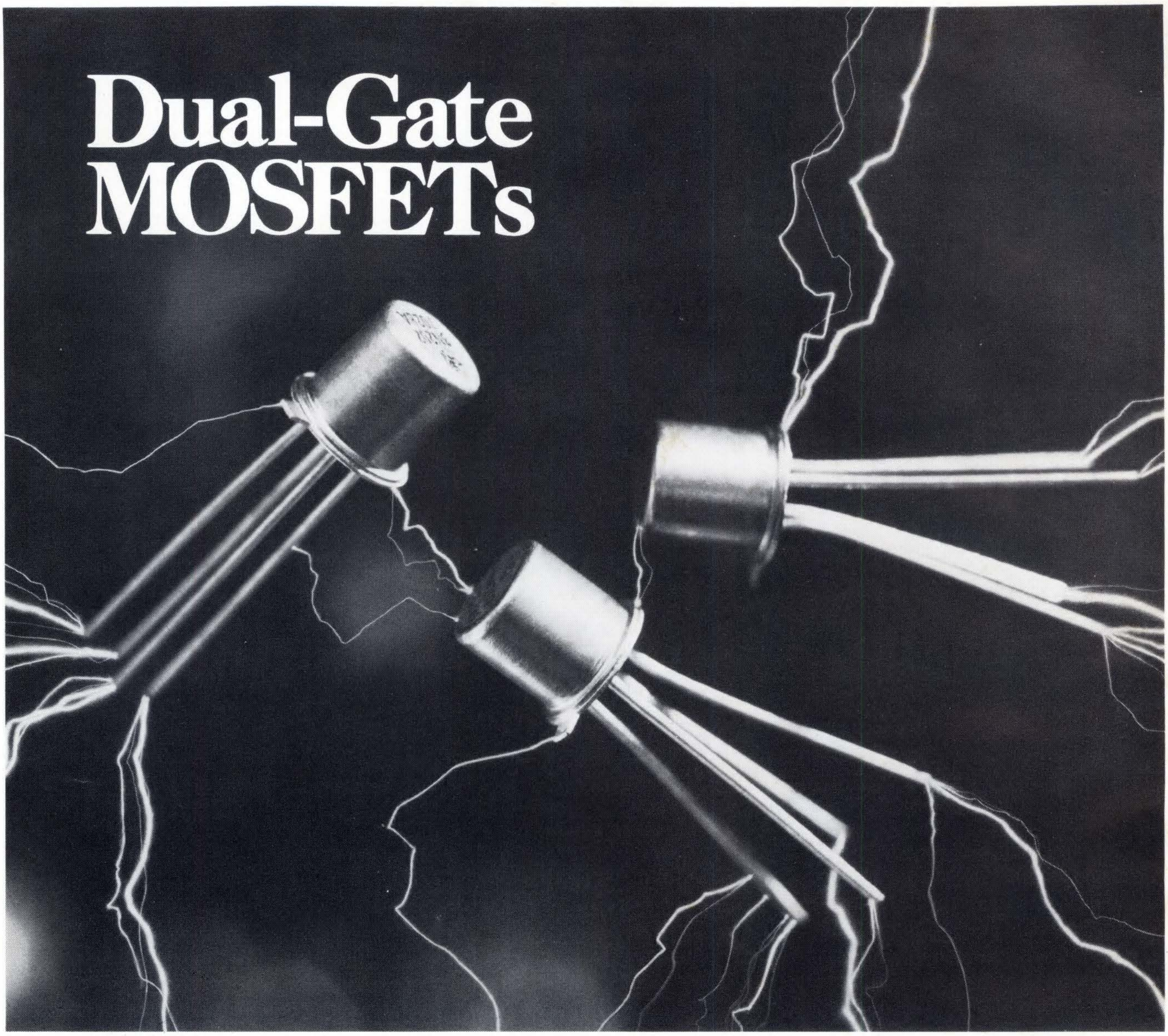
EDN

NEW in this issue— a special section for designers of computer mainframes, peripherals and systems.

A CAHNERS PUBLICATION

NOVEMBER 15, 1970



Safe from costly transient voltages

Transient voltages during assembly may damage up to 30% of the MOS transistors you use.

Not any more.

Now, TI builds MOSFETs with monolithic, back-to-back diode protection that's designed to block out troublesome transients.

And, they eliminate time-consuming precautionary assembly steps. That means lower production costs, fewer wasted devices.

The 3N201, 3N202 and 3N203 dual-gate MOSFETs, with integrated diode protection, have wide application in VHF and FM RF amplifiers, IF amplifiers, mixers and demodulators.

You can expect better system performance because of these unique TI MOSFET advantages: 10 db higher output impedance; low feedback capacitance of 0.03 pF maximum; and a typical low noise figure of 2.8 db.

All together, these characteristics add up to the performance you want at considerably lower cost.

Priced below comparable devices and in a different league compared to intricate tube 'n socket technology, these MOSFET prices are set to your advantage: 3N201, $1.00; 3N202, 95¢; 3N203, 90¢ (500-999).

All three are available now from TI stock or authorized distributors. Ask for the new data sheet and application reports. Write: Texas Instruments Incorporated, PO Box 5012, MS 308, Dallas, Texas 75222.

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A good bench DVM is fast and accurate...

A great bench DVM is fast, accurate, and easy to use!

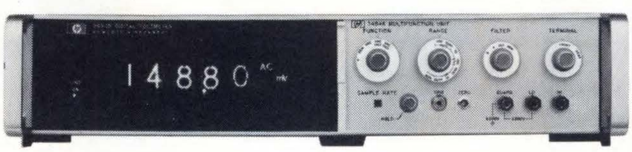
HP's 3480 is a great bench DVM. Simple, foolproof controls and full, five-decade autoranging reduce operating effort and errors. Fast response time and low noise make millivolt adjustments easy. And high noise rejection makes the last digit fully useable.

Low injected noise will not disturb the circuit under test. And constant $>10^{10}\,\Omega$ input resistance on the lower three voltage ranges reduces loading errors.

The digital readout display is presented in standard format for easy reading, easy understanding; i.e., +143.17 mV—not backwards, or inside out. Other convenience features include a sampling-rate indicator and a manual trigger for quick one-shot samples.

Options and plug-ins are available to give you combinations of five DC ranges, five true-RMS AC ranges, and six ohms ranges. And you pay for only the capabilities you want. Prices begin at $1500 for five ranges of fully autoranging DC.

For further information, contact your local HP field engineer, or write to Hewlett-Packard, Palo Alto, California 94304. In Europe: 1217 Meyrin-Geneva, Switzerland.

