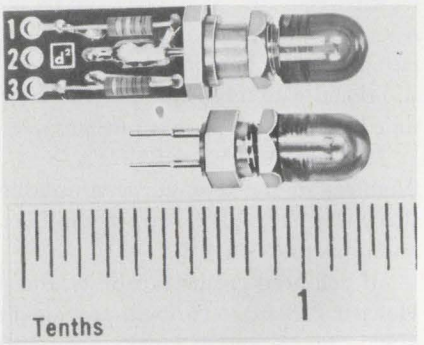
ELECTRONIC COUNTERS

02912

Count on us for as little as $425.



Miniature indicators work from transistors

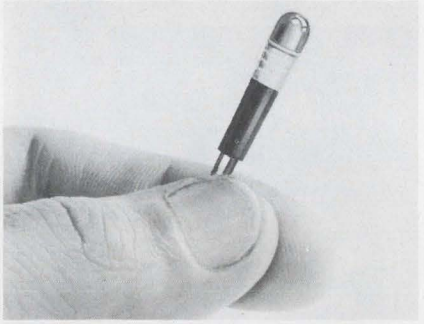


Display Devices Inc., P.O. Box 667, Encinitas, Calif. Phone: (714) 753-0113.

Able to be driven directly by transistors, a new line of miniature indicator lights is ideal for high-density packaging applications. Series TDML units utilize standard unbased T-1 lamps, are relampable from the front, and offer a choice of six lens colors. Bare-board configurations and separate indicator lights for mounting directly to a panel are also available.

CIRCLE NO. 281

Tiny indicator lamp has 0.225-in. dia

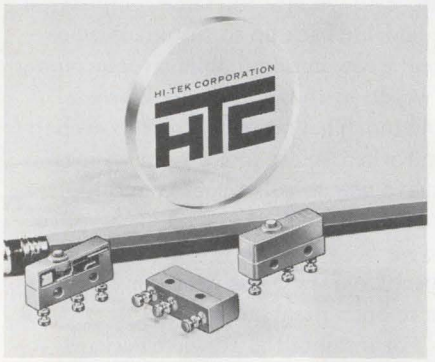


Shelly Associates, Inc., 111 Eucalyptus Dr., El Segundo, Calif. Phone: (213) 322-2374.

Producing a brightness greater than larger-size units, a new microminiature neon indicator lamp measures only 0.225 in. in diameter. Designed to be compatible with transistorized or standard incandescent indicators, Glo-Eye neon lights can be capped with ball, lens or square lenses. Lamps used in the new line are the USAI A1K type and meet MIL-L-15098B specifications.

CIRCLE NO. 282

Subminiature switch operates 10^7 times

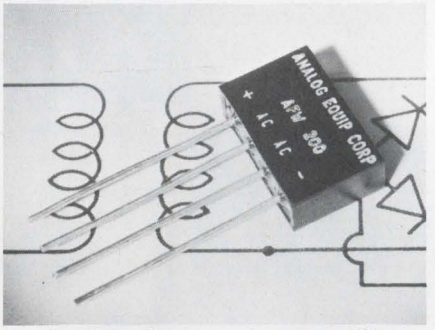


Hi-Tek Corp., Switch Div., 2220 S. Anne St., Santa Ana, Calif. Phone: (714) 540-3520. P&A: $3.50; 3 wks.

Combining a full floating blade with gold alloy contacts, a new subminiature snap-action switch can operate over 10 million times with dry circuit 1-A loads. Model 21 measures 0.25 by 0.61 by 0.8 in., and meets UL, CSA and MIL requirements. Optional terminals include solder, wire-wrap and quick-connect types. The unit is housed in a high-temperature diallyl phthalate case.

CIRCLE NO. 283

Full-wave rectifiers cost only 80¢ each

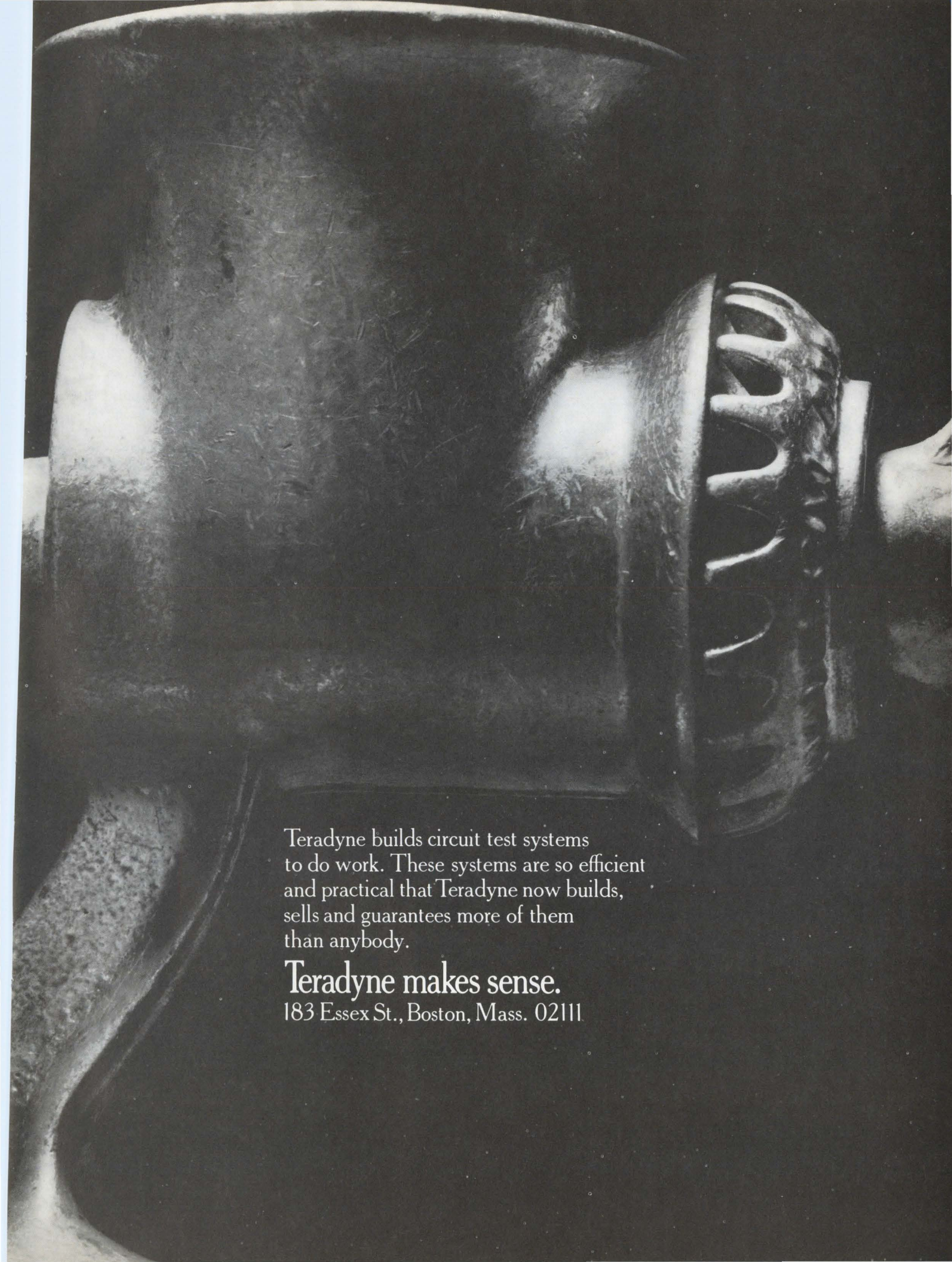


Analog Equipment Corp., 18 Granite St., Haverhill, Mass. Phone: (617) 373-1501. Price: from 80¢.

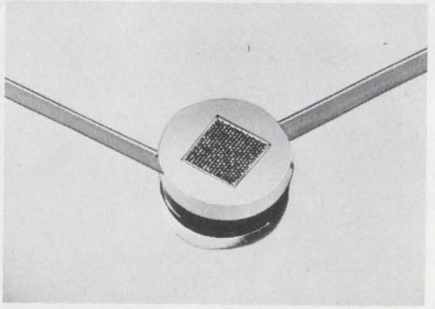
Ideal for commercial and industrial applications, series AFW full-wave bridge rectifiers sell for as little as 80¢ each in small quantities. These pre-packaged silicon rectifier circuits are available with peak reverse voltage ratings of 50, 100, 200, 300, 400, 500, 600, 800 or 1000 V dc. Output current is 2 A at 50°C ambient temperature.

CIRCLE NO. 284

INFORMATION RETRIEVAL NUMBER 102 ►


Teradyne builds circuit test systems
to do work. These systems are so efficient
and practical that Teradyne now builds,
sells and guarantees more of them
than anybody.
Teradyne makes sense.
183 Essex St., Boston, Mass. 02111

Particle detector counts and locates

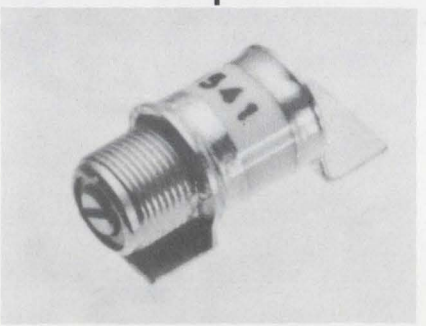


Bendix Corp., Bendix Center, Southfield, Mich. Phone: (313) 352-7613. P&A: $950; 90 days.

Capable of producing a pulse of 5×10^7 electrons for each detected input electron, ion, or photon, a new area-sensitive detector can readout the number of particles detected and where each one is located. Model 5205X has a resolution of 0.006 in. in two dimensions. It can detect inputs located anywhere within a 0.18-in.-square area. Output charge pulses are also imaged in exact positional correspondence with the input event.

CIRCLE NO. 285

Trimmer capacitors work in stripline



Voltronics Corp., West St., Hanover, N.J. Phone: (201) 887-1517. P&A: $4.85 or $6.30; stock.

Designed for stripline applications, two new high-frequency air trimmer capacitors offer a Q rating of 2000 at 100 MHz. Models AJ10 (0.8 to 10 pF) and AJ14 (0.8 to 14 pF) provide completely linear turning and a resolution of 1 pF per 360° turn. Their temperature coefficient is ±20 ppm/°C and operating temperature range is −55 to +125°C. The units have a 0.281-in. diameter.

CIRCLE NO. 286

INFORMATION RETRIEVAL NUMBER 104 ►

The supreme sweeper.

Behold the Model 1001: 0.5 MHz to 300 MHz in one sweep; +13 dbm over the entire range at 0.25 db flatness; programmable in frequency, sweep width and 20 db of attenuation; usable as a signal generator with calibrated output attenuator.

Sweeping supremacy for only $995.

All-solid-state clock utilizes novel display

Sigmatron, Inc., 849 Ward Drive, Santa Barbara, Calif. Phone: (805) 967-0131. P&A: $2400; 4 wks.

Claimed to be the first device of its kind, a new digital clock features a light-emitting-film readout for its six-digit display.

With this unique type of readout, the model 225 clock achieves ultra-high contrasts for better readability, high resolutions, high ambient viewing in any environment, longer life and high brightness.

The new versatile clock uses a seven-segment yellow luminescent readout against a dark light-absorbing background to make reading easier. It can display up to 24 hours of time in hours, minutes and seconds.

Model 225, which is supplied as a complete unit, can accommodate four different interchangeable light-emitting-film display panels. These offer a choice of various character heights, including 0.125, 0.25, 0.4 and 0.6 in.

The new clock also provides an extremely low background reflectivity of less than 1%. In addition, its planar display surface allows wide-angle visibility.

Other features include an initial brightness that is greater than 20 foot-lamberts, plus a service life of greater than 50,000 foot-lambert hours at brightness levels exceeding 5 foot-lamberts.

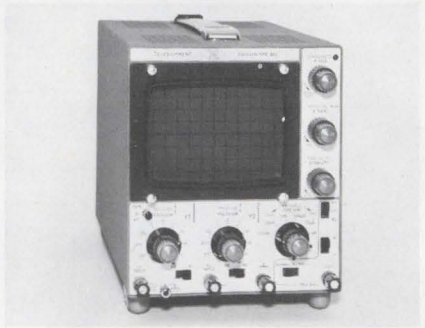
Time is adjustable from the front panel. There are also controls for remote start, stop, reset and test of display-lamp integrity.

Time outputs, which are simultaneous, are BCD coded. They offer complete compatibility with both DTL and TTL circuits.

The price tag of $2400 includes the mainframe plus all four variable-character-height plug-ins.

CIRCLE NO. 288

Dual-beam scope costs only $345

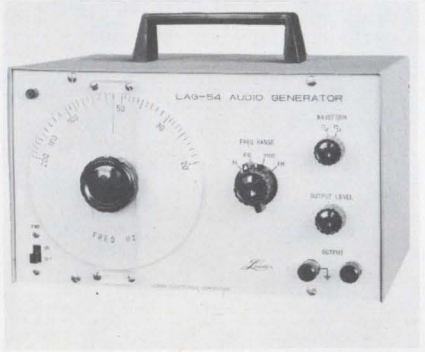


Tektronix, Inc., P. O. Box 500, Beaverton, Ore. Phone: (503) 644-0161. P&A: $345; 3 wks.

With a price tag of only $345, a new dual-beam oscilloscope provides one channel with a bandwidth from dc to 6 MHz and a second channel that covers dc to 3 MHz. Model D51 has deflection factors of 100 mV/cm to 50 V/cm on both channels, sweep rates from 1 μs/cm to 100 ms/cm in six steps, and a measurement accuracy of 5%. It also offers selectable sweep triggering.

CIRLCE NO. 289

Audio generator sells for $84.50



Leader Instruments Corp., 24-20 Jackson Ave., Long Island City, N. Y. Phone: (212) 729-7411. P&A: $84.50; stock.

Costing only $84.50, a new solid-state audio generator, which features FET circuitry, generates sine and square waves over the freqency range of 20 Hz to 200 kHz. Model LAG-54 uses a Wein-bridge oscillator and a Schmitt trigger to shape its output. Sine-wave amplitude is 3 V rms with a 600-Ω impedance; square-wave output is 5 V pk-pk.

CIRCLE NO. 290

INFORMATION RETRIEVAL NUMBER 106 ►

It's your fault!

Now don't take it personally, but we created the Model 4400 Digital Module Tester just for your mistakes (or those of your supplier).

Mistakes that inevitably bug even the best integrated circuits, arrays, printed circuit cards, and complete sub-systems. Small mistakes that turn into big mistakes later when they're part of a final assembly.

So face up to it. The trick is to catch these errors early. Every last one of them. Isolated down to the exact pin at fault. And, if desired, permanently data logged at the same time.

The 4400 does all that. And much more. An automatic DC functional testing system, the 4400 provides both Go/No Go inspection and parametric reading capabilities.

Individual electronics associated with each pin under test permit separate programming of the input logic level or output load, plus monitoring of input current, leakage current, and output logic level on a per pin basis. Voltage or current can be accurately read by an integral ADC at any connection (up to 256 pins possible) and also at the system bias supplies.

The computer paces the 4400's remarkable testing rate. Up to 20,000 tests per second. In addition, the computer's inherent flexibility facilitates ease of test result logging. Finally, since only the software — not the hardware — need ever be changed, the Digital Module Tester is virtually immune to obsolescence.

Programming the tester is easy, too. Test programs are prepared on teletypewriter with computer assistance in an English language format.

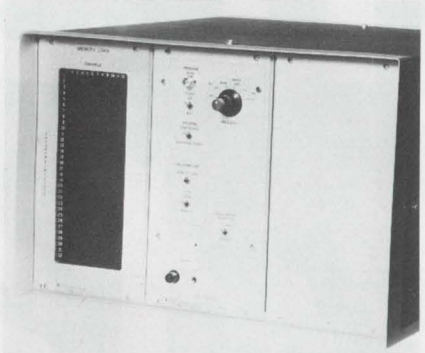
Send for a fully detailed brochure today. And don't feel so bad about your faults.

We all make mistrakes.

Datatron Inc.
1562 Reynolds Avenue
Santa Ana, California 92705
(714) 540-9330

DATATRON **Expanding Man's Capabilities With Data** • Timing • Data Acquisition Systems • Microelectronic Testing • Broadcast Control

Data generator clocks to 25 MHz



Adar Associates, Inc., 85 Bolton St., Cambridge, Mass. Phone: (617) 492-7110.

Functionally testing digital circuits and systems, a new data generator digitizes at rates up to 25 MHz. Model SQ320 stores and presents, on command, a preprogramed data block in a 12-bit 32-word parallel sequential format. It also has remote or local format programing, clocked TTL trigger outputs, and counted or measured word-repeat and serializer options.

CIRCLE NO. 291

Portable voltmeter uses MSI circuits

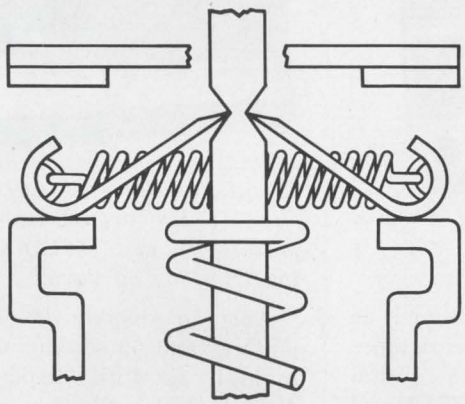
Lear Seigler, Inc., Cimron Div., 1152 Morena Blvd., San Diego, Calif. Phone: (714) 276-3200. P&A: $1125 to $1600; 30 days.

Designated model 6453, a new portable digital voltmeter uses MSI display logic to drive its single-plane readout and keep power consumption down. The unit has a four-digit display with fifth-digit 20% overranging. It measures voltages from 100 mV to 1000 V with an accuracy of 0.01%. Ac and ohms functions are optional.

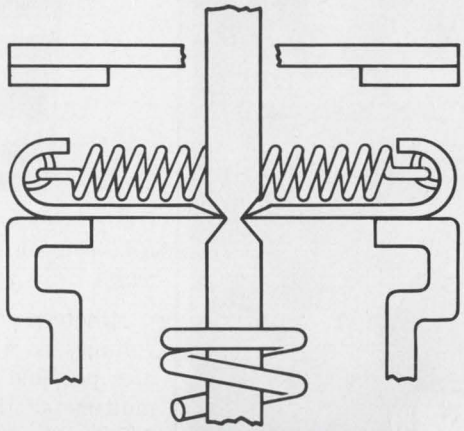
CIRCLE NO. 292

Try a better way.

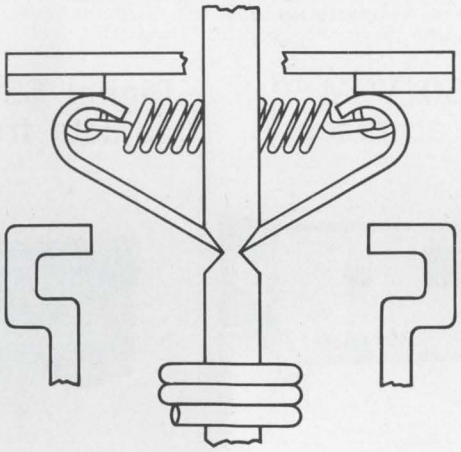
Examine our new military snap-action pushbuttons, and see the difference.



1. Let's start with the advanced switch mechanism design. In this position, the 2-circuit momentary contact switch, built to MIL-S-8805/3B, is not activated. Watch the action.



2. As the plunger is pressed down, the contact arms approach the trip position.

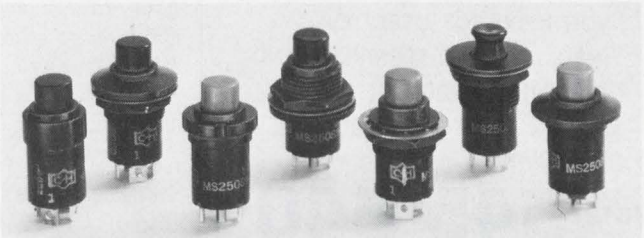


3. The contacts snap up into place and close the NO circuit. This positive snap action provides 120 grams of contact pressure and contact resistance below 10 milliohms—perfect for dry circuits.

This superior mechanical action produces a repeatable trip point accurate to ± .001 inch, making the pushbutton an excellent and economical pressure or limit switch. And it's ideal for panelboard and control-stick use.

The plunger does not rub other parts during operation, preventing contamination due to wear and prolonging switch life. Contacts are self-wiping. And the unique internal silicone seal acts as a rolling sleeve that moves with the pushbutton for reduced wear and longer life.

And here are some features you can't see. Mechanical life, 250,000 operations, far exceeding the specs. Electrical life of 25,000 cycles at full load. Speedy delivery too. And lots more. Contact your Cutler-Hammer Sales Office or Stocking Distributor today.



Cutler-Hammer's new military pushbuttons include seven distinct configurations, screw and solder-lug terminations, five double-break contact arrangements, and momentary-contact and push-pull types.