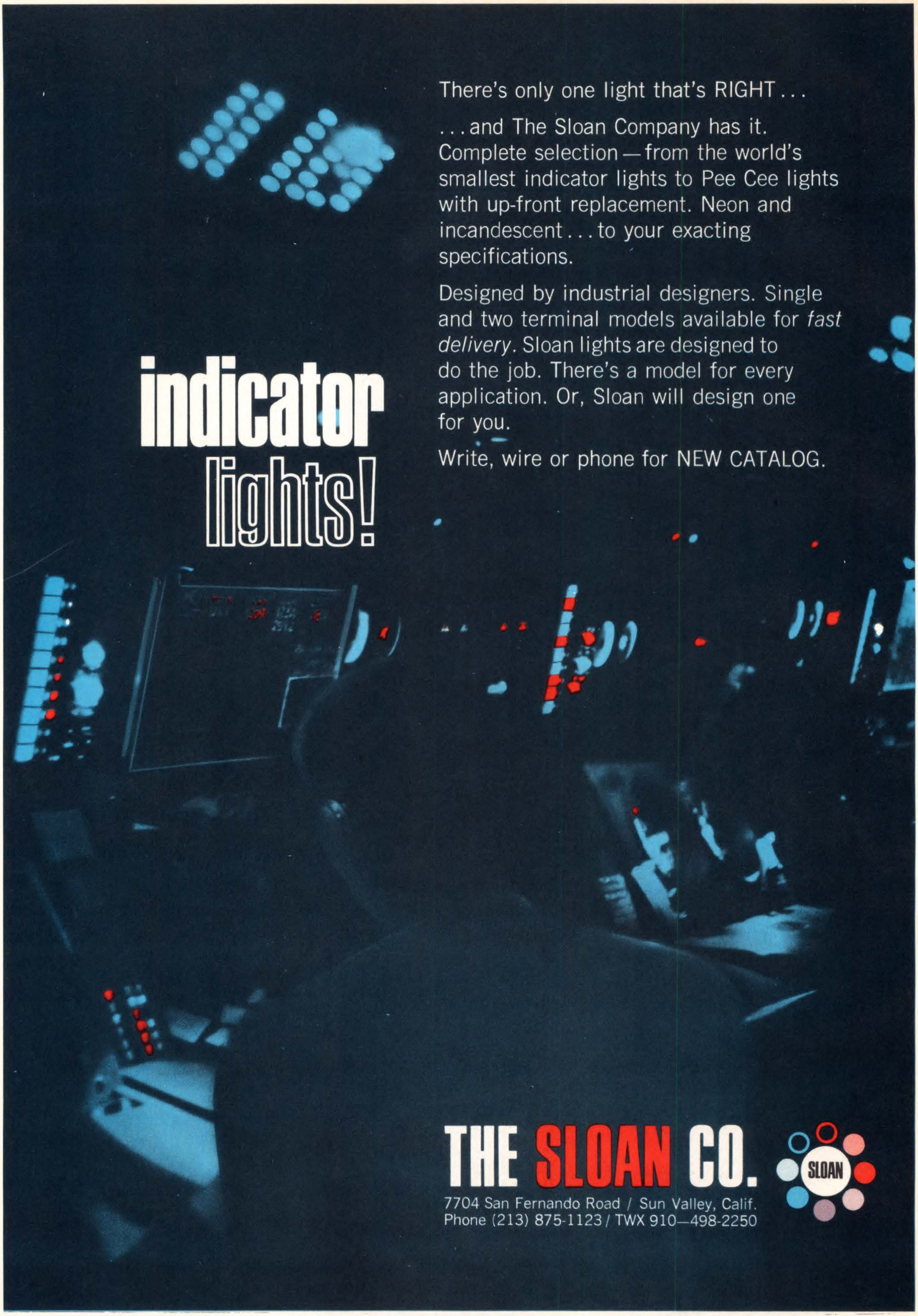


HEWLETT hp PACKARD

DIGITAL VOLTMETERS

090/45

CIRCLE NO. 1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CIRCLE NO. 2

NOVEMBER 15, 1970
VOLUME 15, NUMBER 22

EDN

EXCLUSIVELY FOR DESIGNERS AND DESIGN MANAGERS IN ELECTRONICS

Cover

Front cover photo shows American Calculator Corp.'s new LED-readout MOS/LSI low-cost calculator both in and out of its case. Simplicity of design permits complete assembly in less than 2 hours. See news story on p. 18.

Design News

Design Predictions

Design Features

Design Ideas

Design Interface

Design Products

Design Departments

EDN's DESIGN ACTIVITY FILING SYSTEM is used to classify all design Feature and Design Idea articles. The first word indicates the *activity* discussed in the article. The second word denotes the principal product being used in the activity. The third word modifies the second word. Finally, a number is used to specify frequency, where applicable. This number is the $\log_{10}$ of the frequency in hertz.

ABP
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INTER ELECTRONIQUE

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Editorial

Springboard To A Prosperous Future?

Alternately praised and panned, the metric system marches steadily onto the American scene. Although many manufacturers anticipate costs to be prohibitive, the markets created by a massive metric move would be proportionately lucrative.

Granted, the machines required to change to metric would do little initially for our balance of payments. But the move would allow us to leapfrog manufacturing technology and would encourage replacement of outmoded production machinery. In the end, productivity would improve and we would be in a better position to compete world-wide in terms of both cost and measurement compatibility.

Such a move also would create a new wave of demand for technical manpower the like of which this country has never seen. Hopefully, this demand would be sustained through improved positions in world markets.

Yet, a stampede into metrication could spell disaster. So our moves should be calculated to play every advantage to its utmost and avoid trauma, false starts and waste. If these moves are carefully executed, indications are that the benefits could far outweigh the perils.