Switch to No.1 More than just switches: prompt availability, field help, innovation, quality assurance too.

CUTLER-HAMMER

SPECIALTY PRODUCTS DIVISION, Milwaukee, Wis. 53201

CONTROL

INFORMATION RETRIEVAL NUMBER 108

Multimeter for $375 offers nineteen ranges

United Systems Corp., 918 Woodley Rd., Dayton, Ohio. P&A: $375; 4 wks.

Nineteen ranges of ac and dc voltage, dc current and resistance are possible with a new digital multimeter that costs $375. Model 262 has a dc accuracy of 0.1% of reading and incorporates self-checking calibration and an automatic polarity on all dc ranges. The multimeter may also be equipped with an optional battery pack for complete portability.

CIRCLE NO. 293

Digital $350 VOM has 0.1% accuracy

Eldorado Electrodata Corp., 601 Chalomar Rd., Concord, Calif. Phone: (415) 686-4200. P&A: $350; stock.

Featuring a three-digit display, a new digital volt-ohm-meter offers an accuracy of 0.1% with a price tag of only $350. Model 1810 provides a voltage resolution of 1 mV to 1 V in five range selections. It can measure resistance from 0.1 Ω to 19.99 MΩ in six measurement ranges. In addition, the unit has 100% overranging and automatic polarity.

CIRCLE NO. 294

Digital clock sells for $350

Tyco Laboratories, Inc., Instrument Div., 16 Hickory Drive, Waltham, Mass. Phone: (617) 899-2440. P&A: $350; 45 days.

Able to display 23 hours, 59 minutes and 59 seconds on its 1/2-in.-high six-digit display, a new digital clock sells for only $350. Model CLK-100 is an ac-powered clock with an 8-4-2-1 BCD output along with programmable positive and negative data strobe timing pulses. It advances once per second, from right to left, and is resettable from the front.

CIRCLE NO. 295

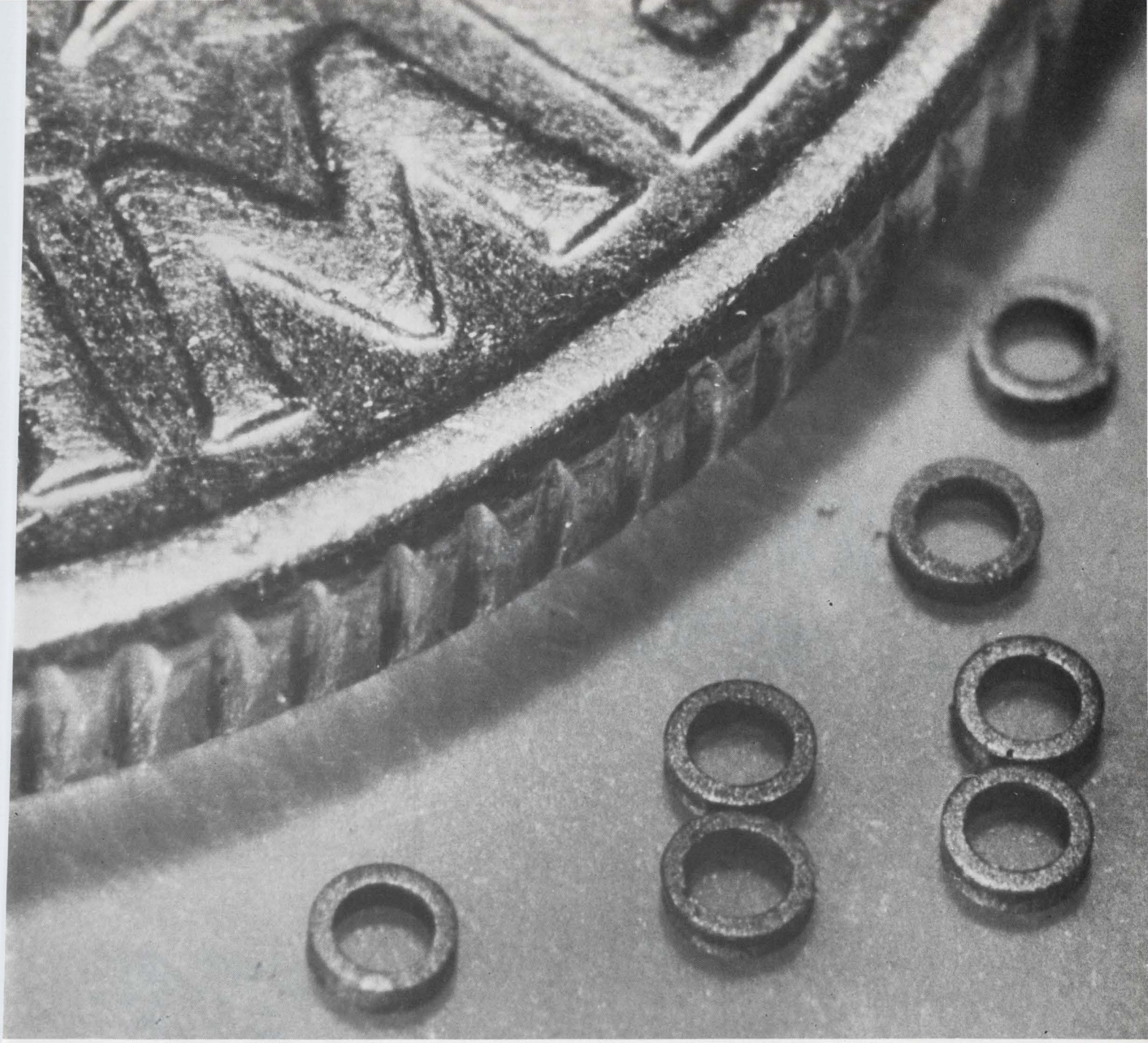
Digital $395 clock adjusts from front

Broadcast Products Co., Inc., 12330 Wilkins Ave., Rockville, Md. Phone: (301) 933-3400. Price: $395.

Offering a six-digit display, a new $395 digital clock can be started, stopped and reset from controls mounted on its front panel. Model BPC-101C can be used as a clock, stopwatch or an elapsed-time indicator. Optional features include a 24/100-hour display to tenths of a second, rear projection display, readout and direct BCD output, and remote function control.

CIRCLE NO. 296

INFORMATION RETRIEVAL NUMBER 110 ►



Unretouched photo of U.S. dime and Data Products' 18-mil cores.

Memory cores, greatly magnified. To show that they are precision-cut. And to show their uniformity. Not shown is the price, recently minified to as little as $2.50/K. Our secret? Technology. In this case a new process developed by our Core Memories Inc. subsidiary. It cookie-cuts cores from continuous ferro-plastic tape. Assures consistent density and size; unvarying electrical and mechanical characteristics. Produces a 90% yield, even on 18-mil cores. Permits off-the-shelf delivery. Let Data Products technology minify your core costs.

DATA PRODUCTS technology gives your computer the edge

DATA PRODUCTS

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Los Angeles, 213/887-8000 Minneapolis, 612/338-4717 Dallas, 214/239-9641 Acton, Mass., 617/263-3961 Bethesda, Md., 301/652-8120
Melbourne, Fla., 305/262-4773 Amsterdam, The Netherlands 020/156-297 London, England (1) 579-3116

Frequency meter doubles performance

Eldorado Electrodata Corp., 601 Chalomar Rd., Concord, Calif. Phone: (415) 686-4200. P&A: $550; 2 to 3 wks.

Said to be an alternate to expensive reciprocal counters, a new economy expanded digital frequency meter is actually two instruments in one. In its expanded frequency mode, model 365 can make rapid low-frequency measurements from 30 Hz to 3 kHz with a resolution of 0.001 to 1 Hz. In its normal mode, the new meter counts from dc to 10 MHz with a resolution of 1 Hz to 1 kHz.

CIRCLE NO. 340

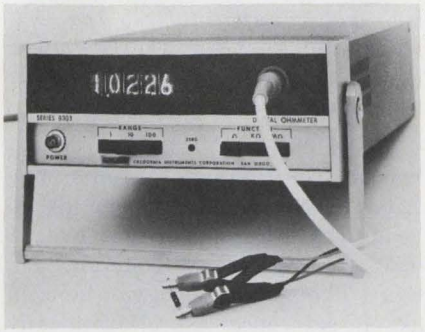
Solid-state hf receiver tunes digitally to 10 Hz

Racal Communications, Inc., 8440 Second Avenue, Silver Spring, Md. Phone: (301) 587-8515. P&A: $4700; 30 days.

Utilizing an integral digital-display counter, a hf solid-state communications receiver can be tuned to within 10 Hz. The RA6218 achieves this accuracy by locking its electronic seven-digit counter to a built-in stable crystal-frequency source. High stability and accurate frequency settling are attained by a synthesized drift-cancelling system and electronic band-switching.

CIRCLE NO. 341

Five-digit ohmmeter reads 1Ω to 100 MΩ



Calico Div., California Instruments Corp., 3511 Midway Dr., San Diego, Calif. Phone: (714) 224-3241. P&A: $1495; 30 days.

With its non-blinking five-digit readout, model 8303 ohmmeter makes full-scale measurements from 1 Ω to 100 MΩ at accuracies of ±0.02% of reading and ±0.01% of full scale. Its input is a four-wire Kelvin-compensated cable that is protected against inadvertent voltages. The unit has a 0.01% resolution and 20% overranging.

CIRCLE NO. 342

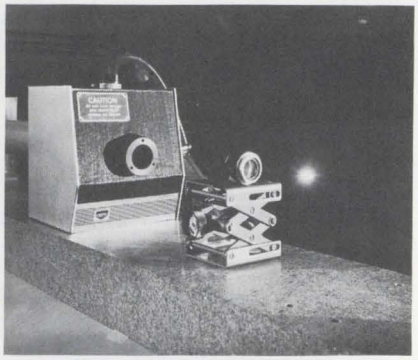
Analog generator shapes time functions

EMR-Hatboro, a Schlumberger Co., East County Line Rd., Hatboro, Pa. Phone: (215) 672-1240.

Using built-in digital programing, a new analog function generator can produce any desired function of time. Called the Profiler, the instrument features programmable segment end points, segment times, number of segments or cycles, and total number of program repeats. All generated functions are composed of sequentially connected linear or haversine segments. Two versions are available, the 1641 and 1641P.

CIRCLE NO. 343

Pulsed gas lasers sock out 10^6 W

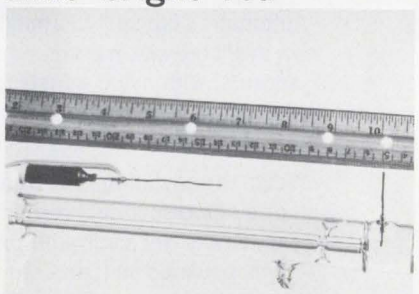


Laser Systems Corp., 313 N. First St., Ann Arbor, Mich. Phone: (313) 761-7150.

Three new pulsed carbon-dioxide gas lasers can produce optical pulses of over a million watts of peak power at pulse rates of 10 to 100 times per second. These characteristics mean that the new lasers could be used for accurate radar work, or adapted to produce spotwelds and holes as desired in a variety of materials. In addition, they are suitable for experimentation in many diversified areas.

CIRCLE NO. 344

He-Ne $50 lasers emit bright red



Metrologic Instruments, Inc., 143 Harding Ave., Bellmawr, N. J. Phone: (609) 933-0100. P&A: $49.50 to $99.50; stock.

Priced from $49.50 to $99.50, three new He-Ne laser tubes and optics, without a power supply or other hardware, operate at the bright-red 633-nm wavelength. Model 205 is a multi-mode 0.3-mW laser with 1.5-milliradian beam divergence; model 210 is a single-mode 0.7-mW output unit with 0.8-milliradian beam divergence; and model 220 is a laser tube with Brewster windows on both ends.

CIRCLE NO. 345

Helium-neon laser has two outputs

University Laboratories, 733 Allston Way, Berkeley, Calif. Phone: (415) 848-0491. P&A: $525; stock to 30 days.

Model 280 He-Ne laser produces two nearly collinear outputs, one from each end of its cylindrical head. Each beam provides over 1 mW of unpolarized coherent red light. The second beam can be used as a reference to electronically monitor the relative power output of the main beam, as a visual indicator on a target to verify that the instrument has not moved, or as an alignment aid for use midway in long optical trains.

CIRCLE NO. 346

Pill-type diodes minimize losses

MSI Electronics Inc., 34-32 57th St., Woodside, N.Y. Phone: (212) 672-6500. P&A: $21; 2 wks.

Housed in a low-loss high-density alumina pill package, a new series of tuning diodes boast a typical package capacitance of 0.15 pF and a series inductance of only 0.05 nH. This means that the new devices are particularly useful in the uhf and microwave frequency regions. Types E1712 to E1726 provide a breakdown voltage of 30 V with leakage currents of only 20 nA.

CIRCLE NO. 347

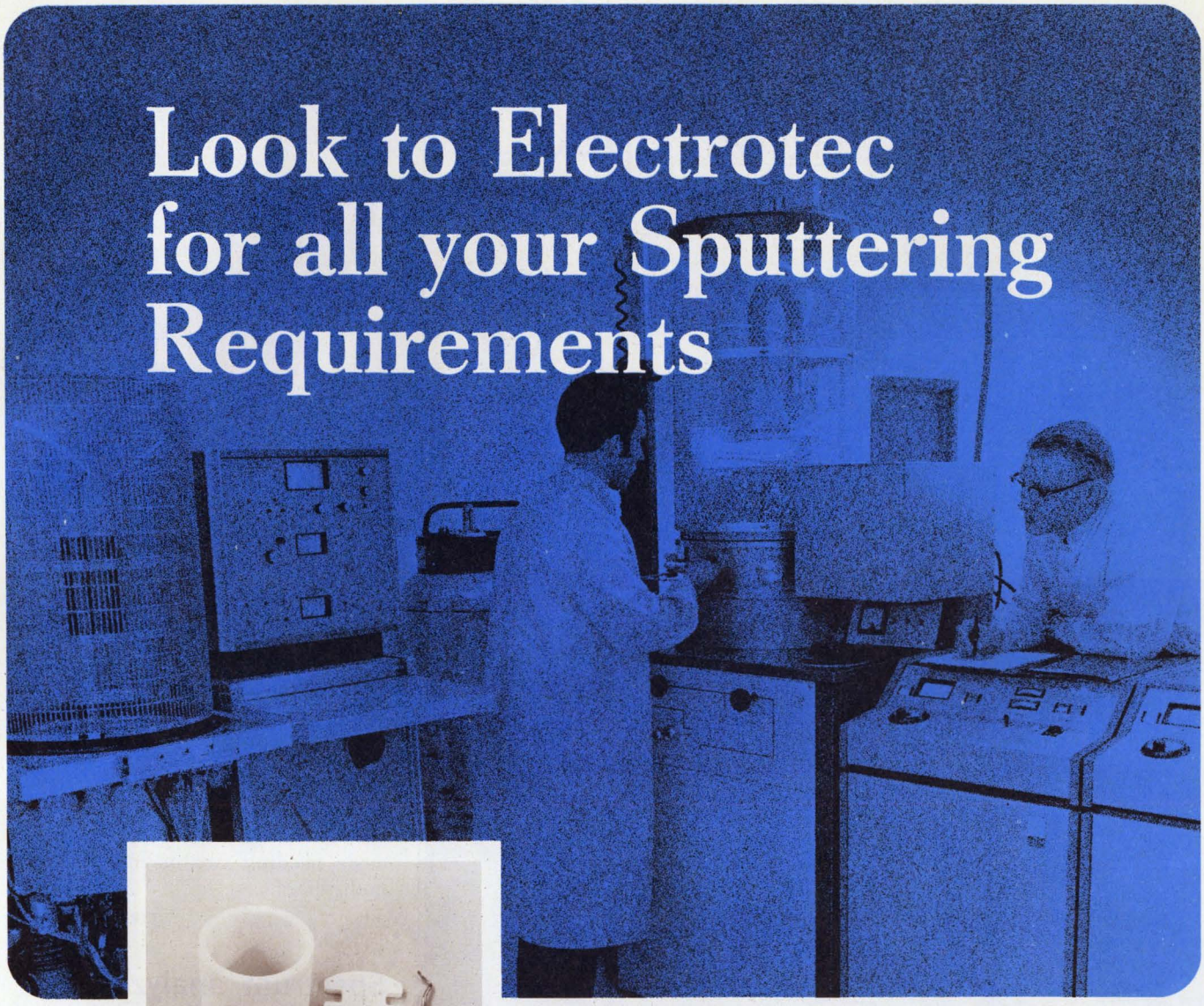
Thin-film resistors work in stripline

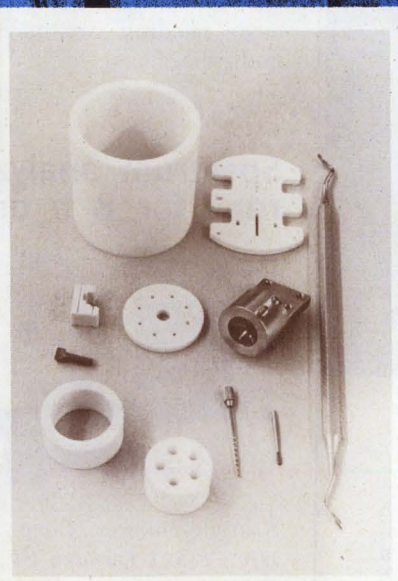
Struthers Electronics Corp., Railroad Place, Mamaroneck, N. Y. Phone: (914) 698-3000. Price: $40/kit.

Combining stability with ruggedness, a new line of microstrip stripline film resistors can be used as terminations alongside a circuit board, can be dropped into slots in the board itself, and can act as elements for matching or attenuator pads. The film element cannot pull loose, or become damaged in soldering, and is protected by a hard coating against all external effects.

CIRCLE NO. 348

Look to Electrotec for all your Sputtering Requirements





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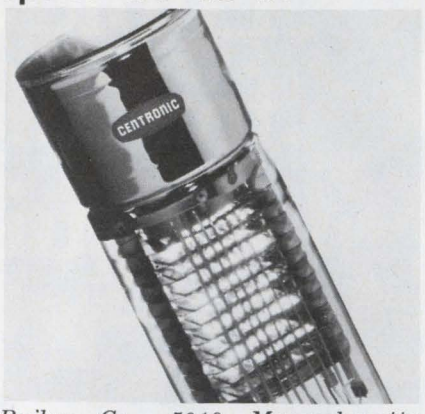
INFORMATION RETRIEVAL NUMBER 114

Photomultiplier spans UV to IR

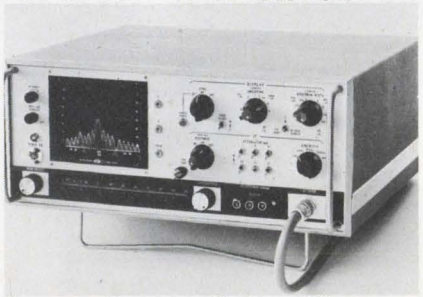


Bailey Co., 5919 Massachusetts Ave., Washington, D. C. Phone: (301) 656-2625.

With its unique tri-alkali cathode, Centronic 2-in. photomultiplier covers the ultraviolet through infrared region with a minimum cathode sensitivity of 180 μA per lumen, a quantum efficiency to 27%, and a typical dark current of 1 to 2 nA. Offering a wide spectral response from 165 to 850 nm, the Q4283R covers a range previously needing two or more photomultipliers.

CIRCLE NO.. 349

Spectrum analyzer runs for 8 h on dc



Systron-Donner Corp., Microwave Div., 14844 Oxnard St., Van Nuys, Calif. Phone: (213) 786-1760. P&A: from $3950; 60 days.

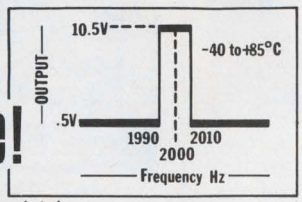
Covering the frequency range of 10 MHz to 6.5 GHz (useable to 10.5 GHz) in six bands, a new portable spectrum analyzer can operate from up to eight hours from its internal rechargeable battery. The weight of model 751, with battery, is only 30 lbs. Scan width is selectable from 100 kHz to 500 MHz, with a calibrated resolution from 1 kHz to 1 MHz.

CIRCLE NO. 350

NEW! Telemeter Frequency Switch

1 hz - 40,000 hz

Look at this "ZAP" response!



These new Go/NoGo completely solid-state Audio Switches fire whenever input frequency goes above, below or within definite frequency limits... as accurate as 1 cycle per thousand, with maximum response of 2 input cycles.

Input frequency can be a sine or square wave . . . even measures length of time between pulses. Easily handles 1hz to 40,000hz . . . or higher, if dividers and/or mixers are used. Special high-pass, low pass and band pass functions available too. **Priced from $99.50 each.**

GOSH instruments, inc.