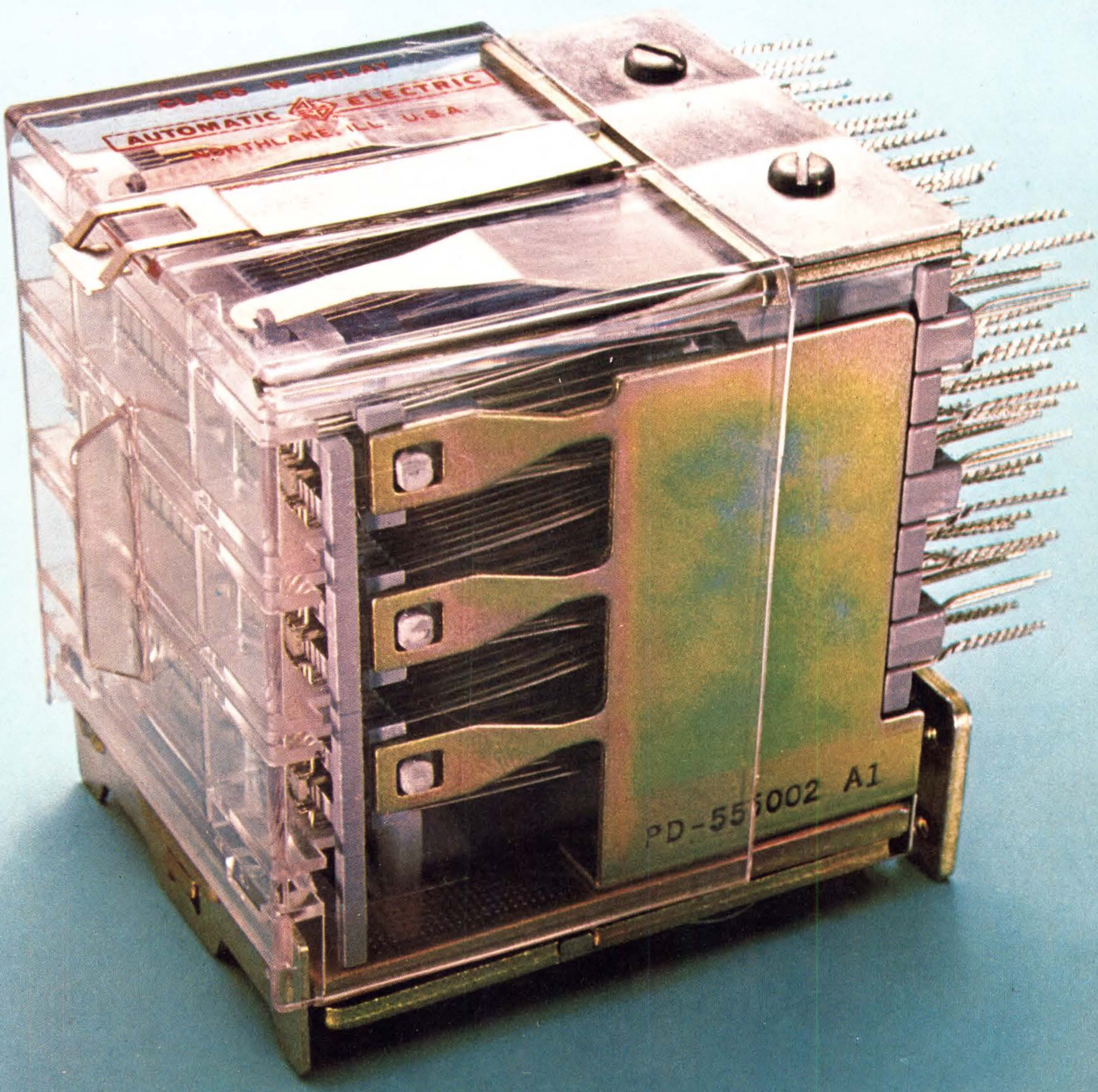
In August 1968, Congress authorized the Secretary of Commerce to study the probable impact of metrication on the U.S. A report back to Congress is due next August. If Congress responds with a go-ahead of some kind, it is staggering to contemplate the market that will be created.

Though fraught with risk, metrication could spell a revitalization of American industry. The meter, rather than being only a 39.37-inch yardstick, could be a springboard to a new era of prosperity.

G. Boe

Editor

Reliability is staggered steps and a hunk of DAP.



Expect over a billion operations.

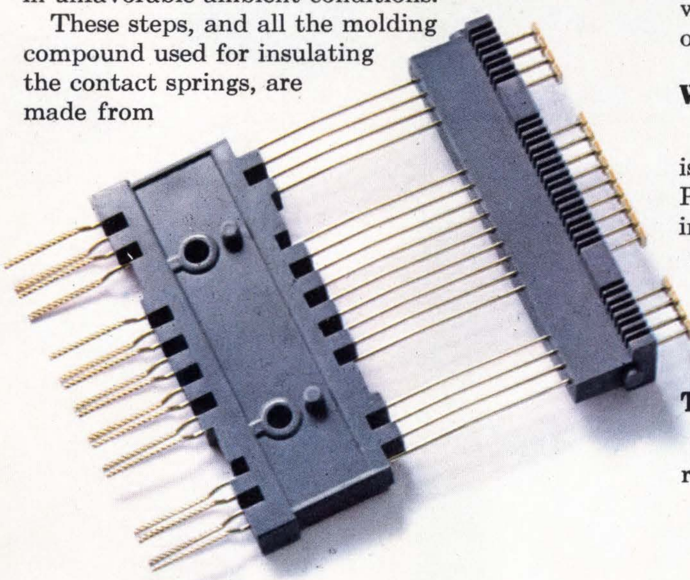
Our Class W wire-spring relay is different. In fact, there's nothing like it in the entire industry. Where else can you find a relay with lots of contacts and a mechanical life of more than a billion operations! That's about two and a half times the life of the best conventional relay around.

Another nice thing about our Class W is that it takes up a lot less space and costs less than using a bunch of other relays. That's because we build our Class W relay with one, two or three levels of contact assemblies, with 17 form C combinations per level. By the way, they're available with gold contacts for low-level switching.

Making it tough on creepage.

All those staggered steps you see on the side were put in to raise the breakdown voltage between terminals. These molded steps add extra creepage distance between the terminals. This really counts for high voltage testing, or when using our Class W in unfavorable ambient conditions.

These steps, and all the molding compound used for insulating the contact springs, are made from



diallyl phthalate. (They call it DAP for short.) It has great insulating properties and it wears like iron. Even if the humidity is high, you have excellent protection.

Redundancy—two springs are better than one.

Each of our long wire-spring contacts has an independent twin with the same function. One tiny particle of dust could prevent contact on other relays. Not with our Class W. You can be sure one of the twins will function. That's back-up reliability.

The twin contacts are twisted together at the terminal end. Then we give them a spanking (you might call it swedging) to provide solderless wrap.

We're for independence.

Our springs are longer, because the longer the spring, the more independent they get. And the better contact they make. Don't forget, the wire-spring relay is the most reliable way to get a permissive make or break contact. You can rely on it.

The middle contact springs have to be stationary. To make sure they stay that way forever, we actually mold them between two thick pieces of DAP on both ends. Just try to move one.

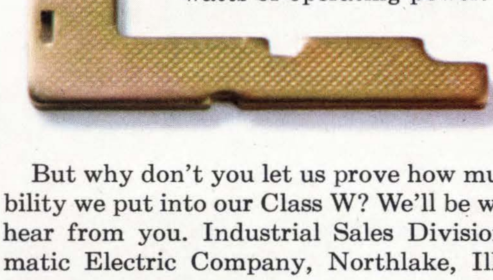
When we say flat, it's flat.