Wethersfield, Connecticut 06109 / phone (203) 527-4794

INFORMATION RETRIEVAL NUMBER 122

WHEN THE FUSE GOES OUT, THE LIGHT GOES ON!

Littelfuse Indicating Microfuse Holders for military and commercial applications. Ranges 2-1/2 thru 250 Volts. Also available with RFI shielding.

LITTELFUSE

DES PLAINES, ILLINOIS

INFORMATION RETRIEVAL NUMBER 123

New Oak Versatility

OAK ECONO-LINE PUSHBUTTON T.M.

JUST 25¢ A BUTTON*

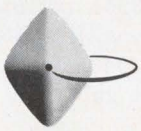
*For most applications

We've got the button... throws from 1 PST to 8 PDT per button; sizes: .388" sq., .388" x .585" or .388" x .782"; legends engraved to your specifications; black or white buttons are standard, other colors on special order.

Push Rod Stroke... 5/32" plus 3/64" overtravel; push rod lengths optional at 1/2", 5/8" standard length, 3/4", 7/8" and 1".

Easy to wire... clips are Oak-pioneered double-wiping. For printed circuit boards or wire-soldering, PCB terminals are 3/32", 1/8", 3/16" standard length, 7/32" and 1/4" shoulder to tip. Choose terminals for wiring only or P.C. dual-purpose which have the wire hole in addition to the P.C. lug.

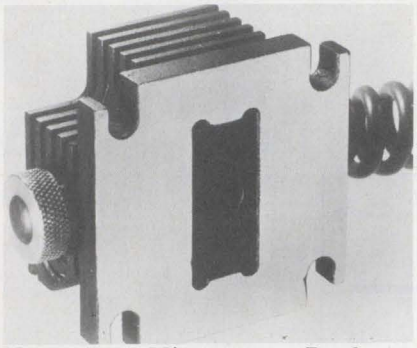
Compact Convenience... more buttons per area—24 on .394" centers, 16 on .591" centers, 12 on .788" centers. Any switching—momentary, push-push, interlock, or blockout or combinations. For full details, write today for Bulletin SP-346.



OAK MANUFACTURING CO.
A Division of OAK ELECTRO/NETICS CORP
Crystal Lake, Illinois 60014
Phone: 815-459-5000 TWX: 910-634-3353

INFORMATION RETRIEVAL NUMBER 124

X-band oscillators punch out 100 mW

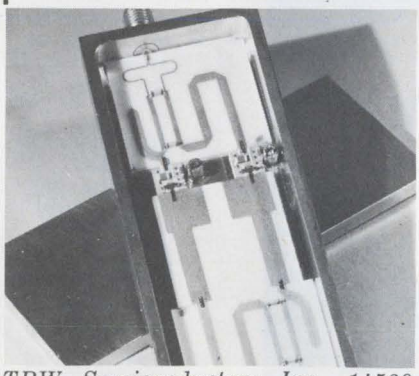


Monsanto Microwave Products, 11636 Administration Dr., St. Louis, Mo. Phone: (314) 694-4816.

Series VX2020 X-band Gunn-effect cw oscillators provide a minimum output power of 100 mW with a variation of less than 2 dB over their entire tuning range. The devices are mechanically tunable over a 20% bandwidth within the frequency range of 8.2 to 12.4 GHz. They have a loaded Q of 1000 and hold fm noise to less than 0.7 Hz rms.

CIRCLE NO. 351

Solid-state amplifiers perform like TWTs



TRW Semiconductors Inc., 14520 Aviation Blvd., Lawndale, Calif. Phone: (213) 679-4561. P&A: $1285; stock.

Capable of providing the performance of traveling-wave tube circuitry, three new broadband solid-state power amplifiers supply a minimum rated output of 10 W. Type PA-3940 covers the band of 1 to 1.5 GHz with 6-dB gain; type PA-3941 performs from 1.5 to 2 GHz with a 5-dB gain; and type PA-3942 covers 2 to 2.3 GHz with 4-dB gain.

CIRCLE NO. 352

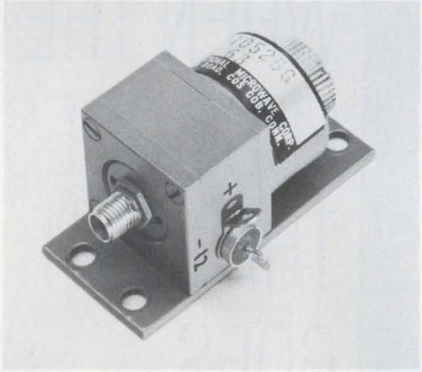
Microwave sweeper measures selectively

Siemens Aktiengesellschaft, Technischer Pressedienst, 8000 Munchen 1, Postafach 463, Germany.

Over a frequency range of 5.8 to 8.5 GHz, a microwave sweep measuring setup operates with a heterodyne detector to allow the advantages of selective measurements like high sensitivity and interference elimination. The generator and detector of model K 1046 cover a test level range of +10 to −99 dBm, with calibration in absolute units.

CIRCLE NO. 353

X-band oscillators work without mixers



International Microwave Corp., 33 River Rd., Cos Cob, Conn. Phone: (203) 661-6277. Availability: 30 to 60 days.

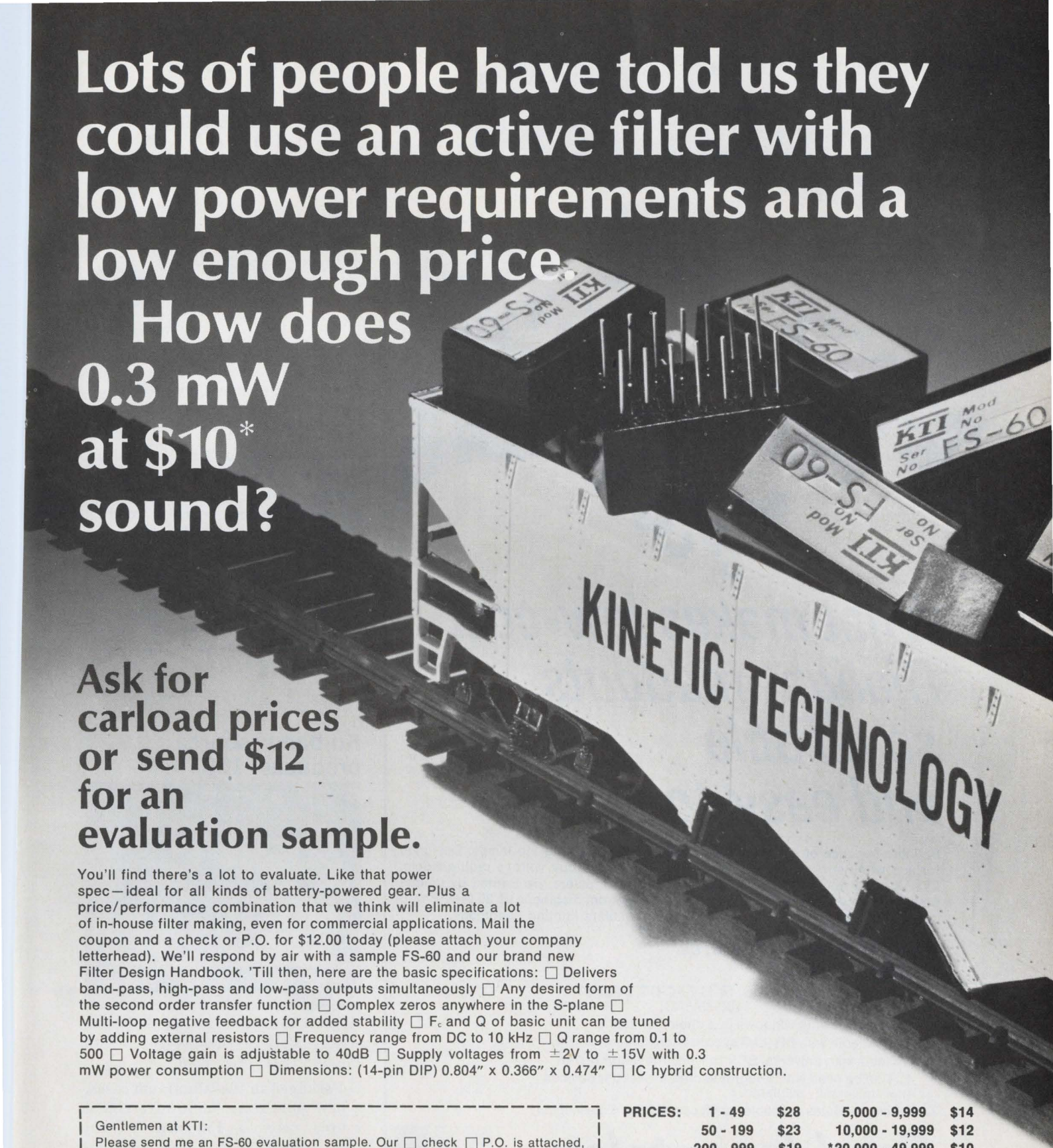
Operating directly from 12 V dc, a new series of X-band Gunn oscillators keep noise so low that balanced mixers are not required for noise cancellation. Fm noise in a 1-kHz slot, 10 kHz from the carrier, is 24 Hz, and is only 6 Hz when 100 kHz from the carrier. Thermal frequency stability is 30 kHz/°C and rf power varies from 5 to 50 mW.

CIRCLE NO. 354

INFORMATION RETRIEVAL NUMBER 126 ►

Lots of people have told us they could use an active filter with low power requirements and a low enough price.

How does 0.3 mW at $10* sound?



Ask for carload prices or send $12 for an evaluation sample.

You'll find there's a lot to evaluate. Like that power spec—ideal for all kinds of battery-powered gear. Plus a price/performance combination that we think will eliminate a lot of in-house filter making, even for commercial applications. Mail the coupon and a check or P.O. for $12.00 today (please attach your company letterhead). We'll respond by air with a sample FS-60 and our brand new Filter Design Handbook. 'Till then, here are the basic specifications: ☐ Delivers band-pass, high-pass and low-pass outputs simultaneously ☐ Any desired form of the second order transfer function ☐ Complex zeros anywhere in the S-plane ☐ Multi-loop negative feedback for added stability ☐ F_c and Q of basic unit can be tuned by adding external resistors ☐ Frequency range from DC to 10 kHz ☐ Q range from 0.1 to 500 ☐ Voltage gain is adjustable to 40dB ☐ Supply voltages from ±2V to ±15V with 0.3 mW power consumption ☐ Dimensions: (14-pin DIP) 0.804" x 0.366" x 0.474" ☐ IC hybrid construction.

Gentlemen at KTI:
Please send me an FS-60 evaluation sample. Our ☐ check ☐ P.O. is attached, in the amount $12.00. Send me more information on:
☐ FS-60 ☐ All active filters ☐ Hybrid subsystems
☐ Please add my name to your permanent mailing list

Name_____

Company_____

Address_____

City_____

State_____ ZIP_____

My applications are:_____

PRICES:			
1 - 49	$28	5,000 - 9,999	$14
50 - 199	$23	10,000 - 19,999	$12
200 - 999	$19	*20,000 - 49,999	$10
1,000 - 4,999	$16		

KTI

KINETIC TECHNOLOGY, INCORPORATED
3393 De La Cruz Boulevard
Santa Clara, California 95051
(408) 246-8100 TWX: 910-338-0279

The name to remember for Hybrid Integrated Systems and Active Filters . . .

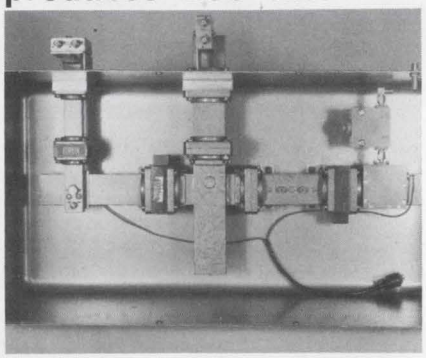
Fixed attenuators are flat to 0.2 dB

Narda Microwave Corp., Commercial St., Plainview, N. Y. Phone: (516) 433-9000. P&A: $85; stock.

A new series of fixed coaxial attenuators exhibit a flatness of ±0.2 or ±0.3 dB throughout the frequency range from dc to 12.4 GHz. Attenuation values for the 777C series include 3, 6, 10 and 20 dB. Maximum VSWR is 1.15 from dc to 6 GHz and 1.2 from 6 to 12.4 GHz. All units are bidirectional with type N stainless-steel connectors that meet the requirements of MIL-C-39012.

CIRCLE NO. 355

Ku-band source produces 150 mW



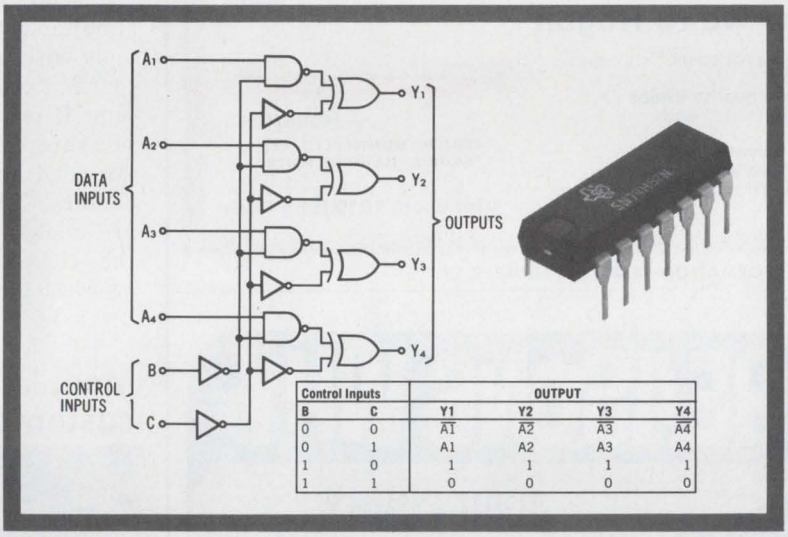
Applied Research Inc., 76 S. Bayles Ave., Port Washington, N.Y. Phone: (516) 883-5700.

Packaged in two aluminum cases, a new solid-state microwave signal source delivers 150 mW in Ku band. Model 503537 has five coherent outputs: a fundamental frequency of 1347.5 MHz, and second, fourth, sixth and twelfth harmonics of 2695, 5390, 8085 and 16,170 MHz, respectively. Output power is 15 and 150 mW for the fundamental, and 10, 75, 5, and 150 mW for the harmonics.

CIRCLE NO. 356

The Choice is TTL.

TI's new MSI arithmetic element. Add it to your adder...

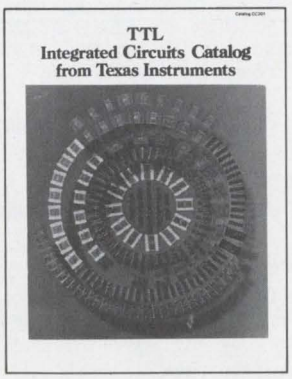


Control Inputs		OUTPUT			
B	C	Y1	Y2	Y3	Y4
0	0	$\overline{A1}$	$\overline{A2}$	$\overline{A3}$	$\overline{A4}$
0	1	A1	A2	A3	A4
1	0	1	1	1	1
1	1	0	0	0	0

and subtract four.

TI's new 4-bit true/complement element (SN54H87/SN74H87) replaces five IC packages usually necessary for arithmetic operations—a net saving of four packages or 40% of component costs.

This versatile MSI circuit allows you to perform arithmetic operations when used with a binary full adder. You can add, subtract, direct transfer (do nothing), or decrement (subtract) by manipulating the two control lines. And it's fast—typical propagation delay of 13 ns from data input to output.



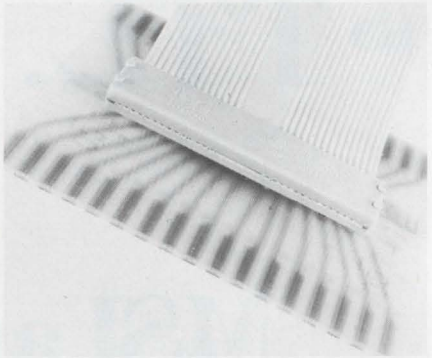
The 74H87 in plastic dual-in-line sells for $5.12 (100-999 quantities) and is ready for immediate delivery.

We've summed up the SN54H87/SN74H87 in a data sheet. To which we'll add a copy of our new 424-page TTL catalog containing data sheets on all Series 54/74 circuits. Circle 119 on the Reader Service Card, or write Texas Instruments Incorporated, P.O. Box 5012, M.S. 308, Dallas, Texas 75222. Or call your authorized TI Distributor.

TEXAS INSTRUMENTS
INCORPORATED

PACKAGING & MATERIALS

Transition connector handles 34 positions

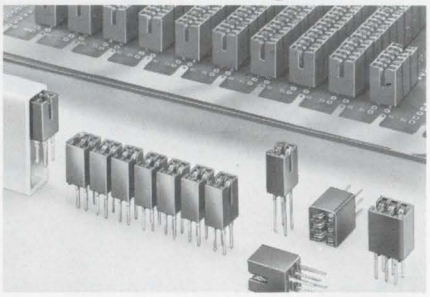


3M Co., 3M Center, Dept. E19-37, St. Paul, Minn. Phone: (612) 733-4962.

Interfacing up to 34 printed-circuit board positions to round-connector flat cable can be done simultaneously in less than 30 seconds with a new transition connector. Scotchflex 3402 uses self-stripping U contacts to make gas-tight pressure connections to AWG #28 stranded and AWG #30 solid conductors. Simultaneous transitions are made on 0.05-in. centers when the U contacts are forced down over the insulation.

CIRCLE NO. 357

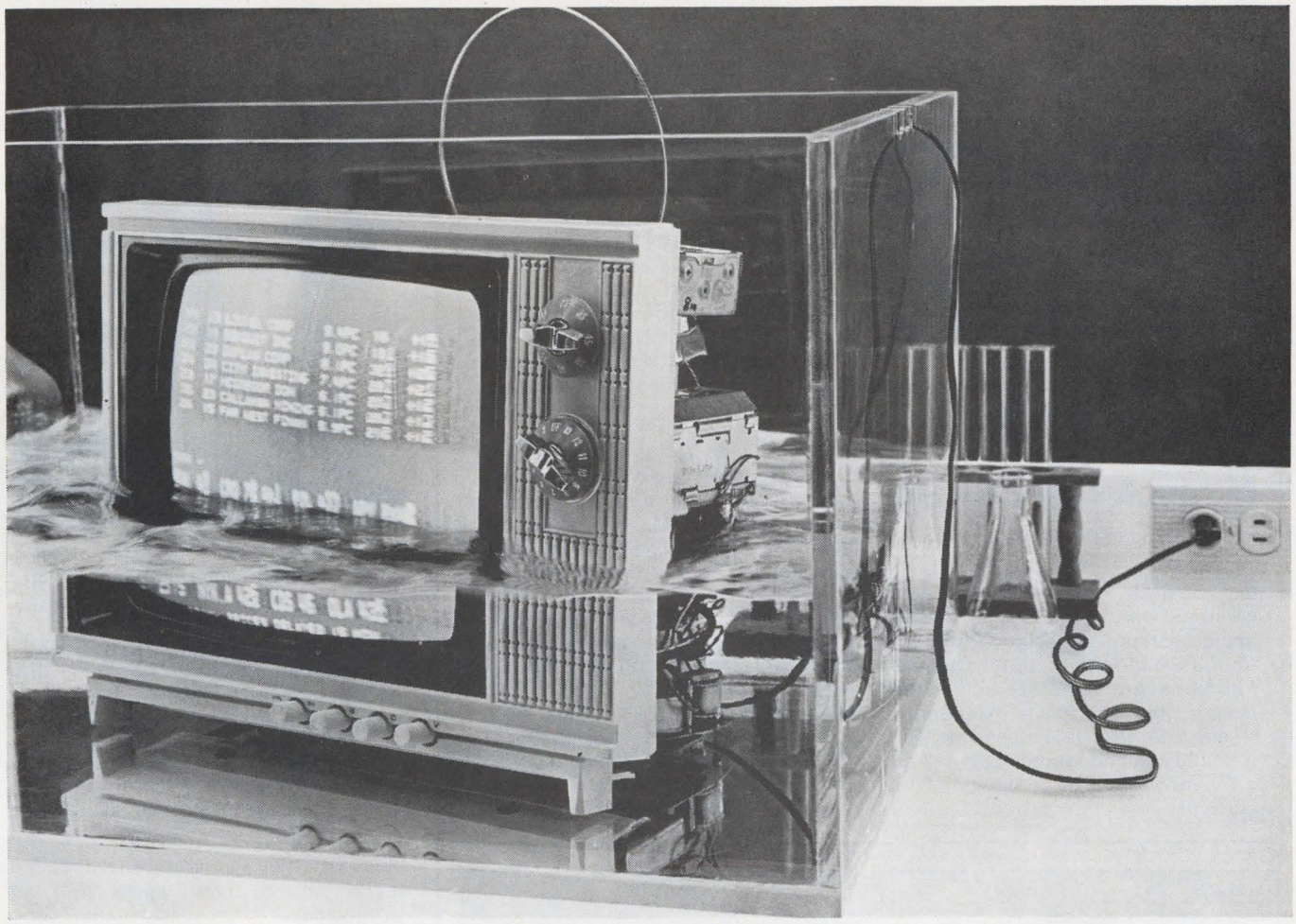
Modular connector customizes length



Methode Electronics, Inc., Connector Div., 7447 W. Wilson Ave., Chicago, Ill. Phone: (312) 867-9600.

Easily mounting with their press-fit terminations into the plated-through holes of printed-circuit mother boards, Reli-Amod modular edge-type connectors can be built-up to whatever length desired. End modules have four contact terminations, while center modules haxe six. Two 0.031-in-square wire-wrap termination lengths are available—0.375 and 0.595 in.

CIRCLE NO. 358



Our new dry test bath is getting a great reception

This should give you a pretty clear picture of what Fluorinert® Brand Electronic Liquids are all about.

They give you a dry test bath for temperature and gross leak testing of electronic and microelectronic units and integrated circuits. They detect flaws and leaks with great accuracy . . . and are efficient over a wide range of temperatures.

Fluorinert Liquids have high dielectric strength . . . which means you can safely test on-circuit. They do not react with the most sensitive of materials . . . which means you can test about anything.

Fluorinert Liquids drain clean, dry fast and leave no messy residue. You can use and ship units directly out of the test bath, without cleaning.

In fact, Fluorinert Electronic Liquids are now approved for the MIL-Standard 883 and the MIL-Standard 750A gross leak tests for microcircuits.

We have lots more information about this remarkable new test bath. The coupon will bring it all or call your local 3M representative.

Fluorinert® Electronic Liquids 3M
BRAND COMPANY

3M Company, Chemical Division, 3M Center
St. Paul, Minn. 55101

Dept. KAP 10-69

Send me all the details about Fluorinert Brand Electronic Liquids.

Name_____

Company_____ Title_____

Address_____

City_____ State_____ Zip_____

INFORMATION RETRIEVAL NUMBER 131

Diamond abrasive sprays on work

Starnetics Co., P.O. Box 9308, North Hollywood, Calif. Phone: (213) 769-8437. Availability: stock.

Packaged in an aerosol container, Diamant Spray MF is a diamond-abrasive material formulated with a novel chemical base that assures permanent stability and diamond particle suspension. Agglomeration is prevented by controlled reaction. The new spray will not clog in the presence of abraded metal and is now water and oil soluble.

CIRCLE NO 359

Industrial aerosols come in 20-oz cans

Bradford Industries, 100 Fordyce St., Dallas, Tex. Phone: (214) 741-5244. Price: $1.29 to $2.89.

Developed to assist in the manufacture, assembly, maintenance and repair of electronic and electromechanical equipment, more than twenty industrial aerosol chemical products are now offered in a 20-ounce container. Featured are electronic and mechanical production aids, special-purpose lubricants and cleaners, and safety products.

CIRCLE NO. 360

Emi/rfi gasketing doubles protection

Emerson & Cuming, Inc., Microwave Products Div., Canton, Mass. Phone: (617) 828-3300.

Containing a neoprene tubing insert to assure good compression and recovery characteristics as well as additional strength, Eccoshield SV tubing, type NI, is a flexible gasketing for the control of emi and rfi. The conductive tubing, which forms the outer part of the gasket, is a vinyl resin containing pure silver. Nominal outer diameters are 3/16, 1/4 and 5/16 in.

CIRCLE NO. 361

Heat-sink compound lubes thermal path

Transene Co., Inc., Route 1, Rowley, Mass. Phone: (617) 948-2501. Price: $3/lb.

Serving as a coupling agent to reduce thermal contact resistance, Xtherm is a thermally conductive heat-sink grease that is applied to the base and mounting stud of transistors, diodes and rectifiers. It contains alumina in a laminar crystallographic orientation dispersed in a special silicone base. The heat removed is often ten times better with Xtherm than with dry plate mountings.

CIRCLE NO. 362

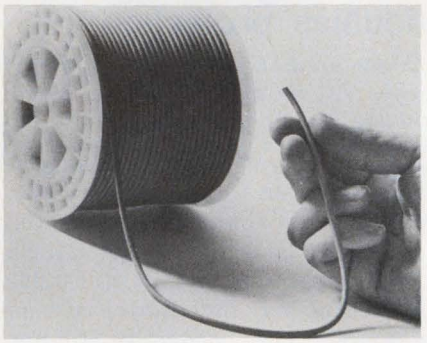
Non-woven tapes up mica content

General Electric Co., Insulating Materials Div., Schenectady, N. Y. Phone: (518) 374-2211.

Non-woven glass-reinforced Mica Mat tapes offer increased mica content per unit thickness to provide greater voltage life. Designed for temperature loads up to 155°C continuous operation, the tapes may be used in either ac or dc applications. They are not cross-weaved, resulting in improved flexibility.

CIRCLE NO. 363

Environmental gasket seals out rfi also



Chomerics, Inc., 77 Dragon Court, Woburn, Mass. Phone: (617) 935-4850.

Supplied on reels in unlimited lengths and standard cross-sections, a new non-corrosive strip gasketing provides both rfi and environmental sealing in a single structure. Available in both Cho-Seal and Cho-Sil materials, this strip gasketing exhibits a compression-deflection rating as high as 50% with 30 pounds per inch and a recovery above 85% after 70 hours at 100°C.

CIRCLE NO. 364

Carbon textiles resist 5000°F

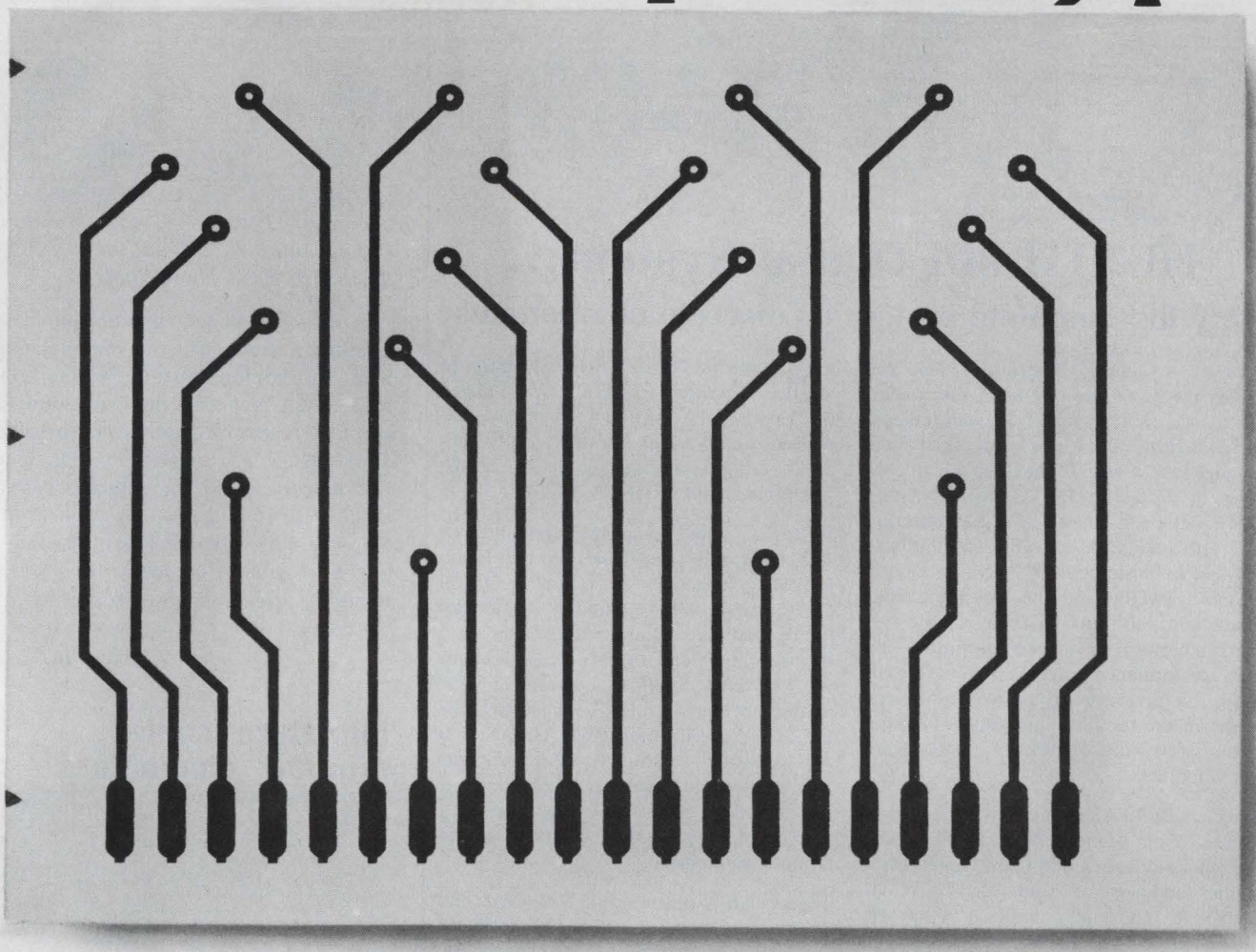
HITCO, Materials Div., 1600 W. 135th St., Gardena, Calif. Phone: (213) 321-8080.

Developed for numerous industrial applications requiring high-temperature textiles, a new complete line of fibers and fabrics will withstand temperatures up to 5000°F. Made of pure carbon or graphite, the fibers are available in various forms, such as roving, yarn, cordage, cloth in various weaves, sleeving, tapes, bulk fiber and felt. They are also completely inert and immune to attack from most chemicals.

CIRCLE NO. 365

INFORMATION RETRIEVAL NUMBER 135 ►

Introducing the 7½ minute prototype.



Getting prototype circuit boards used to be the biggest nuisance in design projects.

It took a lot of man-hours, expense, and a lot of space for bulky, awkward equipment.

No more. With Xerox Standard Equipment, chemical resist images can be transferred to copper-clad laminates and prepared for conventional etching—in 7½ minutes flat.

For just pennies per prototype.

And there are no wet, messy chemicals (the xerographic process is completely dry).

No air-controlled darkroom (the Xerox equipment can be set up in a small corner almost anywhere).

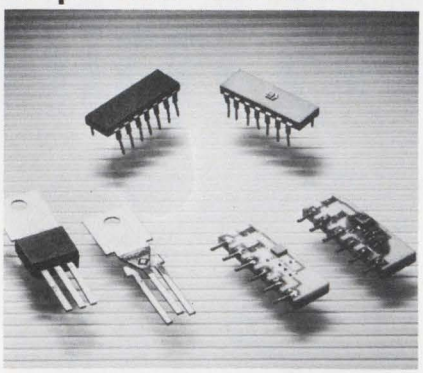
No need for highly-trained technicians (most people can learn to handle it in just 60 minutes).

Of course, the 7½ minute prototype is only one of the ways you can use Xerox Standard Equipment.

If you have another 7½ minutes, we'll explain some of the others. Write Dept. BC14, Xerox Corporation, Rochester, New York 14603.

XEROX

Plastics solvent strips and deflashes

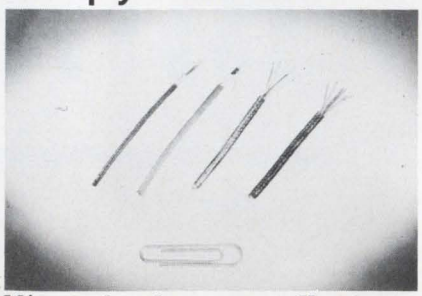


Dynalog, Inc., 7 Great Meadow Lane, Hanover, N.J. Phone: (201) 887-9270. Price: $10/quart.

A new reactive solvent for dissolving cured silicone compounds and anhydride cured compounds will not affect fragile interconnections or corrode metals. Unresolve Plus SG is a true solvent and does not merely swell the plastic. When used cold, it will remove flash from the leads of silicone and anhydride cured transfer-molded epoxies without affecting the properties of the part.

CIRCLE NO. 366

Miniature cables multiply conductors

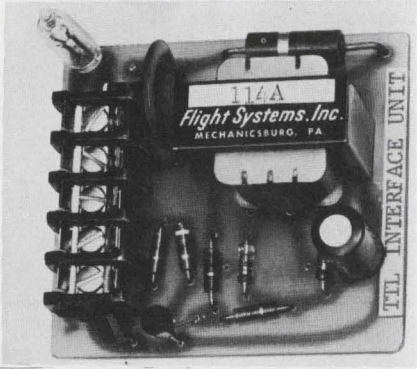


Microtech, Inc., 777 Henderson Blvd., Folcroft, Pa. Phone: (215) 532-3388. P&A: from 10¢/ft; stock.

A new line of miniature coaxial and multi-conductor cable is now available for high-density packaging applications and miniaturization demands in aerospace, medical, transducer, computer and IC applications. The line consists of two coaxial cables with maximum outer diameters of 0.06 and 0.078 in., and two multi-conductor cables of four and seven conductors with outer diameters of 0.11 and 0.12 in.

CIRCLE NO. 367

Line-to-logic unit is self-sufficient

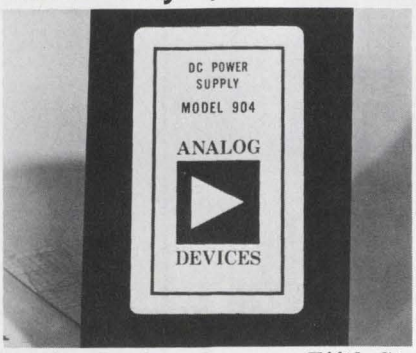


Flight Systems, Inc., P.O. Box 25, Mechanicsburg, Pa. Phone: (717) 697-0333. Price: $7 to $8.

Converting line-voltage command signals to TTL or DTL levels, a new interface unit does not need a dry circuit to operate. Its isolation of over 100 MΩ means sensitive logic-level circuitry will not be damaged and the input can be shorted without harm. Model 114A is all solid state, with no moving parts or light bulbs to wear out.

CIRCLE NO. 368

Stable supply costs only $39



Analog Devices, Inc., 221 Fifth St., Cambridge, Mass. Phone: (617) 492-6000. P&A: $39; stock.

Providing a dual output of ±15 V at 50 mA, a new plug-in modular power supply for operational amplifiers features a ±0.1% line and load regulation for a cost of only $39. Model 904 has a ripple of 0.5 V rms (2 mV pk-pk), an output impedance of 0.2 Ω at 10 kHz, and an input isolation of 500 MΩ shunted by 100 pF. The unit measures 3.5 by 2.5 by 0.88 in.

CIRCLE NO. 369

Miniature regulators supply up to 50 mA

Analog Equipment Corp., 18 Granite St., Haverhill, Mass. Phone: (617) 373-1501. Price: $5.25.

Supplying positive or negative regulated voltages from 18 to 28 V, a new series of miniature voltage regulators offers an output current capability as high as 50 mA. Series AE units use all-silicon semiconductors to provide a typical regulation of better than 0.5%. They are economical devices designed to operate over the temperature range of 0 to 70°C.

CIRCLE NO. 370

RZ GLASS

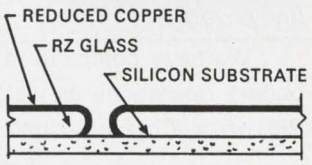
...the big news in sputtering targets...from Owens-Illinois

Owens-Illinois RZ Glass Sputtering Target is a NEW copper alumino-silicate glass readily sputtered on a silicon substrate. After sputter deposition, the RZ glass layer is etched to open up contacts to the silicon substrate. A simple oxidation-reduction process then produces *pure* copper conductive layers on the RZ glass, even in etched undercuts.

RZ glasses are ideal for making single or multilayer interconnections in medium or large-scale integrated circuits. The conductive layer is produced uniformly on RZ-coated substrates regardless of surface geometry.

You now have your choice of *three* sputtering targets from Owens-Illinois . . . 1. NEW RZ copper alumino-silicate, silicon-matching, 2. EE-9 alumino-silicate, silicon-matching, 3. EE-10 alumino-silicate, alumina and gallium arsenide matching.

All three are readily deposited at rates of 250 Å/minute with standard R.F. sputtering equipment, followed by simple etch when needed. A new manufacturing process holds the sodium content of these glasses below 20 ppm.



Owens-Illinois can supply targets promptly in lengths, widths, and thicknesses to fit your R.F. set-up and substrate dimensions. We'll work with you on materials to meet your special needs.

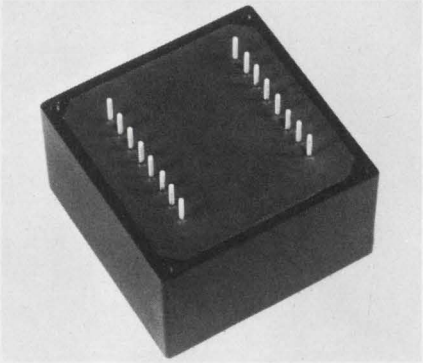
Complete data, specifications, and sputtering procedures developed in the Owens-Illinois microelectronics research labs will be sent to you promptly on request. Ask for information on these other O-I electronic materials: package sealants, substrate glazes and insulating films, preform materials, glazed IC packaged parts and substrates. WRITE TO:

THE O-I FAMILY OF WORK-TOGETHER ELECTRONIC MATERIALS.

OWENS-ILLINOIS
ELECTRONIC MATERIALS
Toledo, Ohio 43601

INFORMATION RETRIEVAL NUMBER 142

Compact servo op amp delivers 100 W at 5 A

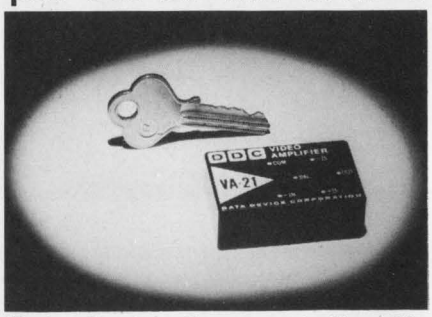


Control Systems Research, Inc., 614 Allegheny River Rd., Verona, Pa. P&A: $180; 1 to 2 wks.

Measuring 3-1/8 by 3-1/8 by 1-1/2 in., a new ac and dc servo operational amplifier can deliver a full 100-W output. Model PA-2 has a maximum output voltage of ±24 V at a maximum current of ±5 A. It also features adjustable current limiting, short-circuit protection, a dc-to-10-kHz bandwidth, low drift, over-temperature protection, and operation from nonregulated power supplies.

CIRCLE NO. 371

Fast data amplifiers put out 20 mA at 10 V



Data Device Corp., 100 Tec St., Hicksville, N.Y. Phone: (516) 433-5330. P&A: $65 to $75; stock to 3 wks.

Two new high-speed data amplifiers offer outputs of ±20 mA at ±10 V, 20-μV/°C voltage drift and 0.5-nA/°C current drift. Model VA-21 video amplifier provides a slewing rate of 750 V/μs, with a 12-MHz frequency for full output. Model FS-21 amplifier settles to 0.5% within 100 ns maximum. Both units operate over the temperature range of 0 to +70°C.

CIRCLE NO. 372

For maximum frequency stability, get Motorola oscillators.

Currently available in production or prototype quantities.

When the maximum in frequency stability is required, choose from Motorola's line of proportional ovenized precision oscillators. All are enclosed in an ovenized housing where the quartz crystal and its oscillator circuit are held to temperature changes of small fractions of a degree.

High Stabilities. To parts in 10^{-10} vs: environmental factors.

Wide Frequency Range. From 60 KHz to 20 MHz normal. Extended ranges available on special order.

Wide Temperature Range. From −55° C to +125° C.

Low Aging. Less than 5×10^{-10}/day.

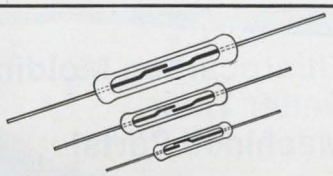
And if you need a non-standard oscillator, let us know your requirements. We'll design one specifically to meet your needs.

For complete information send for your free copy of Bulletin TIC-3401 today. Write Component Products Dept., Motorola Communications & Electronics Inc., 4501 W. Augusta Blvd., Chicago, Illinois 60651.

MOTOROLA

INFORMATION RETRIEVAL NUMBER 144

Picky! Picky!



HATHAWAY MICRO-MINIATURE, MINIATURE, AND INTERMEDIATE DRIREED SWITCHES

You bet we are! Some people wonder how we can consistently produce such high quality Drireed relays. The answer is testing, rigid quality control, and skilled personnel. Our reeds are good because we make them that way, and keep proving it to ourselves and to our users. Hathaway Drireeds go from pin-sized micro-miniatures up to heavy-duty intermediates. They all turn out giant-sized performance.