Each frame, banged out by a gigantic machine is extra thick and extra flat. Then they're planished. Planishing is another step we go through in forming the frame to add strength and stability by relieving surface strain.

We've made our spring-loaded pile-up clamp extra thick, too. Once it's tightened down, the whole pile-up is nice and tight, and stays tight.

There's more.

We could tell you a lot more about our Class W relays. Like how the tough high-temp molded cover protects against dust and has molded ribs to keep the spring contacts in place. Or how this relay with 51 circuit transfers is so sensitive it requires only four to six watts of operating power.



But why don't you let us prove how much reliability we put into our Class W? We'll be waiting to hear from you. Industrial Sales Division, Automatic Electric Company, Northlake, Ill. 60164.

AUTOMATIC ELECTRIC
GENERAL TELEPHONE & ELECTRONICS

CIRCLE NO. 8

Low-Noise Transistor Amplifiers (Partial List)

Type	Frequency Range (GHz)	Max. Noise Figure (dB)	Gain (dB) min.	Gain Flatness (dB) min.	Power Output[1] (dBm) min.	Typical Intercept Point (dBm)	VSWR Input/Output max.	RF Connector[2]	Size (inches)	Weight (oz.)	Primary Power
WJ-5030	0.05-0.50	3.5	30	±1.0	−3	+7	2.5/2.0	OSM	1.0 x 1.3 x 2.9 (25 x 33 x 74 mm)	3 (85 g)	+15 Vdc
WJ-736	0.5-1.0	4.0	25	±1.0	+10	+20	2.0/2.0	OSM	1.0 x 1.3 x 2.9 (25 x 33 x 74 mm)	3 (85 g)	−15 Vdc
WJ-738	0.5-1.0	4.0	25	±1.0	+10	+20	2.0/2.0	OSM	1.3 x 2.3 x 2.9 (33 x 58 x 74 mm)	6 (170 g)	115 Vac
WJ-737	1.0-2.0	6.0	25	±1.0	0	+13	2.0/2.0	OSM	1.0 x 1.3 x 2.9 (25 x 33 x 74 mm)	3 (85 g)	−15 Vdc
WJ-739	1.0-2.0	6.0	25	±1.0	0	+13	2.0/2.0	OSM	1.3 x 2.3 x 2.9 (33 x 58 x 74 mm)	6 (170 g)	115 Vac
WJ-739-14	1.0-2.0	5.0	28	±1.0	0	+13	2.0/2.0	N	1.3 x 2.3 x 2.9 (33 x 58 x 74 mm)	9 (255 g)	115 Vac
WJ-739-15	1.0-2.0	8.0	35	±1.5	+10	+20	2.0/2.5	N	2.5 x 2.5 x 3.5 (63 x 63 x 90 mm)	22 (624 g)	115 Vac
WJ-780	1.0-2.6	7.0	27	±1.5	+5	+18	2.5/2.5	OSM	1.3 x 2.3 x 3.9 (33 x 58 x 99 mm)	9 (255 g)	115 Vac
WJ-6007	1.0-4.0	7.5	25	±1.5	+5	+17	2.0/1.0	OSM	1.3 x 2.3 x 2.9 (33 x 58 x 74 mm)	6 (170 g)	115 Vac
WJ-737-14	1.43-1.54	5.5	25	±1.0	0	+13	2.0/2.0	OSM	1.0 x 1.3 x 2.9 (25 x 33 x 74 mm)	3 (85 g)	−15 Vdc
WJ-5004-2	2.0-4.0	8.5	30	±1.0	+10	+20	2.0/2.0	N	2.5 x 2.5 x 3.5 (63 x 63 x 90 mm)	22 (624 g)	115 Vac
WJ-5004-4	2.0-4.0	7.0	25	±1.0	+5	+20	2.0/2.0	OSM	1.3 x 2.3 x 3.9 (33 x 58 x 99 mm)	6 (170 g)	115 Vac
WJ-5090-4	2.0-4.5	7.5	25	±1.5	+5	+17	2.0/1.0	OSM	1.3 x 2.3 x 2.9 (33 x 58 x 74 mm)	8 (227 g)	115 Vac
WJ-772-5	2.2-2.3	6.0	25	±1.0	+5	+18	2.0/2.0	OSM	1.3 x 2.3 x 3.9 (33 x 58 x 99 mm)	9 (255 g)	115 Vac
WJ-5004-3	3.7-4.2	9.0	15	±0.5	0	+10	1.2/1.2	N	1.0 x 1.3 x 5.9 (25 x 33 x 150 mm)	3 (85 g)	−48 Vdc

[1] Power output where gain is reduced by 1 dB.
[2] Type N, OSM and TNC connectors available for all amplifiers.

Low-Noise Traveling-Wave Amplifiers (Partial List)

Type	Freq. Range (GHz)	NF (db)	S.S. Gain (db)	Sat. Power Output (dBm)	Wgt. (lbs)
WJ-278	0.5-1.0	4.5	25	−10	17
WJ-293	0.5-1.0	8.0	25	+5	6
WJ-404	0.5-1.0	8.5	25	+5	14.5
WJ-397	0.5-2.0	7.0	25	+3	18
WJ-278-9	0.6-0.8	3.2	25	−10	17
WJ-268	1.0-2.0	5.0	25	−10	17
WJ-2[illegible]4	1.0-2.0	8.0	25	+7	6
WJ-294-5	1.0-2.0	8.0	28	+7	6
WJ-328-1	1.0-2.0	12.0	35	+10	17
WJ-374	1.0-2.0	5.5	25	0	17
WJ-405	1.0-2.0	8.5	25	+7	14.5
WJ-457	1.0-2.0	8.0	25	+7	6
WJ-280	1.0-2.6	8.0	35	−10	17
WJ-294-2	1.0-2.6	8.5	25	+7	6
WJ-442	1.0-4.0	7.0	25	0	18
WJ-370-3	1.4-2.3	4.5	20	−13	38
WJ-268-20	1.435-1.535	4.0	25	−10	17
WJ-268-24	1.435-2.3	5.0	25	−10	17
WJ-374-1	1.435-2.3	5.0	25	0	17
WJ-269	2.0-4.0	5.5	25	−10	17
WJ-295	2.0-4.0	8.5	25	+7	6
WJ-295-3	2.0-4.0	10.0	31	+10	6
WJ-295-5	2.0-4.0	8.5	28	+7	6
WJ-329-1	2.0-4.0	12.0	35	+10	17
WJ-375	2.0-4.0	6.5	25	0	17
WJ-406	2.0-4.0	8.5	25	+7	14.5
WJ-422	2.0-4.0	7.5	25	+10	6.5
WJ-458	2.0-4.0	8.5	25	+7	6
WJ-462	2.0-4.0	10.0	40	+10	4
WJ-477	2.0-4.0	12.0	25	+20	7
WJ-486	2.0-4.0	15.0	40	+13	3.5
WJ-3003	2.0-4.0	10.0	30	+20	18
WJ-281	2.0-4.5	8.0	35	−10	17
WJ-343	2.0-8.0	7.0	25	0	18
WJ-355	2.2-2.3	3.7	25	−10	17
WJ-375-7	2.2-2.3	4.5	13	Note	17
WJ-295-2	2.3-4.5	9.0	25	+7	6
WJ-494	2.5-10.0	10.0	25	0	18
WJ-381	2.6-5.2	9.5	25	+7	6
WJ-482	2.6-5.2	7.5	25	+10	7.5
WJ-3001	2.6-5.2	10.0	40	+10	3.5
WJ-3031	2.6-5.2	15.0	40	+13	3.5
WJ-375-1	2.7-3.1	4.5/5.0	23	0	17
WJ-295-34	2.9-3.1	5.0	24	−3	6
WJ-375-4	3.4-3.6	4.5	25	0	19.5
WJ-269-58	3.7-4.2	5.0	25	−10	17
WJ-381-11	3.7-4.2	8.0	28	+7	6
WJ-439	3.7-4.2	8.0	25	+7	17
WJ-481	3.7-4.2	6.5	28	+10	7.5
WJ-3025	3.7-4.2	10.0	40	+20	18
WJ-3034	3.7-4.2	10.0	30	+20	7.5
WJ-271	4.0-8.0	6.5	25	−5	17
WJ-286	4.0-8.0	8.0	35	−5	17
WJ-296	4.0-8.0	9.0	25	+7	6
WJ-296-5	4.0-8.0	9.0	28	+7	6
WJ-331-1	4.0-8.0	12.0	35	+10	17
WJ-407	4.0-8.0	9.0	25	+7	14.5
WJ-376	4.0-8.0	7.0	25	0	17
WJ-423	4.0-8.0	7.5	25	+10	6.5
WJ-459	4.0-8.0	9.0	25	+7	6
WJ-463	4.0-8.0	10.0	40	+10	4
WJ-476	4.0-8.0	12.0	25	+20	7
WJ-485	4.0-8.0	15.0	35	+12	3.5
WJ-3004	4.0-8.0	10.0	30	+20	18

Type	Freq. Range (GHz)	NF (db)	S.S. Gain (db)	Sat. Power Output (dBm)	Wgt. (lbs)
WJ-3043	4.0-8.0	10.0	25	+7	12.5
WJ-3033	4.0-12.0	8.5	25	0	18
WJ-296-2	4.3-7.35	9.0	25	+7	6
WJ-349	4.5-6.5	5.0	25	−10	17
WJ-382	4.8-6.2	6.0	25	+13	18
WJ-382-5	4.8-6.2	6.0	25	+13	38
WJ-3002	5.2-10.4	10.0	40	+10	3.5
WJ-3032	5.2-10.4	15.0	35	+12	3.5
WJ-297-2	7.0-11.0	9.5	25	+7	6
WJ-396	7.0-11.0	6.0	25	−3	8.5
WJ-424-14	7.0-11.0	8.0	30	+10	6.5
WJ-464-1	7.0-11.0	10.0	40	+10	3.5
WJ-484	7.0-11.0	13.0	38	+13	3.5
WJ-484-3	7.0-11.0	15.0	38	+13	5.0
WJ-484-10	7.0-11.0	12.0	37	+13	5.0
WJ-363-15	7.25-7.75	7.0	30	+13	17
WJ-3005-5	7.25-7.75	9.0	30	+20	18
WJ-363-3	8.0-10.0	7.0	30	+13	18
WJ-377	8.0-12.0	9.0	25	0	17
WJ-276	8.0-12.0	8.5	25	−5	17
WJ-287	8.0-12.0	10.0	35	−5	17
WJ-297	8.0-12.0	10.0	25	+7	6
WJ-297-5	8.0-12.0	10.0	28	+7	6
WJ-332-1	8.0-12.0	12.0	35	+10	17
WJ-363	8.0-12.0	8.0	30	+13	18
WJ-345	8.0-12.0	7.0	25	−3	18
WJ-384	8.0-12.0	8.5	25	+10	18
WJ-408	8.0-12.0	9.5	25	+7	14.5
WJ-424	8.0-12.0	7.5	25	+10	6.5
WJ-424-16	8.0-12.0	9.0	28	+13	6.5
WJ-460	8.0-12.0	10.0	25	+7	6
WJ-464	8.0-12.0	10.0	40	+10	4
WJ-472	8.0-12.0	12.0	25	+20	7
WJ-484-12	8.0-12.0	13.0	38	+13	3.5
WJ-491	8.0-12.0	8.0	27	+10	17
WJ-3005	8.0-12.0	10.0	30	+20	18
WJ-3044	8.0-12.0	10.0	25	+7	12.5
WJ-437	8.0-18.0	9.5	25	+3	18
WJ-424-6	8.5-9.5	6.5	25	+10	6.5
WJ-345-11	8.5-9.6	6.0	25	−3	18
WJ-363-4	10.0-12.0	7.5	30	+13	18
WJ-307-5	10.0-16.0	10.0	25	+7	18
WJ-307-15	10.7-18.0	11.0	25	+7	18
WJ-342-2	10.7-18.0	13.0	30	+7	6.5
WJ-307-24	12.0-14.0	8.0	25	−5	18
WJ-307	12.0-18.0	10.0	25	−5	18
WJ-342	12.0-18.0	12.0	25	+7	6.5
WJ-342-9	12.0-18.0	12.0	28	+7	6.5
WJ-371	12.0-18.0	9.0	25	+12	18
WJ-425	12.0-18.0	10.0	25	+10	7.0
WJ-461	12.0-18.0	12.0	25	+7	6.5
WJ-465	12.0-18.0	12.0	25	+10	4
WJ-489	12.0-18.0	13.0	35	+13	5
WJ-489-10	12.0-18.0	13.0	37	+13	5
WJ-3045	12.0-18.0	12.0	25	+7	12.5
WJ-3006	12.0-18.0	13.0	30	+20	18
WJ-393	18.0-26.5	13.0	25	0	18
WJ-393-6	18.0-26.5	11.0	25	0	18
WJ-3000	18.0-40.0	14.0	25	+7	25
WJ-393-8	18.5-20.0	9.0	25	0	18
WJ-393-4	20.0-24.0	15.0	35	+4	18
WJ-338	26.5-40.0	14.0	25	+3	25
WJ-338-6	28.0-34.0	15.0	25	+5	25
WJ-338-5	34.0-36.0	13.0	25	+3	25
WJ-449-1	40.0-50.0-	17.0	20	+5	27
WJ-449-2	40.0-60.0	19.0	20	+3	27

Note: The amplifier shall have a maximum of 1.0 dB gain compression at an input level of −15 dBm.