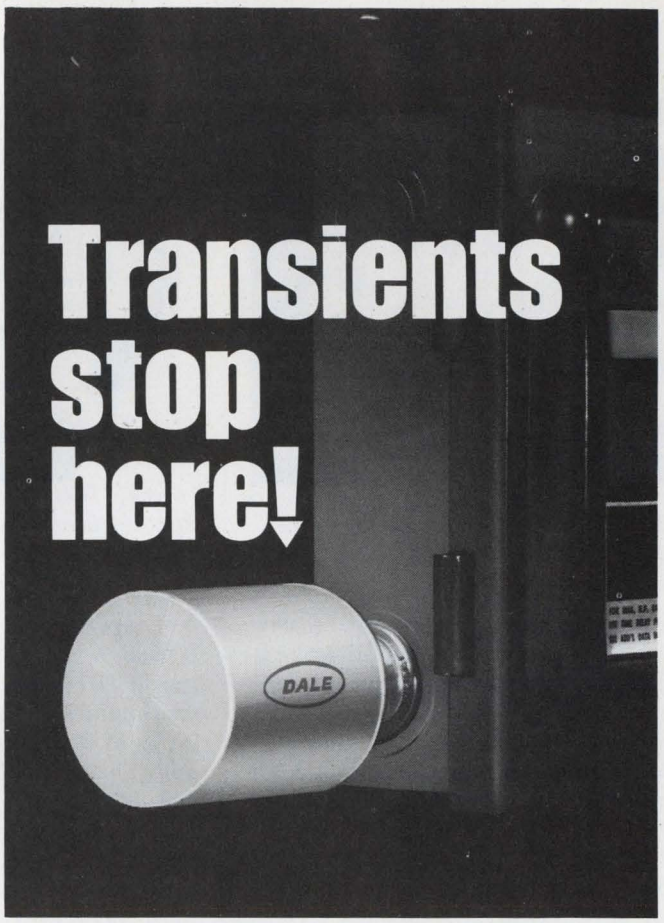
Send for our full line mini-catalog.

Address: 5250 East Evans Avenue, Denver, Colorado 80222, (303) 756-8301—TWX—910-931-0569.

HATHAWAY
components
A DIVISION OF HATHAWAY INSTRUMENTS, INC.

To buy less would cost you more

INFORMATION RETRIEVAL NUMBER 145



New Dale Arrester Provides Reliable, Low-Cost Surge Protection

Dangerous transient voltages get nowhere when you put Dale's new Surge Protector in their path. For a few dollars, this new design provides the best insurance you can buy against damage from direct lightning strikes, and from transients induced by lightning and switching. Here are just a few of its advantages over other low-cost protectors:

SENSITIVITY Typical breakdown voltage is 1500 volts when subjected to a voltage pulse rising at 10 kv/μsec. Power-follow current is extinguished within ½ cycle or less.

REPEATABILITY Will bypass repeated overvoltages without significant change in breakdown level.

It's weatherproof, mounts anywhere, meets all applicable NEMA, USAS and IEEE standards. For a few bucks, it can save you a bundle. Write for complete information.

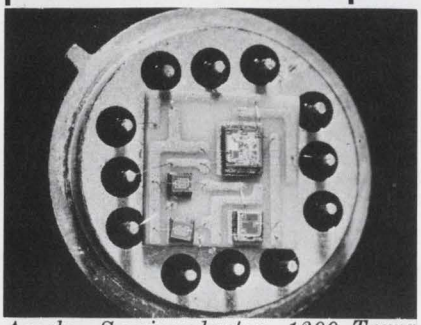
DALE®

DALE ELECTRONICS, INC.
SIOUX DIVISION Dept. ED
Yankton, South Dakota 57078
A subsidiary of The Lionel Corporation

Producers of: Toroids, Series Resonant Traps, Variable Pitch Inductors, Miniature High Frequency Inductors, Degaussing Coils, Industrial and Military Coils, Subminiature Coils, Surge and Lightning Arresters, Custom Assemblies, Motor Driven Potentiometers.

INFORMATION RETRIEVAL NUMBER 146

High-impedance op amp presents 10^5-MΩ input

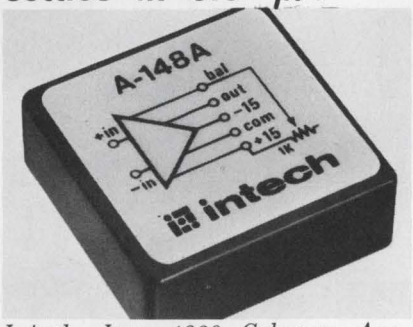


Amelco Semiconductor, 1300 Terra Bella, Mountain View, Calif. Phone: (415) 968-9241. Price: $22.

With bias and offset currents of 40 and 15 pA respectively, a new hybrid operational amplifier exhibts an input impedance of 10^{11} Ω. Model 2741 has a power dissipation of 50 mW, internal 6-dB/octave frequency compensation, high gain and low common-mode rejection. The unit can offset external voltages and is short-circiut proof. It is available in either a flatpack or in a TO-8 can.

CIRCLE NO. 373

FET-input op amp settles in 0.6 μs

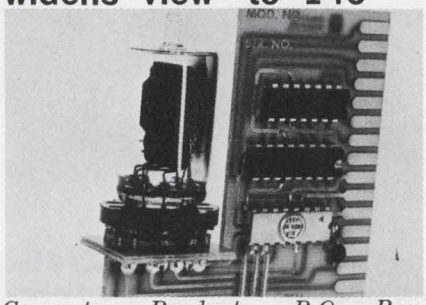


Intech, Inc., 1220 Coleman Ave., Santa Clara, Calif. Phone: (408) 244-0500. P&A: $40 to $50; stock.

Designed with an FET input, a new operational amplifier has a typical settling time of 0.6 μs to reach 0.01% of final value and a maximum settling time of 1 μs to 0.1% of final value. Series A-148 units have a 25-pA bias current and a 10^{11}-Ω input impedance. Minimum slewing rate is 50 V/μs and minimum gain is 50,000. Temperature coefficients range from 15 to 50 μV/°C.

CIRCLE NO. 374

Bright readout module widens view to 140°



Computer Products, P.O. Box 23849, 2709 N. Dixie Highway, Fort Lauderdale, Fla. Phone: (305) 565-9565. P&A: from $35.90; 1 to 5 days.

Using a seven-segment side-viewing readout tube, a new decimal mounting and display module series has a 140° viewing angle with enough brightness to be viewed in direct sunlight. Series DM-600 modules are driven by an MSI BCD-to-seven-segment decoder/driver circuit. They offer variable brightness control and TTL/DTL input/output compatibility.

CIRCLE NO. 375

circuit problems?

Signalite Glow Lamps have solved problems in these areas:

• Voltage Regulation & References • Photo-Cell Drivers • SCR Triggering
• Timing • Photo Choppers • Oscillators • Indicator Lights • Counters
• Voltage Dividers • Surge Protectors • Logic Circuits • Flip-Flops
• Memory • Switching • Digital Readouts

Signalite glow lamps combine long life, close tolerance and economy, and are manufactured with a broad range of characteristics to meet individual application requirements. For a creative approach to your design problem . . . contact Signalite's Application Engineering Department.

ULTRA HIGH LEAKAGE RESISTANCE. Devices with leakage resistance in excess of 10^{12} ohms are available for circuits requiring this property. Such applications would include sample and hold for A to D conversion, and capacitor memory systems.

SEE Signalite Application News for TYPICAL APPLICATIONS

PHOTO-CELL APPLICATIONS The A074 and A083 have been designed for use with Cadmium Sulfide or Cadmium Selenide photocells. Applications include photo choppers, modulators, demodulators, low noise switching devices, isolated overload protector circuits, etc. Speed of operation is limited only by the photo-cells.

SEE Signalite Application News for TYPICAL APPLICATIONS

SIGNALITE APPLICATION NEWS

is used to communicate new and proven techniques and applications of Signalite's neon lamps and gas discharge tubes. Signalite Application News provides a forum for an exchange of ideas to keep the design engineer aware of the versatility of neon lamps and their many applications. Copies are available from your Signalite representative or by contacting Signalite.

circle 149

VOLTAGE REGULATORS BETTER THAN 1% ACCURACY These subminiature voltage regulators are used in regulated power supplies, as reference sources, photomultiplier regulators, oscilloscopes calibrators, etc. They are available in voltages from 82 to 143 V. They are used in multiples as regulators in KV ranges.

See Signalite Application News for TYPICAL APPLICATIONS.

NEON TIMERS The bi-stable characteristics and high leakage resistance of Signalite's special glow lamps make them ideal as a component for timing circuits. The basic circuit resembles a relaxation oscillator network.

SEE Signalite Application News for TYPICAL APPLICATIONS

Signalite

INCORPORATED

NEPTUNE, NEW JERSEY 07753

(201) 775-2490

A General Instrument Company

313

INFORMATION RETRIEVAL NUMBER 150

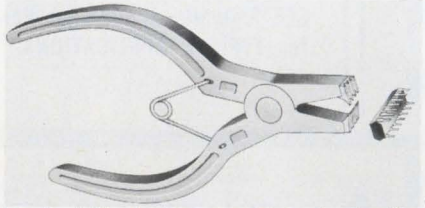
Automatic cutter trims wire plus

Compton Industries, Inc., 413 Commerce Rd., Vestal, N. Y. Phone: (607) 729-9221. Price: from $495.

Working to a tolerance of 3% for diameters up to 3/16 in., a new automatic cutter will trim insulating sleeving, bare-wire jumpers, wicks, solder, braided wires, fiberglass and teflon tubing, and wires from AWG #18 to #50. Merely changing Com-Tek's dial setting or flipping its multiplier switch allows the length of the pieces cut to be changed while the unit is in operation.

CIRCLE NO. 338

DIP extractor ends bent leads



Techni-Tool, Inc., 1216 Arch St., Philadelphia, Pa. Phone: (215) 568-4457. P&A: $12.95; stock.

Part of second-generation tooling, a new DIP extractor plier removes the package straight up out of the board without bending any leads. Type 4916 handles dual-in-line packages with 14, 16, 24 and 36 leads. It has metal teeth and a self-closing molded body. The new tool simplifies removal, is safe to operate and will not lift up socket pads.

CIRCLE NO. 339

New Plug-In Timer with Spider Clutch provides ¼ of 1% repeat accuracy

Spider is the name of our revolutionary clutch which provides our new Series GP Plug-in Timers with ¼ of 1% repeat accuracy.

The patented Spider Clutch, an exclusively new feature of Series GP, incorporates the high accuracy of infinite engagement clutches with the mechanical integrity of toothed clutches. The Spider insures non-slip repeat accuracy that's unequalled by any other positive engagement, motor-driven timer.

Series GP is completely interchangeable with most of today's widely used plug-in type delay/interval timers. Priced as low as $29.10 (500-999 units). For additional information, ask for bulletin 310. Call 201-887-2200.

SINGER

INDUSTRIAL TIMER CORPORATION

U.S. HIGHWAY 287, PARSIPPANY, N.J. 07054

INFORMATION RETRIEVAL NUMBER 153

FREE CATALOG!

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1000's OF UNUSUAL BUYS FOR INDUSTRY

Many on-the-job Helps . . . Quality Control Aids! Write for this completely new, 1970 Catalog. New items, new categories, new illustrations, 148 easy-to-read pages packed with hundreds of charts, diagrams, illustrations. A treasure-house of optical and scientific information . . . unusual bargains galore. Optics for industry, research labs, design engineers, experimenters, hobbyists! Instruments for checking, measuring — to speed work, improve quality, cut production costs. We give you facts: what it is — how it works — where it's used.

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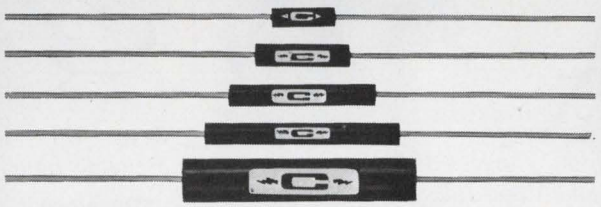
INFORMATION RETRIEVAL NUMBER 154

MINIATURE MEGOHM RESISTORS



T.C. Absolute: 80 PPM/°C*
T.C. Tracking: to 5 PPM/°C on special order.

Applications include high voltage dividers, high resistance networks, precision RC timing circuits, etc. We specialize in network sets with matched characteristics. Facilities available to perform Hi Rel screening.

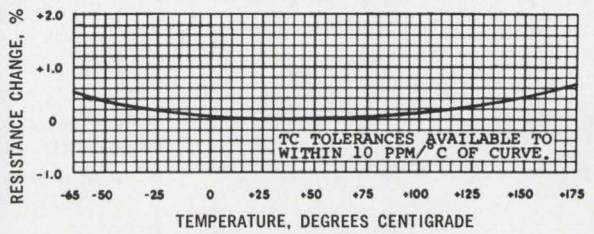
Model No.	Wattage	Max. Voltage	Dielect. Str'gth	Resistance Min.	Resistance Max.	Dimensions Length	Dimensions Dia.	Dimensions Lead Dia.
MH 651	.5	600	750	500 K	5 meg.	.313 ±.020	.094 ±.006	.025 ±.002
MH 661	.6	1000	2000	1 meg.	10 meg.	.500 ±.030	.114 ±.010	.025 ±.002
MH 681	.8	1500	2000	1 meg.	15 meg.	.750 ±.030	.114 ±.010	.025 ±.002
MH 713	1.0	2000	2000	1 meg.	20 meg.	1.000 ±.030	.114 ±.010	.025 ±.002
Type MH with special internal shielding, designed to eliminate degradation due to corona								
MH 711	1.0	2000	2000	1 meg.	20 meg.	1.200 ±.040	.220 ±.015	.025 ±.002

***Temperature Coefficient:** 80 ppm/°C referenced to 25°C, Δ R taken at −15°C and +105°C. **Maximum operating temperature:** 175°C. **Resistance Tolerance:** ±1% (tolerances to .2% on special order). **Insulation Resistance:** 100 megohms, minimum. **Overvoltage:** 1.5 times working voltage for 5 seconds, R shift .8% max. **Thermal Shock:** MIL-STD-202, method 107, cond. C, R shift .5% max. **Moisture Resistance:** MIL-STD-202, method 106, R shift .8% max. **Loadlife:** 1000 hours at rated power, R shift .8% max. **Encapsulation:** Molded Silicone. **Leadwire:** Gold Plated Dumet 1½" long ±⅛".

MICRONOX™ Resistance Films

Micronox resistance films are produced exclusively by Caddock Electronics. They are composed of complex oxides fired in air at temperatures above 1400°F. The resulting films are relatively insensitive to high ambient temperatures and thermal shock. Films show negligible effect from moisture.

This totally new approach to precision resistors and networks opens new design possibilities because of the wide resistance range, precise temperature characteristics, and high temperature and power capability. Temperature coefficient can be accurately reproduced (within ±10 ppm/°C of curve if required). The typical curve shown below will vary slightly with resistivity of the film and configuration of the substrate.

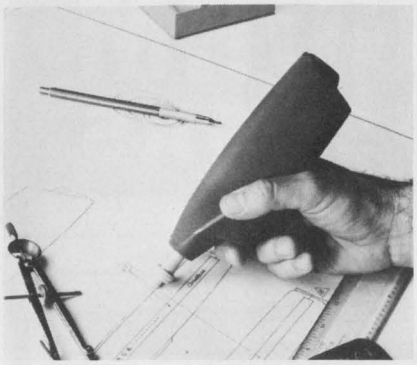


CADDOCK ELECTRONICS

3127 Chicago Avenue, Riverside, California 92507 • (714) 683-5361

INFORMATION RETRIEVAL NUMBER 155

Electric eraser eliminates cord



Pierce Corp., Instrument Div., Mound View Rd., River Falls, Wis. Phone: (715) 425-6761.

Hailed as an industry first, a new cordless electric eraser is now available for engineering draftsmen, architects, designers and general office use. The compact rechargeable unit offers excellent mobility and ease of handling, besides being lightweight and shockproof. The erasing unit rests on a charging console when not in use, similar to an electric shaver.

CIRCLE NO. 376

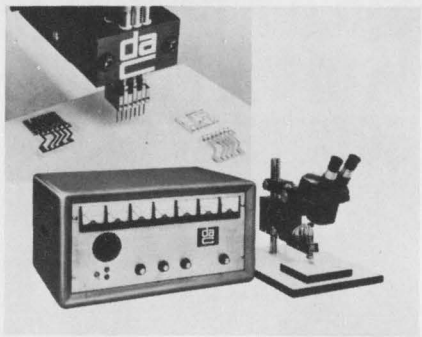
Soldering tip tinner eliminates corrosion

Zeva Electric Corp., 3 Great Meadow Lane, Hanover, N. J.

Developed for high-heat high-volume production soldering, a new non-toxic tip tinner for soldering irons contains no acid-type fluxes, thus eliminating corrosion on the tip, on the soldering connections, and even on neighboring parts. This new product is intended to replace costly dip tinning operations for iron-clad long-life soldering tips. It comes in rolls of 10 cans weighing approximately 3/4 oz each.

CIRCLE NO. 377

Lead frame solderer bonds in under 1 s

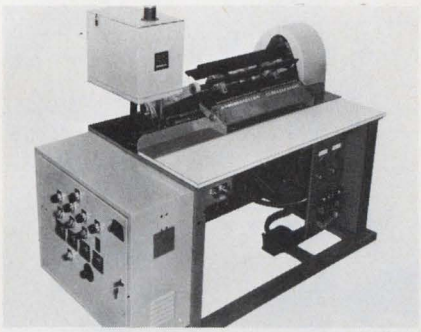


Development Associates Control, 725 Reddick Ave., Santa Barbara, Calif. Phone: (805) 963-3708. P&A: $5000 to $7500; 45 to 60 days.

A new reflow soldering system for the attachment of lead frames to ceramic substrates completes bonding of all leads in less than one second. The system consists of a multi-probe soldering head, a multiple-output power supply and a set of optics. The probes are quickly replaceable by a single set screw for ease of maintenance.

CIRCLE NO. 378

Coating machine does small components

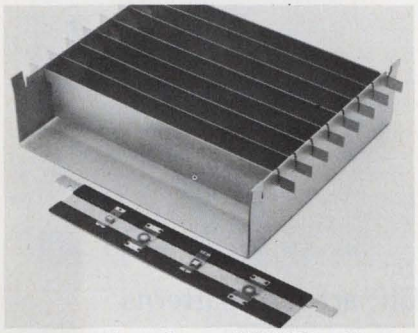


English Electric Corp., Badalex Group, One Park Ave., New York City. Phone: (212) 679-3522. P&A: $11,000; 4 to 6 months.

A new component-coating machine, which uses the fluidized bed principle, provides a truly conformal coating with recycling possibilities. Model CC3 is primarily intended for the epoxy-resin coating of radial-lead components such as small printed circuits, capacitors and resistors. An unskilled operator can turn out 15,000 units per hour.

CIRCLE NO. 379

IC transfer system uses magnetic strips

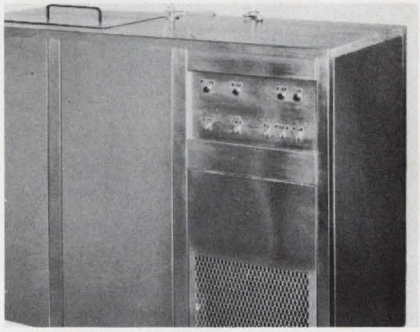


Macronetics, Inc.. EXTEL Manufacturing Div., 220 California Ave., Palo Alto, Calif. Phone: (415) 321-1744. Price: $15.25 to $26.60.

Model 90 magnetic transfer system for flatpacks and DIPs expedites efficient in-plant handling of these devices during processing and station-to-station transportation. The new system consists of slotted stackable trays that accommodate up to nine anodized aluminum blades with bonded magnetic-rubber strips.

CIRCLE NO. 380

Ultrasonic degreasers multiply cleaning power

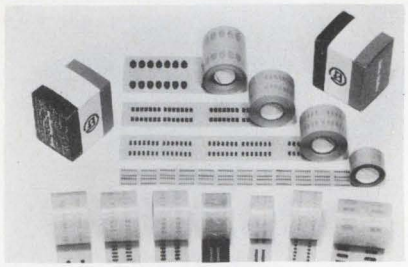


Crest Ultrasonics Corp., Scotch Rd., Mercer County Airport, Trenton, N.J. Phone: (609) 883-4000.

Packing a five-stage cleaning cycle and multi-frequency cleaning power within a single machine, a new line of ultrasonic vapor degreasers increase productivity as well as cleaning efficiency. CDU cleaners use a special titante alloy transducer bonded in metal to simultaneously generate a wide band of ultrasonic frequencies, 20 through 90 kHz, within the cleaning chamber.