UNITED KINGDOM: Shirley Ave., Windsor, Berkshire, England
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The Serious Shopper's Guide to

LOW-NOISE AMPLIFIERS

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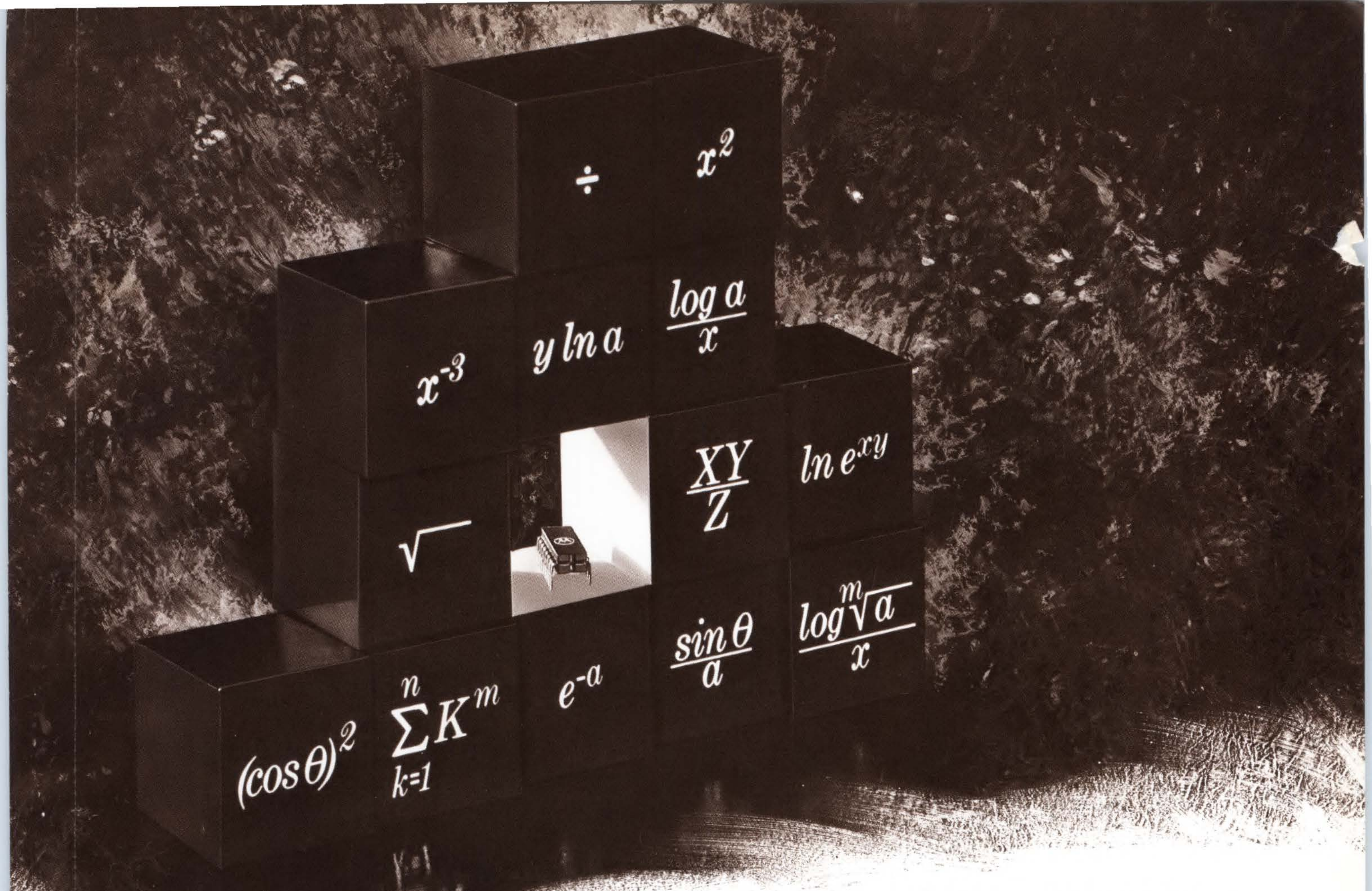
CIRCLE NO. 9



Second generation IC "Multiplier Plus"

Plus What?... Plus built-in voltage regulator and current converter

Motorola's new MC1594/1494 introduces the second generation of monolithic IC four-quadrant multipliers based on the variable transconductance principle. The "multiplier plus" is easier to use than the familiar industry standard MC1595/1495, and it offers a new high level of performance.

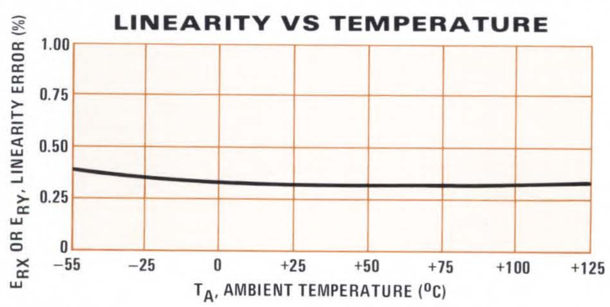
"Plus" features for cost reduction

The built-in current and voltage regulator eliminates the effects of power supply fluctuation and reduces the number of external components required. It regulates all current sources on the monolithic chip, effectively immunizing the multiplier to supply voltage fluctuations. It also provides two (+4.3 V) regulated voltages to bias the offset adjust potentiometers. Interaction among the pots during adjustment is eliminated. Changes in offset voltage caused by supply irregularities are eliminated. Four external resistors are eliminated.

At the other end of the multiplier the differential current converter provides a single-ended output current referenced to ground.

"Plus" features for Improved Performance

Linearity of 0.5% max (X or Y) for the MC1594 sets a new standard of excellence, and the MC1494 offers a fine 1.0% max error (X or Y). The "multiplier plus" is easier for the designer to use because it handles input and output voltages of ±10 V with ±15 V supplies. And power supply sensitivity is also significantly improved.