CIRCLE NO. 381

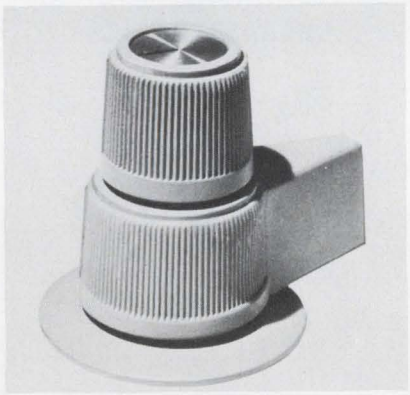
Evaluation Samples



DIP artwork patterns

Designed for high-density printed wiring patterns where conductor paths and spacing tolerances are critical, a new line of 14- and 16-lead dual-in-line-package (DIP) artwork patterns provide accuracies to 0.002 in. They conform to MIL-STD-275 and Institute of Printed Circuit guidelines, and are printed on 1.5-mil pressure-sensitive matte acetate. The new patterns are also available in compatible transparent red and blue for making master artwork for two-sided printed wiring boards in which perfect registration is achieved by photographic separation of the different-colored circuit patterns. Bishop Graphics, Inc.

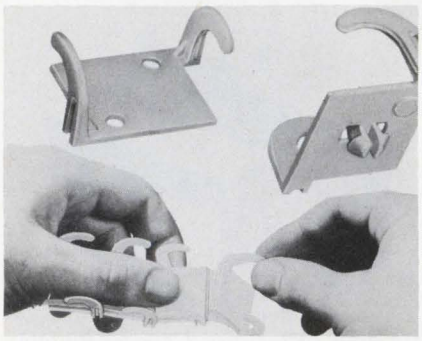
CIRCLE NO. 382



Instrument knobs

Dual concentric instrument knobs are now available as free evaluation samples to suit specific control needs. Choose from ten standard colors and three different shaft sizes (to accommodate shaft diameters of 1/8, 3/16 or 1/4 in.). In addition, there is a variety of skirts, flanges, and decorative caps. Aluminum inlays can be provided in colors and with index marking. Kentron Corp.

CIRCLE NO. 383



Non-binding cable clamp

Called the Cable Keeper, a new molded nylon cable clamp eliminates the problem of binding, common with the usual type of clamp. It is particularly suitable in applications where binding causes a change in impedance. The novel double-half-loop design holds cable securely yet does not cut into the insulation. Cable Keeper is supplied in three styles, each with a different mounting method. A free sample is available. Weckesser Co., Inc.

CIRCLE NO. 384

Durable nameplates

Adding a new dimension to heavy-duty permanent nameplates is Durashield, an embossable nameplate using high-strength adhesive. The nameplate's printing is protected against weather, abrasion and chemicals beneath a clear shield of five-mil polyester film. Durashield is designed for use as decorative nameplates, serial plates, instructional markings or gauge plates for outdoor as well as indoor use, on flat or simple curved surfaces. It comes in roll form or in individual sheets. Free samples are available. Avery Label Co.

CIRCLE NO. 385

INFORMATION RETRIEVAL NUMBER 163 ►

Introducing a little revolution in fail-safe reed switching.

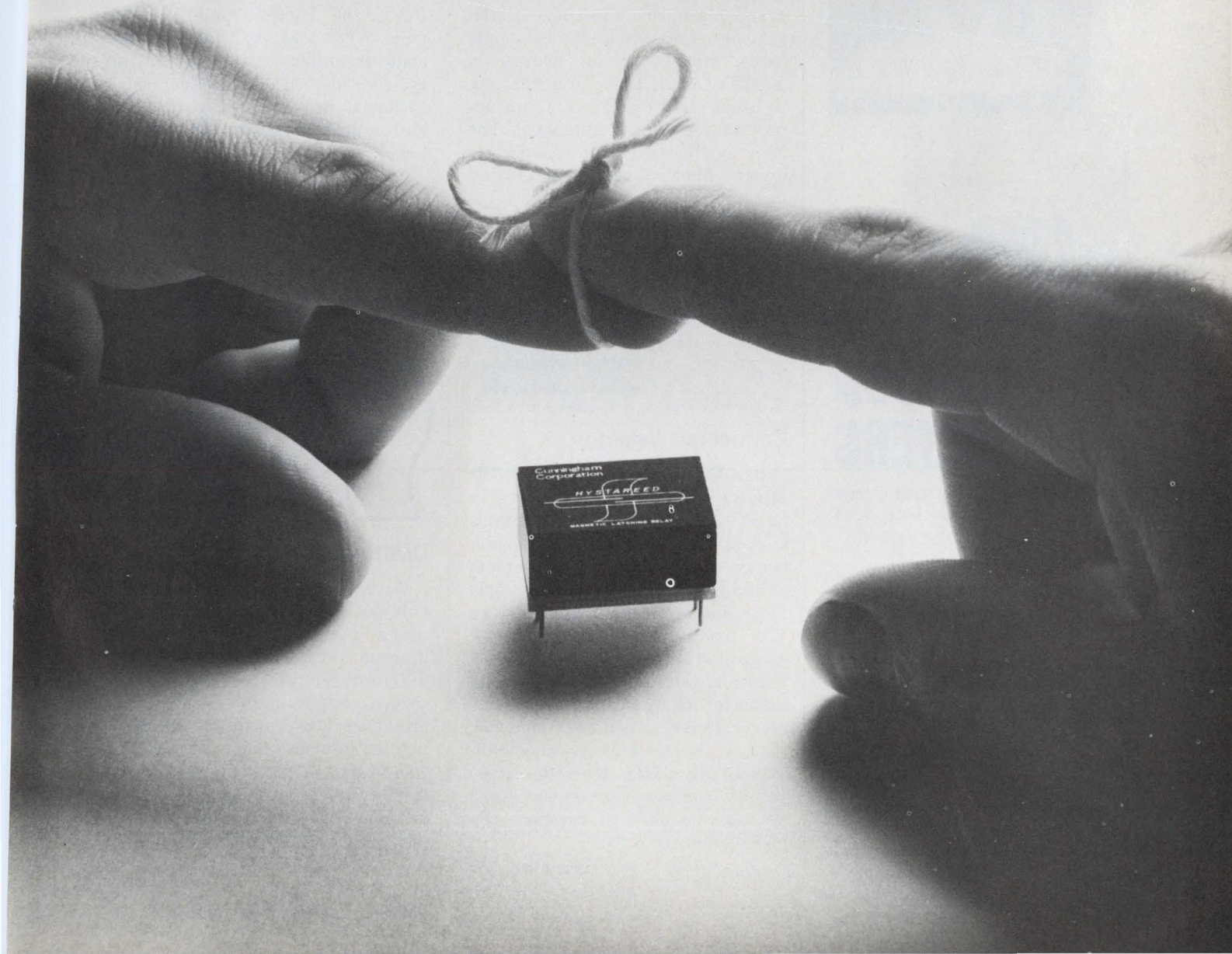
This new Cunningham Hystareed™ Magnetic Latching Relay operates *without permanent biasing magnets* or holding currents. Latches and stays latched. Won't change its programmed state because of vibration, shock, power interruptions or transients. Needs no adjustment or calibration. Available up to 6 form A's, 4 form C's in a single assembly. Operates as standard relay for scanning.

Ideal for: data acquisition, low-level switching, computer interfacing, logic control, industrial machinery control.

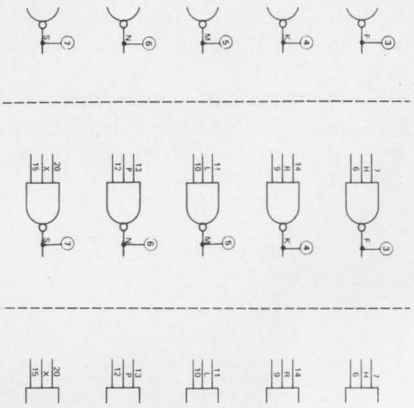
Samples available. For complete facts, request Brochure No. 606B. Write or phone Cunningham Corporation, Carriage St., Honeoye Falls, N.Y. 14472. Phone (716) 624-2000.

Cunningham Corporation

SUBSIDIARY OF GLEASON WORKS



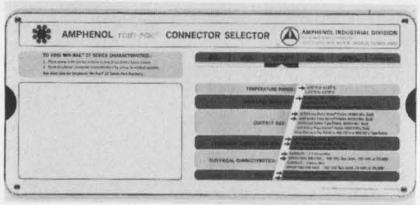
Design Aids



Logic aids

Standard logic symbols, for use as engineering and drafting design aids when detailing TTL and DTL cards, eliminate the need for the engineer or draftsman to draw symbols by hand on his logic diagram. Since each sheet has enough symbols for three typical logic cards, time-consuming errors in using a circuit twice or forgetting to use a circuit and adding an unnecessary card are eliminated. The logic symbols are printed on clear mylar film. Wyle Laboratories, Computer Products Div.

CIRCLE NO. 386



Connector selector

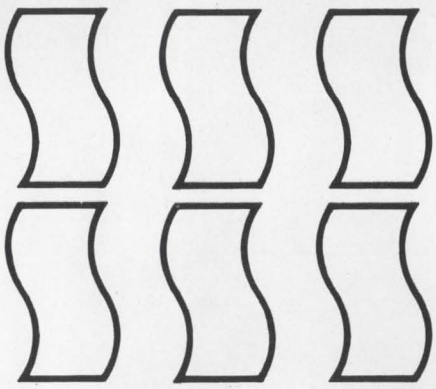
Besides cataloging Amphenol's Min-Rac series 17 connectors, a handy connector slide rule contains a complete competitive part-number cross-reference in a convenient vertical format. The user simply picks out one of six family types (i.e. fixed contact, high density, encapsulated contact, hard dielectric) and then reads pin-and-socket connector characteristics. Temperature range, insulator material, contact size, and electrical specifications are shown. For added versatility, the new connector selector can also be used in reverse. Amphenol Industrial Div.

CIRCLE NO. 387

French curve set

Normally retailing for $1.50, a set of three French curves is now available free to readers of ELECTRONIC DESIGN. Designated No. FC-3, the curves range in size from 5-1/2 to 12-1/2 in. They are made from 0.09-in.-thick green-tint eye-ease molded plastic. Each set is packaged in a durable vinyl snap-button protective case. Alvin & Co., Inc.

CIRCLE NO. 388



Drafting aids

Covering data processing symbols to BS 4058, a new line of drafting aids also includes PERT diagram symbols and work flow diagram symbols, as well as consecutive letters and numbers. There are over 180 symbols available printed in black or five other colors. They are printed on 0.0012-in.-thick transparent matt surface, and are suitable for dye-line printing photography. Circuitape Ltd.

CIRCLE NO. 389

INFORMATION RETRIEVAL NUMBER 165 ►

One for the road.

417-the lightweight recorder for heavy duty field use

Hit the road with the rugged, portable Lockheed 417. Take it where the data is—around the plant, around the lab, around the campus or around the world.

Weight: only 28 lbs. with battery—50 lbs. under any comparable recorder. Measures 14″x15″x6″ (fits under a plane seat).

Runs on 110/220v AC/DC or internal battery. Power consumption as low as 10w.

Accuracy matches large rack machines. Has phaselock servo for precise speed control. Records on 7 channels, IRIG compatible.

Tagged as low as $7,000.

Exclusive low-mass differential capstan drive gives precision recording even in rough field conditions. Simplified, maintenance-free mechanism works under vibration and in any position.

Frequency response: 100 kc direct, 10 kc FM.

Send for our catalog containing full details on the 417—one of a family of precision data recorders for land, ocean, air and space application. Write: Boyd McKnight, Dept. ED-100, Lockheed Electronics Company, Edison, New Jersey.

Have questions on data recording? Call (201) 757-1600.

LOCKHEED

Lockheed Electronics Company. A Division of Lockheed Aircraft Corporation

Annual Reports

Learn how to read annual reports in "How to investigate a company." For a copy, circle no. **474.**

CCI Marquardt Corp., 4111 S. Darlington Ave., Tulsa, Okla.: aerospace technology, transportation, materials handling; sales, $103,917,000; earnings, $3,727,000; assets, $48,110,000; liabiilties, $11,701,000.

CIRCLE NO. 390

Franklin Electric Co., Bluffton, Ind.: submersible and electric motors, food packaging systems, wrapping machines; net earnings, $1,482,652; net sales, $26,697,588; assets, $12,322,142; liabilities, $2,501,274.

CIRCLE NO. 391

KDI Corp., 5721 Dragon Way, Cincinnati, Ohio: computer terminals, education, recreation and environmental systems; sales, $30,542,586; income, $2,112,410; assets, $19,445,436; liabilites, $8,268,233.

CIRCLE NO. 392

New Hampshire Ball Bearings, Inc., U.S. Route 202, Peterborough, N. H.: all types of ball bearings; sales, $12,498,000; income, $149,000; assets, $15,334,000; liabilities, $5,976,000.

CIRCLE NO. 393

Potter-Englewood Corp., 5801 S. Halsted St., Chicago, Ill.: capacitors, filters, machine tool gages, distribution; sales, $36,076,439; income, $464,943; assets, $10,291,584; liabilities, $4,962,976.

CIRCLE NO. 394

Veeco Instruments, Inc., Terminal Drive, Plainview, N.Y.: high-vacuum technology, power supplies; sales, $19,408,885; income, $1,091,299; assets, $13,022,352; liabilities, $5,368,187.

CIRCLE NO. 395

80 MHz WIDEBAND RF POWER AMPLIFIER

MODEL RF-805

- 10 Watts Output into 50Ω
- 0.1 Volts In — 22.5 Volts Out
- .05 MHz to 80 MHz Broadband
- Low Distortion
- Solid State
- Flat 47 db Gain

The RF-805 is a solid state amplifier, broadband from .05 to 80 megahertz, which produces ten watts with —30 db harmonic and intermodulation distortion. Lower distortion is available at lower output levels. Gain is 47 db minimum, constant within 1 db, so that full output is developed with less than 0.1 volt at the 50 ohm input. Accurate output metering and overload protection is provided.

The RF-805 will raise the power of most manual and swept tuned signal generators and thus extend the usefulness and versatility of available signal generators. Receiver testing, wattmeter calibration, antenna testing, RFI testing, attenuator measurements, and filter and component testing will be aided with the use of this equipment.

R F COMMUNICATIONS, INC.
1680 University Avenue • Rochester, N. Y. 14610

INFORMATION RETRIEVAL NUMBER 167

Fast? Fast! Nanosecond fast? Faster!

No question about it.
Computer Labs HS Series
A/D converters are fast.
Aperture time as short
as 0.2 nanosecond!
Word rates vary from
4 bits at 25 MHz
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Even delivery is fast!

COMPUTER LABS
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Greensboro, N. C. 27403

INFORMATION RETRIEVAL NUMBER 168

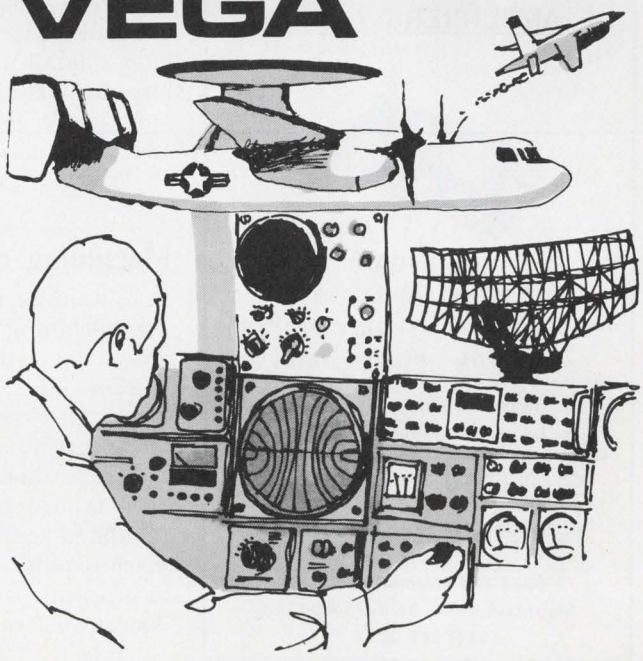
the latest advanced phase coherent transponder

MODEL 333C

The Vega Model 333C Pulse Coherent Transponder is an extremely compact, lightweight and accurate unit used with C-Band tracking radars designed to extract doppler information from the return pulse. The transponder is compatible with the modified AN/FPS-16 and the FPQ-6 radars and may also be used in a non-coherent mode with unmodified radars. With a volume of less than 97 cubic inches and weight of less than 5¼ pounds, the transponder features a high performance superheterodyne receiver with a solid triggering sensitivity of at least –65 dbm and a minimum power output of 100 watts.

Vega Precision Laboratories, Inc.,
239 Maple Avenue W., Vienna, Virginia 22180
Phone: (703) 938-6300

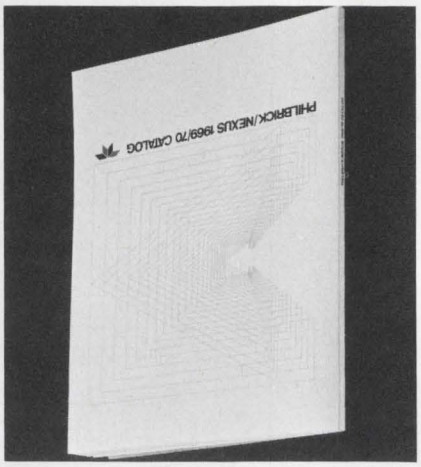
VEGA



INFORMATION RETRIEVAL NUMBER 169

INFORMATION RETRIEVAL NUMBER 170

Application Notes



Op amps plus

A 100-page illustrated catalog features a complete selection of operational amplifiers, nonlinear function modules, instruments, boosters, power supplies, regulators and accessories. Given are selection guidelines, suggested applications, and user parameter definitions. Philbrick/Nexus Research, a Teledyne Co.

CIRCLE NO. 396

Electron analysis

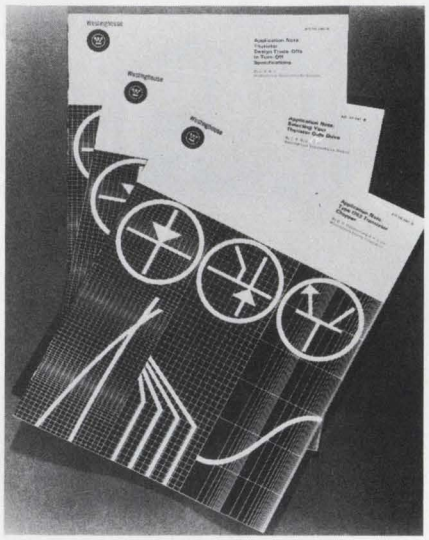
A 14-page comprehensive set of application notes, "The Use of Copper Beryllium Electron Multipliers to Detect Ions, Neutral Particles, Electrons and Photons," is now available. The booklet not only includes detailed curves and data, but also an extensive compilation of references. Johnston Laboratories, Inc.

CIRCLE NO. 397

Machining manual

Containing practical suggestions for machining copper, brass, bronze and nickel silver, a new 36-page edition of "Machining Coppermetals"discusses cutting tool materials, cutting speeds and feeds, and tool rakes and clearances. In addition, typical copper alloy rods are tabulated according to-composition, machinability, and physical and mechanical properties. Anaconda American Brass Co.

CIRCLE NO. 398



Semiconductor notes

The first three booklets in a continuing series of to-be-published semiconductor application notes are now available. One is an eight-page note entitled "Thyristor Design Trade-Offs in Turn-off Specifications," which emphasizes motor controls and inverters. A second four-page publication discusses the alternative to conventional dc linear series voltage regulators in systems requiring high efficiency. The last, "Selecting Your Thyristor Gate Drive," provides useful round-up information for circuit designers, with numerous schematics, graphs and charts. Westinghouse Electric Corp.

CIRCLE NO. 399

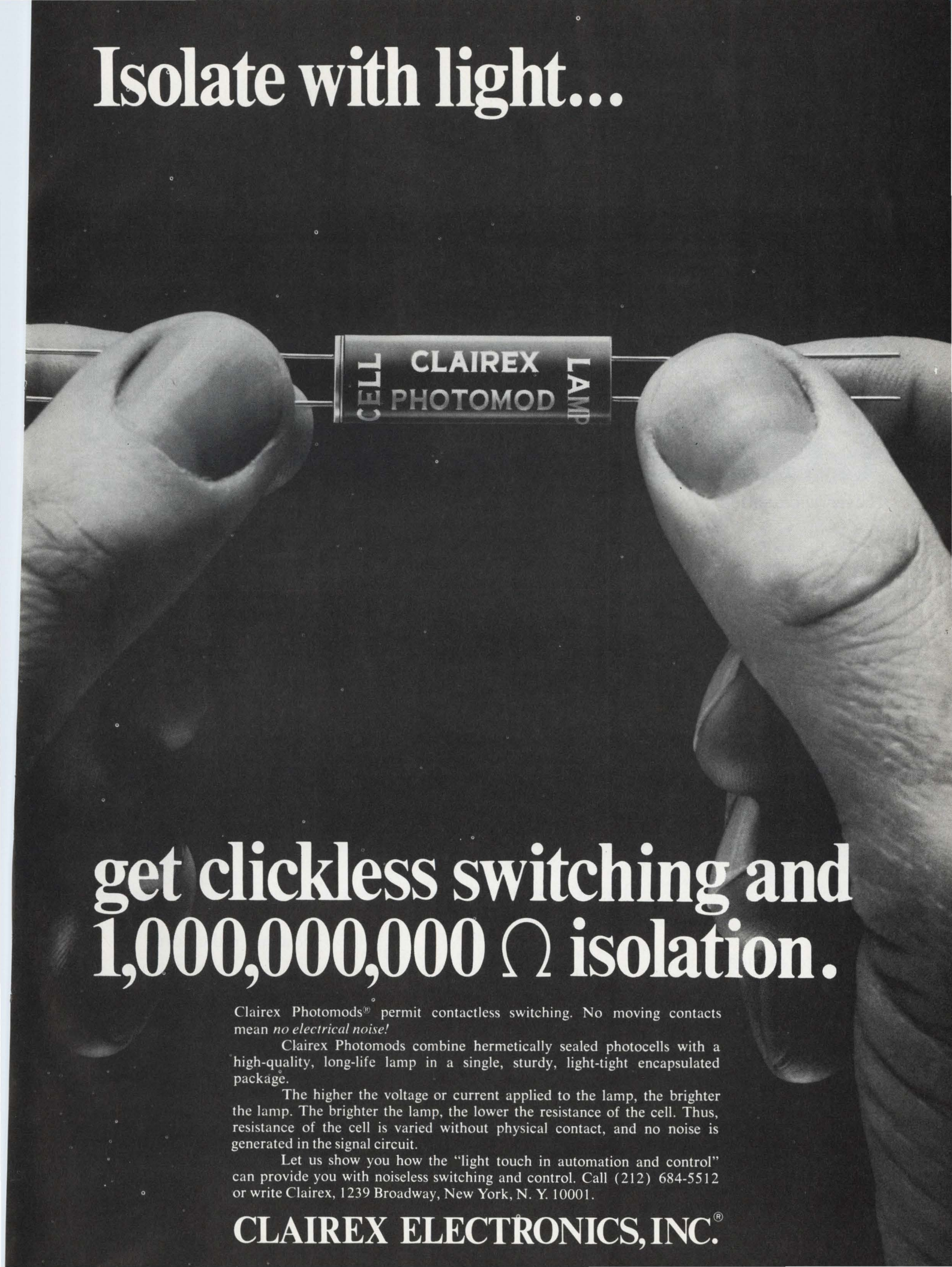
CATV amplifier design

Originally presented at the 18th Annual National Cable Television Association Convention, a paper entitled "CATV Repeater Amplifier Design Utilizing Digital Computer" is now available as a six-page reprint. According to the author, there are three distinct advantages in applying computer-aided-design techniques to CATV equipment: determination of limits of performance, design reproducibility, and application to hybrid and integrated circuit design. Anaconda Electronics Co.

CIRCLE NO. 400

INFORMATION RETRIEVAL NUMBER 171 ►

Isolate with light...



get clickless switching and 1,000,000,000 Ω isolation.

Clairex Photomods® permit contactless switching. No moving contacts mean *no electrical noise!*

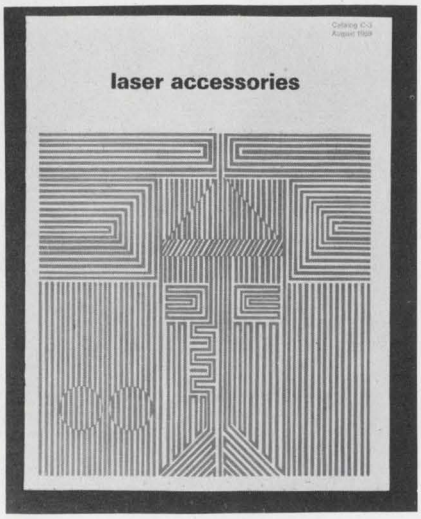
Clairex Photomods combine hermetically sealed photocells with a high-quality, long-life lamp in a single, sturdy, light-tight encapsulated package.

The higher the voltage or current applied to the lamp, the brighter the lamp. The brighter the lamp, the lower the resistance of the cell. Thus, resistance of the cell is varied without physical contact, and no noise is generated in the signal circuit.

Let us show you how the "light touch in automation and control" can provide you with noiseless switching and control. Call (212) 684-5512 or write Clairex, 1239 Broadway, New York, N. Y. 10001.

CLAIREX ELECTRONICS, INC.®

New Literature



Laser accessories

Consisting of 20 pages, a comprehensive catalog on laser accessories illustrates reflex beam expanders, focus assemblies, corner-cube retroreflectors, line filters, bolometers and bolometer amplifiers, beam splitters, and tenth-wave front surface mirrors. Seven pages in the catalog are devoted to the theory and application of the company's line of Pockel Cells. Baird-Atomic, Inc., System Components Div.

CIRCLE NO. 401

DIP panels

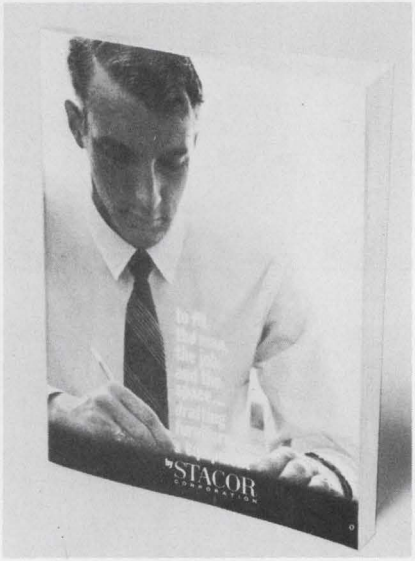
High-density dual-in-line packaging panels are the subject of a new 16-page catalog. Included is test data, technical and dimensional information for two series of IC packaging panels. Augat Inc.

CIRCLE NO. 402

Lafayette catalog

Comprising 496 pages, the new 1970 annual Lafayette catalog is now available. This electronic buyer's guide describes: brand-name stereo amplifiers, tuners, speakers, tape recorders, citizen-band two-way radios and accessories, amateur equipment, cameras, marine equipment, test equipment, tools, books and thousands of other electronic components for the home, industry, and laboratory. Lafayette Radio Electronics.

CIRCLE NO. 403



Drafting furniture

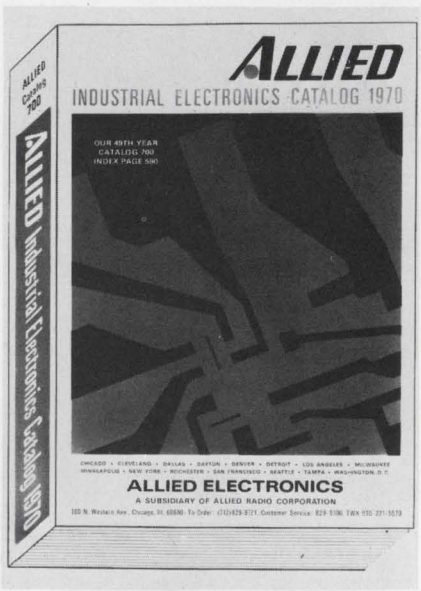
With a four-color cover and two-color printing throughout, a 52-page catalog covers a complete line of drafting and engineering furniture. This includes coordinate group automatic drafting stations, drafting and reference tables, filing systems, stools and chairs, art department equipment, tracing units, engineering and executive desks, and school library furniture. An unusual feature of the new catalog is its table of contents, which refers readers to pages by means of photographs of the furniture rather than by the usual text listings. Stacor Corp.

CIRCLE NO. 404

PC connectors

An expanded 32-page guide describes 18 card-edge connector series including MIL-C-21097, modular, and metal-plate designs. Among the 27 sizes, ranging from four to 84 contacts, are connectors compatible with most terminating techniques including automatic and manual wire-wrap, solder, and taper tab. A three-page illustrated index to all PC connectors permits identifying the required connector series instantly. The guide also contains complete drawings, detailed specifications and connector descriptions. Elco Corp.

CIRCLE NO. 405



Allied catalog

Containing 600 pages, Allied's new 1970 catalog of electronics equipment for industry and government lists over 50,000 separate stock items from over 500 manufacturers for research and development, production, communications, education, control and entertainment. Described are integrated circuit devices, semiconductors, vacuum tubes, relays, timers, transformers, resistors, capacitors, and other components and hardware. Also shown are test instruments, two-way radios, recording and sound equipment, power supplies, electronic counters, industrial materials, technical books, and tools. Allied Electronics Corp.

CIRCLE NO. 406

Modular indicators

An eight-page brochure gives details on modular series V-5A indicators, for use with pneumatic or electronic transmitters to indicate process variables or measure vacuum, pressure, differential pressure, and temperature directly. Included are full specifications, complete descriptions and methods of joining the modules. Diagrams of outline and mounting dimensions are also indicated. Beckman Instruments, Inc., Process Instruments Div.

CIRCLE NO. 407

Quite simply, the most versatile preset counter ever.

It's the new 5330B Preset Counter from Hewlett-Packard. It can do about twice as much work as the second best preset counters. Yet it's priced about the same.

This 10 MHz counter can:

Normalize counted data to units such as gpm, psi and rpm.

Issue control signals when preset count or count rates are reached.

Introduce a selected offset in the reading.

Be programmed remotely by automatic systems.

Totalize, find ratios and time intervals.

The 5330B gate times can be selected by a 5-decade front-panel "N" switch to any number of time units between 1 and 100,000. With a choice of 1μs, 10 μs, 0.1 ms and 1 ms time units ("M"). So you can get normalizing factors from 1 to 10^8.

This flexibility, together with the two limit control switches (L1 and L2), lets you virtually automate many processes such as batching. The limit switches generate output signals when the preset count is reached. These signals become the commands for your computer-run system.

The optional zero offset can be set at any number between 0 and 99,999. This lets your count start from a specific number and return to that number automatically.

All four of these functions can be remotely preset. It's also the first preset counter to offer an anti-noise option. This rejects high frequency noise that might mask low-frequency data.

You can also use this preset counter as a frequency divider. As a delay generator. Or as a precise, digitally selectable pulse generator.

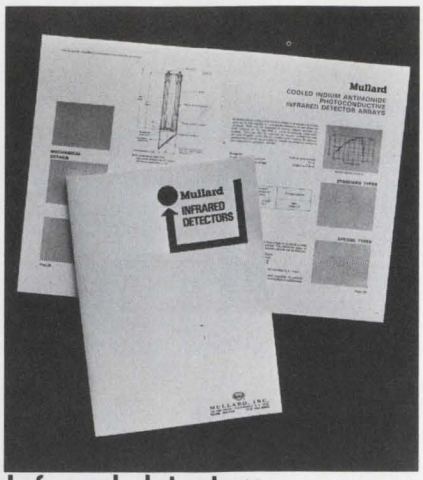
If the 5330B is too versatile for you, the 5330A should be just right. It does slightly less (without limits, but zero offset option available), and costs slightly less.

The 5330A is $1200. The 5330B is $1550. To find out just how much they can do for you, call your local HP field engineer. Or write to Hewlett-Packard, Palo Alto, California 94304; Europe: 1217 Meyrin-Geneva, Switzerland.

HEWLETT hp PACKARD

ELECTRONIC COUNTERS

02915



Infrared detectors

Designed as a ready reference source for designers and electro-optical consultants, a two-color easy-to-use 68-page handbook is a carefully indexed catalog on infrared detectors. There are sections on infrared detection and detectors, mercury-doped germanium photoconductive infrared detectors, yttrium-iron-garnet infrared modulators and cadmium-mercury-telluride infrared detectors. Mullard, Inc.

CIRCLE NO. 408

Scopes and shields

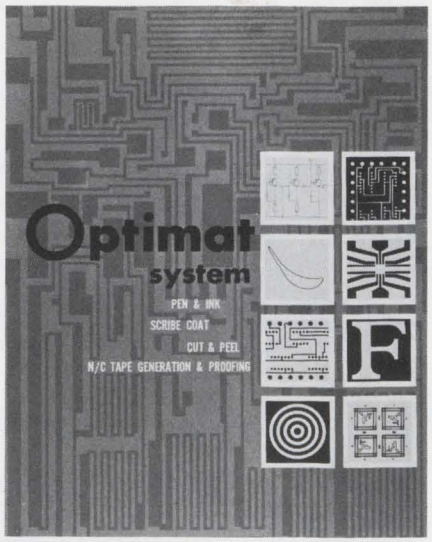
Modular oscilloscopes and magnetic shields and bezels are listed in a new 21-page catalog. Also included are such plug-in modules as high-voltage power supplies, deflection amplifiers and deflection sweep generators. The magnetic shields are intended for use with cathode-ray tubes, photomultiplier tubes, and charge storage tubes. James Millen Mfg. Co., Inc.

CIRCLE NO. 409

Angle indicators

A four-page two-color brochure describes a series of solid-state all-electronic digital angle indicators, for measuring and displaying angle inputs from remote synchros or resolvers. The brochure includes outline drawings and ordering information on basic units, multiplexed units, cabinet and half-rack configurations, and adapter hardware for multiple full-rack configurations. Astrosystems, Inc.

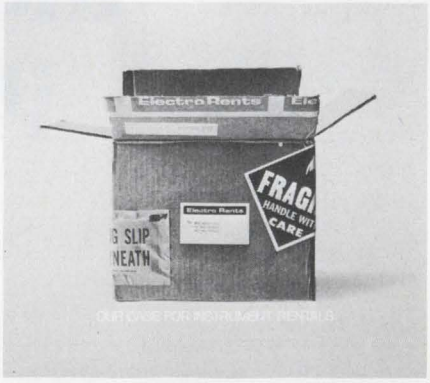
CIRCLE NO. 410



Artwork generation

Automated artwork generation is the subject of a four-page color brochure. Given is detailed information on the layout and readout coordinatorgraphs of the Optimat system, as well as the data processor with appropriate electronic interfacing. Optical Gaging Products, a Division of Ex-Cell-O Corporation.

CIRCLE NO. 411

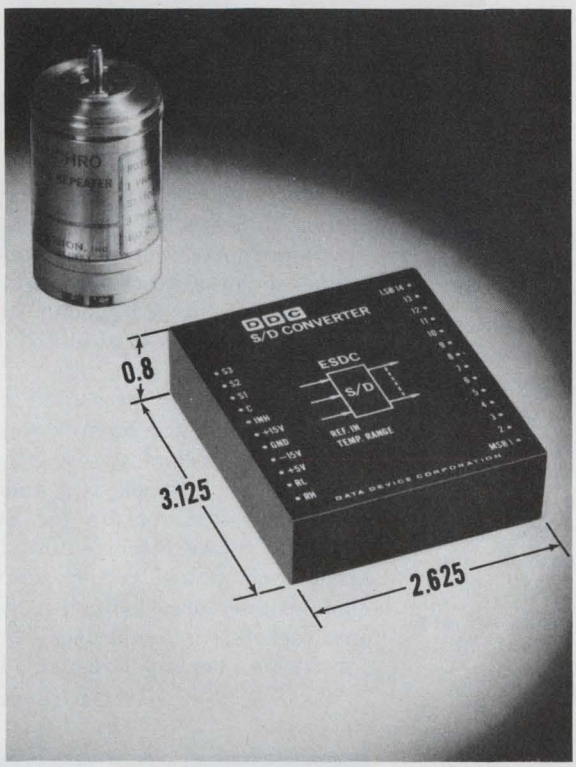


Instrument rental

A new electronic instrument rental catalog features Hewlett-Packard's 9100A programmable calculator and 8553L/8552A spectrum analyzer, Tektronix's 323 portable oscilloscope, Systron Donner's 7015 uhf frequency counter, Dynamic's 7514 differential dc amplifiers and Lambda's complete line of power supplies. Included are the terms and conditions of rental, as well as seven new optional purchase plans with or without maintenance and calibration. Electro Rents.

CIRCLE NO. 412

Synchro-to-Digital Converters Undergo Dramatic Size Reduction



DDC has a new encapsulated module, only 6.6 cubic inches, which offers true 14-bit continuous conversion. The 8 ounce device, called the ESDC, has a specified accuracy of ±4 minutes ±1 LSB over the full operating temperature range. This spec takes into account all errors due to input rates to 360°/second, accelerations to 20°/sec², harmonic distortions to 10%, frequency variations to 10%, and amplitude variations to 10%.

The 2.6″ x 3.1″ x 0.8″ high module is designed for mounting on a printed circuit card. The ESDC is available for either 11.8V rms or 90V rms L-L, 400 Hz synchro inputs. Coding is natural binary 'angle'; digital output is parallel, positive logic at DTL/TTL levels.

Transformer isolation provides high input impedance (10 KΩ minimum) to both signal and reference inputs to prevent loading errors. Power dissipation is less than 2.5 watts. Standard supply voltages are ±15 VDC and +5 VDC; units are also available for use with ±12 VDC supplies.

Initial acquisition occurs during powering up and takes less than ½ second, thereafter the data is always fresh and continuously available. No adjustments are required. The ESDC is a type 2 tracking converter, but with a one bit hysteresis added to eliminate the hunting typical of a type 2 loop. Whenever the data changes 1 LSB the Converter Busy line goes low to signal the system not to read out data during that 10 μsec interval. An Inhibit line is used to prevent changes in the up-down counter while reading out the angle.

Operating temperature ranges are −55°C to +85°C, −25°C to +70°C, and 0°C to +50°C. Hermetically sealed versions for extreme environmental conditions are available, as are units for use with 60 Hz input signals.

Prices (1-9) from $645 depending on operating temperature range.

For detailed specifications and prices, use the Readers Service Card number or call a DDC Applications Engineer.

DDC

DATA DEVICE CORPORATION
100 Tec Street
Hicksville, New York 11801
Phone: 516-433-5330

"DDC Has A Better Design"

INFORMATION RETRIEVAL NUMBER 184

Visual control

Printed in full color, a new catalog graphically shows the versatility and efficiency of all-magnetic visual control systems. Presented are both wall and floor-stand magnetic control boards, perpetual control systems with movable panels, and accessories like color-coded symbols, numbers, letters, arrows and strips. There are also a number of specific application sheets to aid the user in working out similar control boards for his own particular requirements. Magnagraph.

CIRCLE NO. 413

Electroplated gold

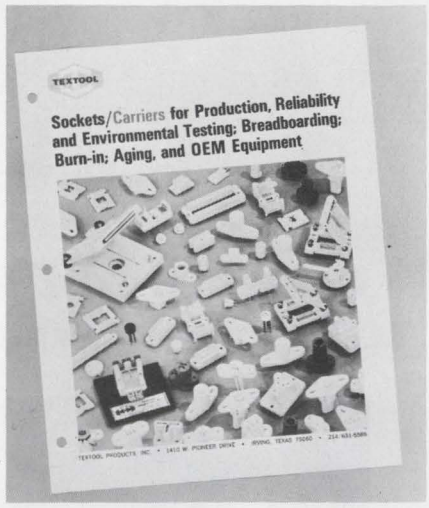
Complete copies of the latest military specification, MIL-G-45204B (issued March 27, 1969), for electroplated gold are now available. The new specification defines three purity types and four hardness grades. For the first time both purity and hardness will be specified. Technic, Inc.

CIRCLE NO. 414

Tin and industry

Originally released this spring, a 48-page book entitled "Tin in Your Industry" delineates how and why modern industry uses tin. Individual sections of the book are devoted to the invention and growth of the world tinplate industry and to such other major uses as solder, bronze, babbitt and miscellaneous alloys. There is also a section on new research developed uses for tin. Malayan Tin Bureau.

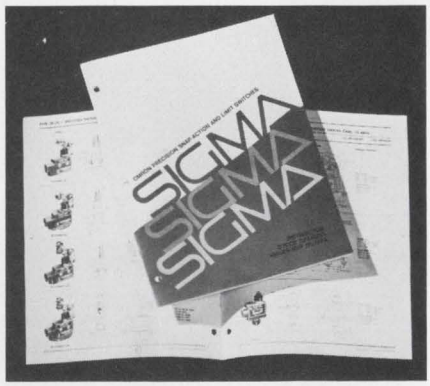
CIRCLE NO. 415



Sockets and carriers

Describing configurations, applications and special features, a new six-page short-form catalog tells of a line of versatile test sockets and carriers for integrated and hybrid circuits, including MSI and LSI devices, rectifiers, and other semiconductors. Also presented is a variety of test and burn-in sockets, power semiconductor test sockets, carriers for flatpack ICs and hybrids, and test sockets for SCRs, TRIACs, power transistors, and other components. Other items include connectors, lollipop carriers and sockets, and end-user sockets for OEMs. Textool Products, Inc.