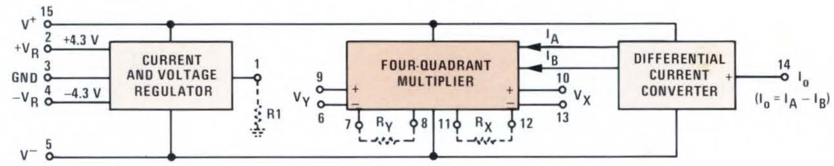
Please turn page for circuit information

MOTOROLA LINEAR

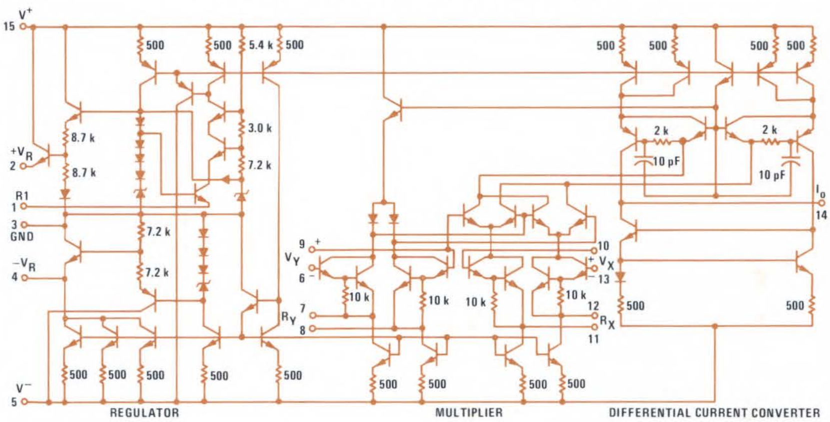
— serving a greater range of analog designs!

Here Is The Second Generation Monolithic IC Multiplier
Motorola's MC1594/1494 "Multiplier Plus"

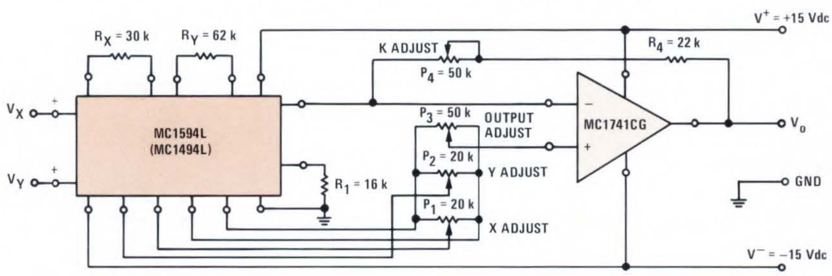
BLOCK DIAGRAM



COMPLETE CIRCUIT SCHEMATIC



TYPICAL MULTIPLIER CONNECTION



Check these performance features

- Excellent linearity
  0.5% max (X or Y) — MC1594L
  1.0% max (X or Y) — MC1494L
- Wide input voltage range — ± 10 V
- ± 15 V supply operation
- Single ended output referenced to ground
- Improved offset adjust circuitry
- Adjustable scale factor
- Power supply sensitivity — 30 mV/V (typ)

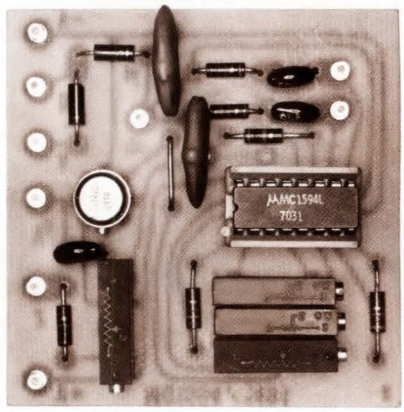
Learn all about the "Multiplier Plus" right away

The MC1594L and MC1494L are available now from your nearest Motorola distributor at 100-up prices of $12.00 - MC1594 and $8.00 - MC-1494. Both devices are in the 16-pin ceramic dual in-line package. For a 14-page applications-specifications data sheet, circle the reader service number or write Motorola Semiconductor Products Inc., P.O. Box 20912, Phoenix, Arizona 85036.

Circle No. 10

The circuitry shown external to Motorola products is for illustrative purposes only, and Motorola does not assume any responsibility for its use or warrant its performance or that it is free from patent infringement.

"Multiplier Plus"
Special Introductory Offer



Complete MC1594 or MC1494 Evaluation and Experiment Kit DC and AC applications — All you need to build it for Multiply • Square • Divide • Square Root • Balanced Modulator • Amplitude Modulator • Phase Detector • Frequency Doubler.

40% Off total 1-up price of all components and hardware!

MCK1594 Kit . . . This $38.45 value only $23.10

MCK1494 Kit . . . A $32.45 value at only $19.50 (substitute MC1494L multiplier)

Parts list
MCK1594 and MCK1494

Quantity	Part Description
1	MC1594L or MC1494L
1	MC1741CG op amp
2	1N5241B Zener Diodes
2	510 ohm, ¼ W, 20% carbon resistors
1	16K, ¼ W, 5% film resistor
1	22K, ¼ W, 5% film resistor
1	30K, ¼ W, 5% film resistor
1	62K, ¼ W, 5% film resistor
2	20K, 15 turn cermet potentiometers
2	50K, 15 turn cermet potentiometers
2	0.1μF ceramic disc capacitors
3	10pF ceramic disc capacitors
1	16-pin dual in-line socket
1	PC board
10	terminals

Also contains complete "How To Do It" construction note and data sheet with applications information.

Specify by MCK1594 or MCK1494 — state quantity — enclose check (P.O. is OK for order over $20.00) — offer expires May 20, 1971 — limit, 5 (five) kits. Send order to Motorola Semiconductor Products Inc., P.O. Box 20912, Phoenix, Arizona 85036.

MOTOROLA LINEAR

— serving a greater range of analog designs!

LSI = Low-Cost Calculator

This is a story about a calculator—a calculator that began with an 11- by 11-inch 8-layer printed circuit board housing 176 discrete integrated circuits. That calculator, because of high tooling and labor costs, could not be manufactured competitively, and so a company folded.

Today this calculator is wearing a new suit. Redesigned by a new company, The American Calculator Corp. located in Dallas, Texas, the printed circuit board is now a simple 2-layer, 6- by 7-in board, thanks to MOS large scale integration (LSI). Its readout consists of seven-segmented light-emitting diode (LED) arrays that provide a most pleasing display. And, with only 2-1/2 hours needed to assemble the prototype completely, it's expected that the entire assembly process, once in production, will take less than 2 hours.