CIRCLE NO. 416

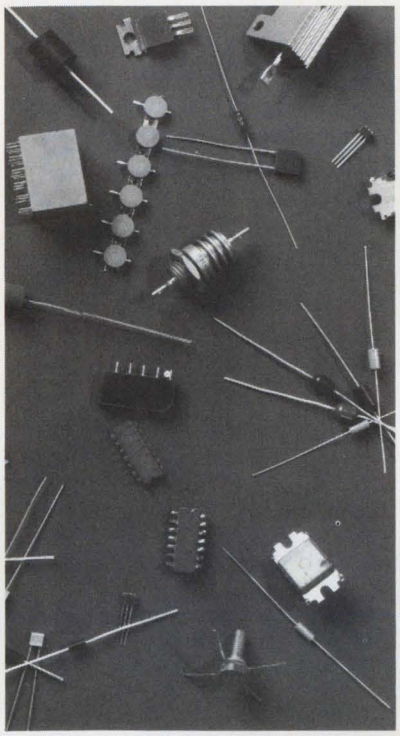


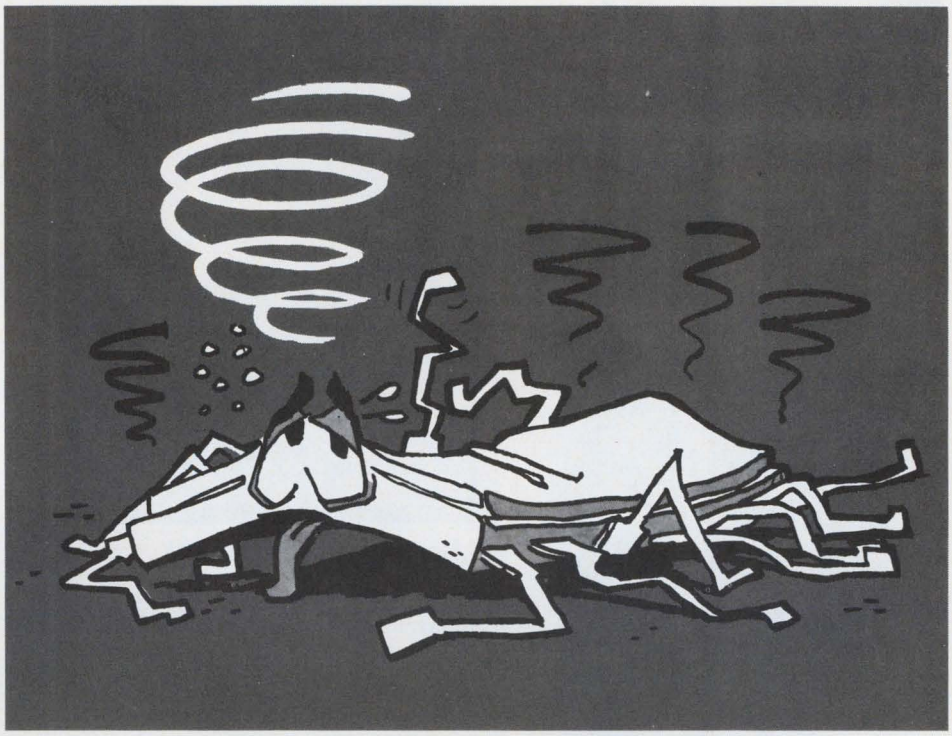
Snap switches

Providing technical data on a line of precision snap switches, a new 28-page distributor stock catalog contains a special section on auxiliary actuators, contact separations and terminal designs. A price list and a comprehensive cross-reference guide are also included. Sigma Instruments Inc.

CIRCLE NO. 417

When your IC bugs out, chances are the heat's on!





Devices packaged in Dow Corning® silicone molding compound are physically and electrically stable —even after long term exposure to both high heat and humidity. Derating, a practice common with organic packaging, is not necessary. In fact, you can design for high device and component density by using silicone molding compound. One manufacturer of glass package power diodes reduced the part to 1/30th of its former volume. Sizes from 1/5th to 1/3rd smaller can be obtained by using silicone molding compound in place of other plastics.

Little moisture absorption. Silicone molding compounds when exposed for 1000 hours to 93% RH at 70 C showed an average weight increase of 0.32% with the greatest increase being 0.5% and the least being 0.17%. Five organic plastics had average weight increases ranging from 1.0 to 2.1% —an average of nearly five times greater than silicone molding compounds under the same test conditions.

No cracking. Unlike other thermal setting plastics, Dow Corning silicone molding compounds are virtually unaffected by thermal shock. For example, a power resistor molded in Dow Corning® 307 compound was cycled repeatedly from —65 to 350 C without damaging the packaging material or the component.

Will not burn. Silicone molding compounds are inherently nonburning. Thus, components and devices packaged in silicone molding compound do not constitute a fire hazard. No flame snuffers are used—a source of ionic contamination for devices packaged in organic materials.

Corrosion free. These silicone molding compounds are free of ionic contaminants which may contribute to metallic corrosion when operating in high humidity and influenced by voltage bias.

Competitive price. Costing only a fraction of a cent per device, Dow Corning silicone molding compounds enjoy a substantial price advantage over metal cans . . . glass packages.

Manufacturing economies. Transfer molding enables manufacturers to package devices and components with a minimum of manual labor and supervision. Good mold release and minimum flash assure high production rates . . . reduced deflashing costs. These manufacturing advantages make silicone molding compounds totally competitive with organic plastics.

So why be bugged by device failures because of a cheap plastic package? Specify Dow Corning® brand silicone molding compound, and get the best package protection in your electronic equipment . . . lets you keep your cool. For technical data, write: Dept. D-8472, Dow Corning Corporation, Midland, Michigan 48640.

DOW CORNING

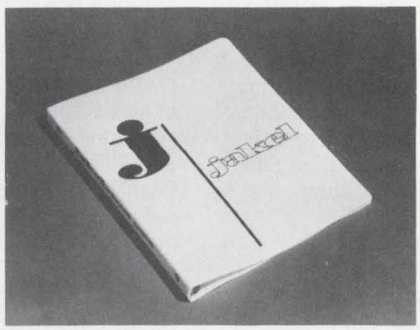
INFORMATION RETRIEVAL NUMBER 186

NEW LITERATURE

Microwave equipment

Revised and expanded, a new microwave test equipment catalog contains information on over 1200 standard waveguide and coaxial instruments and components, which cover the frequency range from 2 to 40 GHz. Complete technical data is given on noise sources, attenuators, directional couplers, phase shifters, crystal mounts, transitions, terminations, waveguide switches, frequency meters, and accessories. In addition, there are a number of engineering reports on noise measurement, attenuators, directional couplers, and filters, as well as charts of standard waveguide data. Waveline Inc.

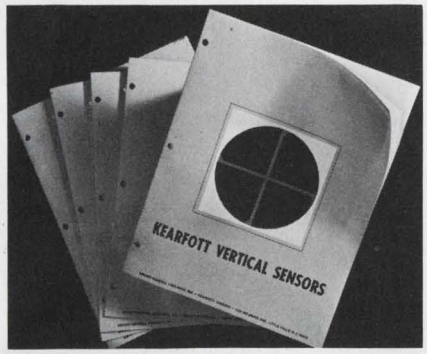
CIRCLE NO. 418



Motors and parts

Bound in a sturdy three-ring cover for easy page additions, a new catalog covers both sub-fractional-horsepower ac motors and metal stampings. The metal stampings include transformer covers, plates, insulators, and other products for the electrical and electronic industries. Jakel Inc.

CIRCLE NO. 419



Sensor catalog

Packed with technical information, a newly revised 14-page catalog describes a wide variety of vertical, level, and tilt angle sensors. The brochure presents text, diagrams, schematics, graphs, tabulations, and application data on electrolytic and electroytic and electromagnetic sensors, including single- and two-axis models. Novel bubble-type sensors are also detailed, as are sensing packages containing one or more sensors together with the circiutry required for particular applications. Singer-General Precision, Inc.

CIRCLE NO. 420

Tool guide

A new 114-page tool directory details standard production-line tools, plus many new innovations and ideas for electronic assembly and maintenance. Also described is a completely new line of tools specifically designed to handle flat-pack and DIP circuitry. Techni-Tool, Inc.

CIRCLE NO. 421

Extending man's senses:

Command joint forces from 20,000 feet.

Bounce a newscast around the world.

Navigate precisely from Cape Horn to the Cape of Good Hope.

Turn night into day with an airborne floodlight.

Set up a TACAN transceiver, anywhere, in minutes.

Airborne command and control stations. Communications satellite networks. The global Omega navigation system. Nighttime military and civilian operations. Portable TACAN.

All demand fail-safe technology – the finest electronics and systems available.

That's our business.

LTV Electrosystems has the scientific and engineering talent, fast-reaction capacity and the production facilities (15 nationwide) to build the sophisticated, new-generation systems our customers need to extend their senses and capabilities into every environment.

Why don't you join us?

See the opposite page for a listing of current professional opportunities at LTV Electrosystems.

LTV ELECTROSYSTEMS, INC.

P.O. BOX 6030, DALLAS, TEXAS 75222

A quality company of Ling-Temco-Vought, Inc. **LTV**

Sealing products

Ceramic-to-metal seal products for electronic applications are shown in a new four-page bulletin. Used where high resistance to thermal conductivity is required, these ceramic-to-metal seals are available as standard or customized units. Vernitron Electrical Components, Norwalk Div.

CIRCLE NO. 422

Microwave products

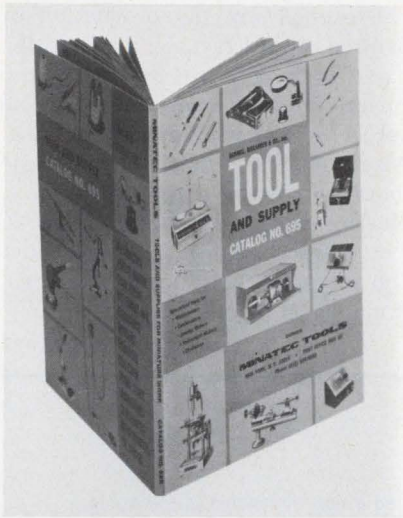
In capsule form, a new four-page catalog describes 2000 microwave products such as fixed, variable, and step attenuators, and rf components like terminations, tuners, connectors and switches. Also included are microwave parameter measuring instruments for fixed- and swept-frequency insertion loss, VSWR gain measurements, and power measuring and calibration instruments. Weinschel Engineering.

CIRCLE NO. 423

Physical measurements

Discussions, definitions, conversion factors and slide-rule settings regarding the new International (SI) System of Units are provided in a new 88-page booklet entitled "Physical Measurements and the Internation System of Units." The brochure is designed for use as a reference during the transition from the old to the new measurement system. Cubic Corp., Systems Div.

CIRCLE NO. 424



Production tools

Fully illustrated, a new 128-page tool and supply catalog is now available to engineers in the electronic and instrument industries engaged in miniature or microminiature component work. Described are the latest in time-saving tools and supplies, including hand tools (pliers, tweezers, screwdrivers), precision machinery (lathes, engravers, polishers), cutting tools (pivot drills, burs, saws, files), and magnifiers (loupes, readers, stand magnifiers, inspection lights). Hammel, Riglander & Co., Inc.

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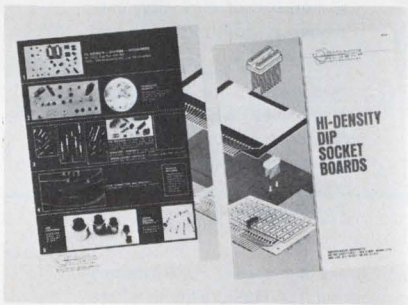

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CIRCLE NO. 426

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A load selection guide for many standard types of reed switches is included in a new condensed eight-page catalog. In addition, easy-to-read charts show contact arrangement, dimensions, switching voltage and other electrical characteristics. Also included is the basic operation of the reed switch with both permanent magnet and electro-magnet actuation. Hamlin Inc.

CIRCLE NO. 427

Air-operated tools

Designed for the production of printed circuit boards, air-operated hand tools for cut-and-bend and cutter-crimping operations are the subject of a new eight-page catalog. Also included is data on pneumatic tools for cutting metal, cable, wire, plastics, wood and fiber glass parts. The catalog contains both product and applications information. Simonds Machine Co.

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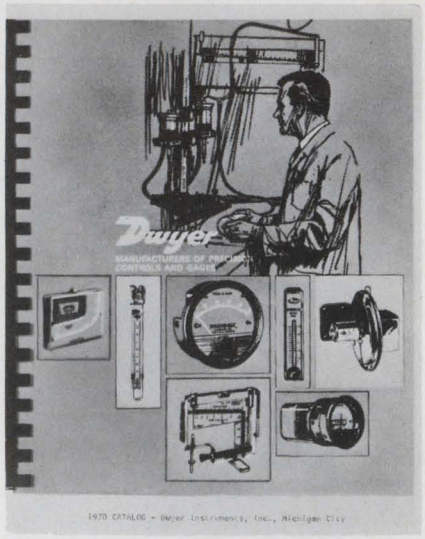

Pneumatic instruments

Designed for users of low-pressure gages, flowmeters, manometers and air-operated electric control switches, a 100-page instrument catalog offers basic technical help and application examples. Included are descriptions of differential pressure, air velocity and combustion testing instruments. Dwyer Instruments, Inc.

CIRCLE NO. 429

Ultrasonic transducers

A full line of ultrasonic non-destructive testing transducers is described in an illustrated 35-page catalog that provides background information on piezoelectric materials and transducer design requirements for various test applications. A description of a high-temperature kit for difficult on-stream thickness testing applications is included, along with a complete listing of transducer accessories. Branson Instruments Co.

CIRCLE NO. 430

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The expanding role of data terminals in time-sharing operations is discussed in an eight-page brochure. Described is how Teletype terminals can give quick access to time-sharing terminals for business planning, manufacturing, financial analysis, engineering, medicine, education, and order processing. Teletype Corp.

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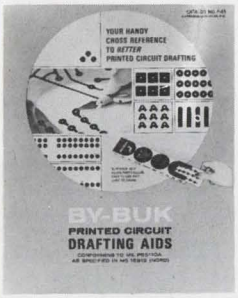

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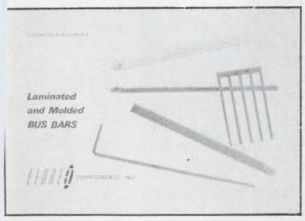

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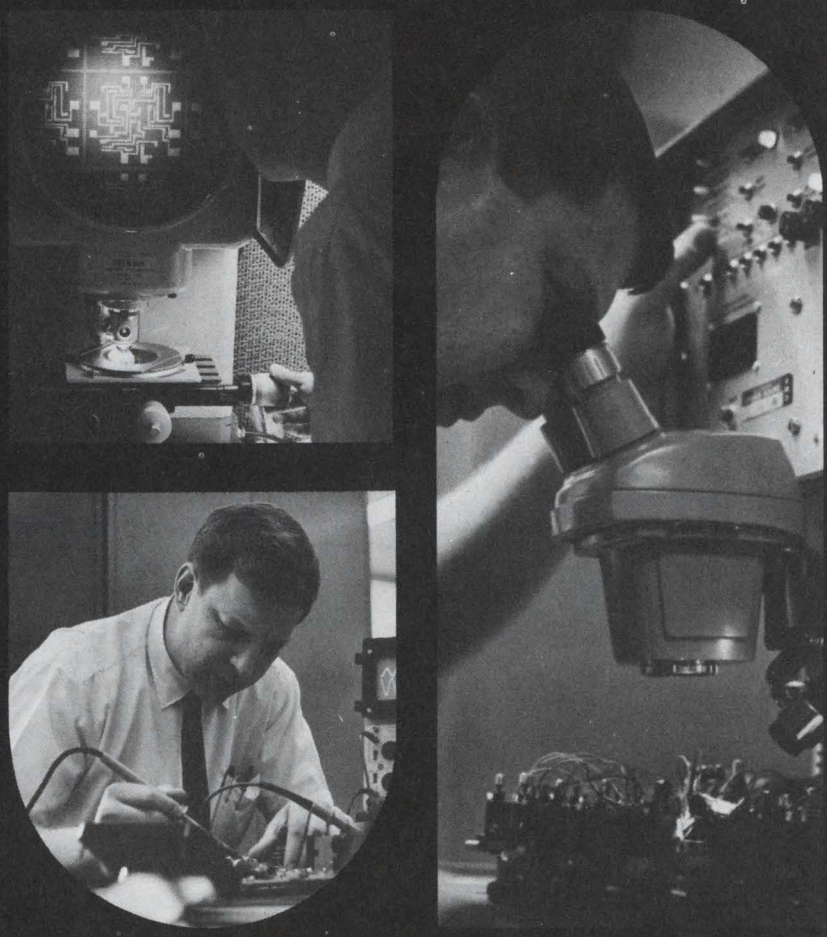

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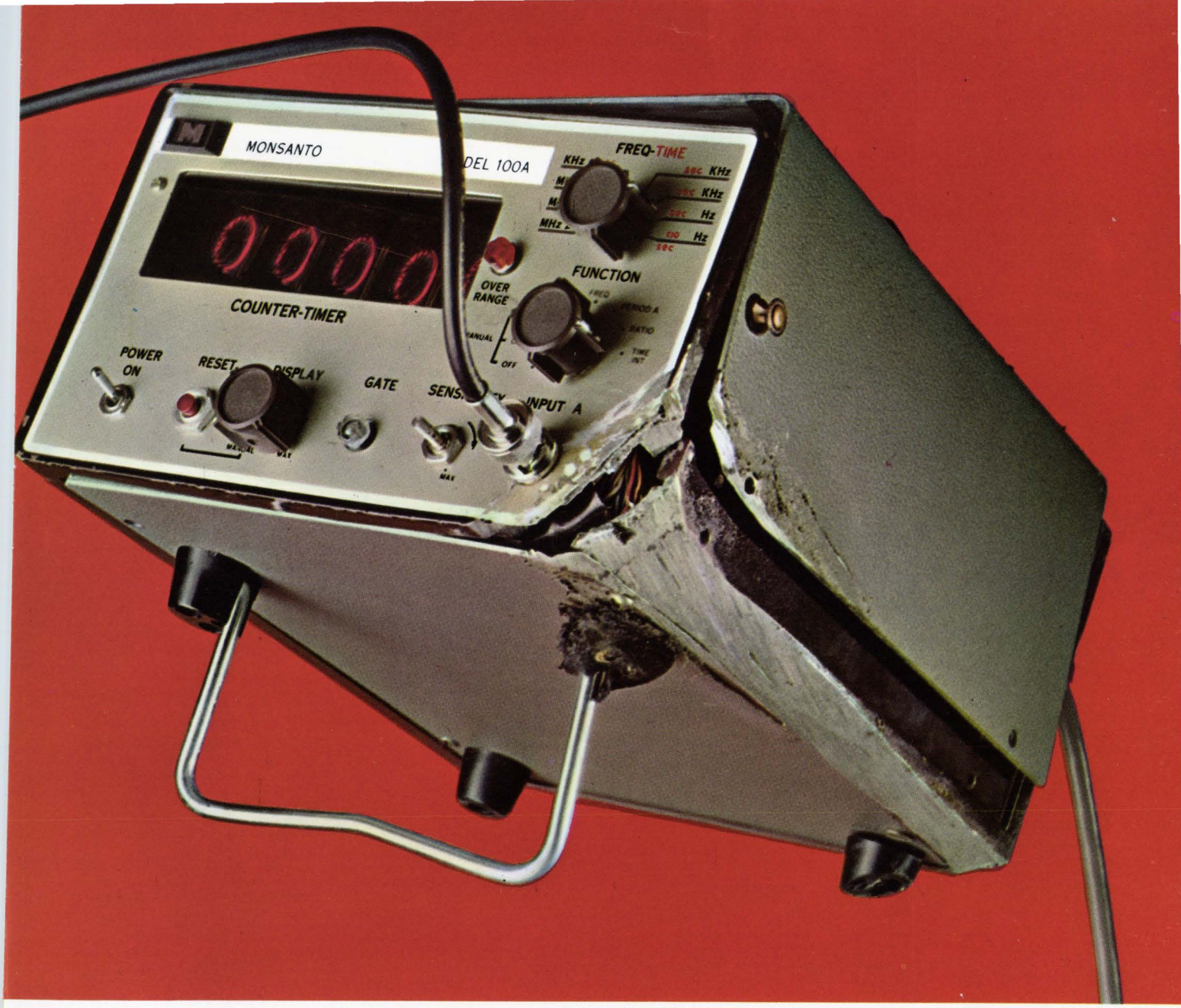

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INFORMATION RETRIEVAL NUMBER 237

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Duty factor . . . . . up to 0.01

For further information, see your local RCA representative. For technical data on the RCA-4068 and other pencil tubes and cavities, write: RCA Electronic Components, Commercial Engineering, Section J-18Q-1, Harrison, N. J. 07029.

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