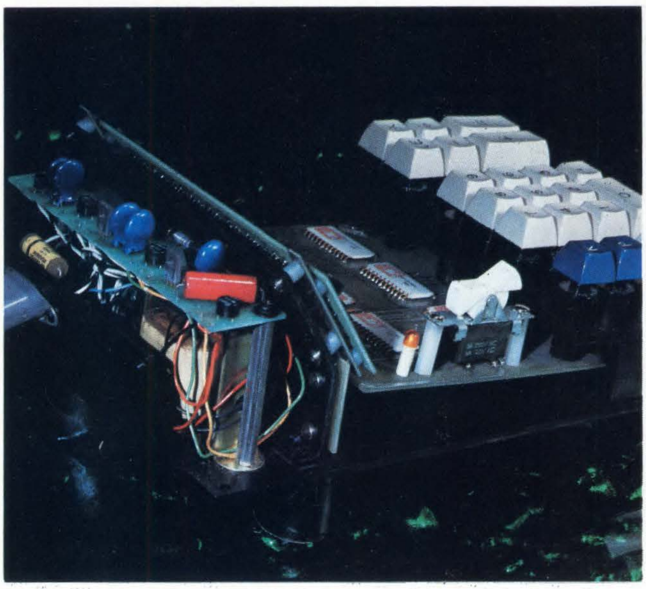
All these factors add up to a calculator that now makes its debut competitively priced with all similar calculator units now on the market. Just as soon as it was learned that the LSI chips now used in the calculator were available, it took just 24 days for American Calculator to go from concept to a finished operating unit.

Designated Model 816 because it accumulates sums and products up to 16 digits that are viewed 8 digits at a time, the 3.5 lb, four-function (add, subtract, multiply, divide) unit requires only 3W of power for operation. Two items account for this low-power operation. First, the 6 MOS/LSI chips require two supplies of -13v at 65 mA and -24V at 25 mA or 1.445W. Each of these six chips contains a total of 8000 transistors. Second, the clock frequency, which is 200 kHz, is also used to multiplex the eight readouts for reduced display power consumption. When the calculator is placed in production, the initial seven segmented displays will be supplied by Texas Instruments Incorporated.

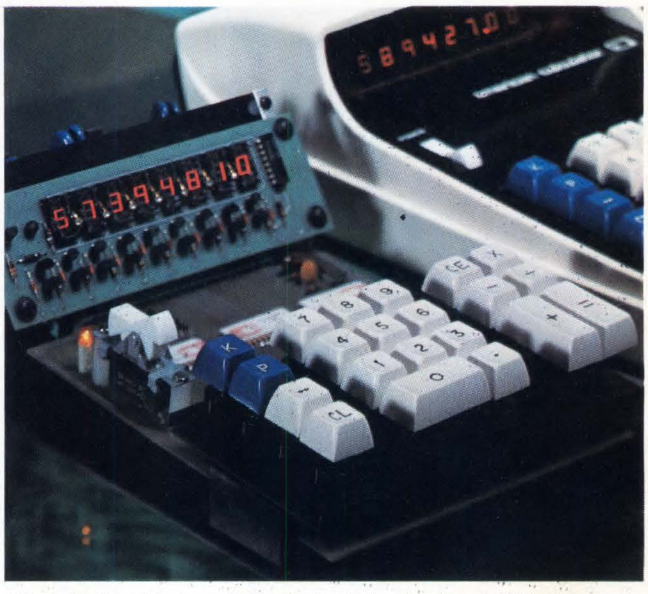
Other features include 0 to 70°C (32 to 158°F) operating temperature range, longest cycle time of 100 ms ability to multiply or divide by a constant and 0 to 7 digit decimal-point selection.

Production schedules call for 100 calculators in November, 550-1250 in December and 2-3k in January. Average price is under $400. Simultaneously, other models will be added to the line that will reduce the weight to 1-1/2 lb, add the functions of square and square root, change the 8/16 display to 14/28 and provide a connector for hookup to a printer for hard copy.

Regarding its long range plans, American Calculator hopes to affiliate with one of the larger calculator

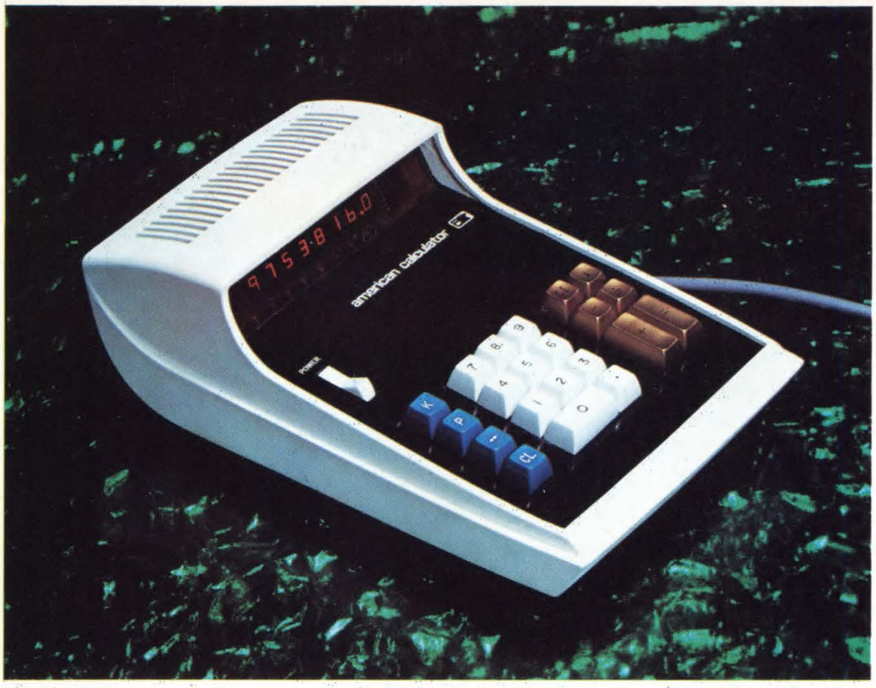


View of the uncased calculator reveals the construction simplicity, thanks to MOS/LSI and the light-emitting diode (LED) display of the new calculator. A large portion of the unit's weight is in the power supply transformer shown.



Close look at keyboard shows the K (multiply or divide by a constant select key), the P (select decimal 0-7 position key), the ↔ (shift to 8 most or 8 least significant readouts key) and the clear, numeral and function select keys.

houses—a house whose calculator line would be complemented by these low cost American made units.



Smart styling of new unit is apparent. Operation in any function mode is exactly as an individual would perform this operation in his head. Turn on power, select decimal position and proceed are all the instructions needed to perform the four functions of add, subtract, multiply and divide.

6 MOS/LSI Chips Hold the Key

Heart of this calculator is its six LSI chips. These include an input chip, a control read-only memory (ROM) chip, a control logic chip, a register chip, an arithmetic chip and an output chip.

The input chip receives input sequences from the keyboard. In performing this function, an input switch matrix is scanned to detect keyboard activity and a suitable bounce delay is generated when an input key is activated. The input chip also composes a 6-bit ROM address code (as a function of the input command) to be used as an initial address of a control sequence to be issued by the ROM. At the appropriate time, the address is transmitted to the control chip and input chip, then it waits until the control chip is not busy before honoring new inputs.

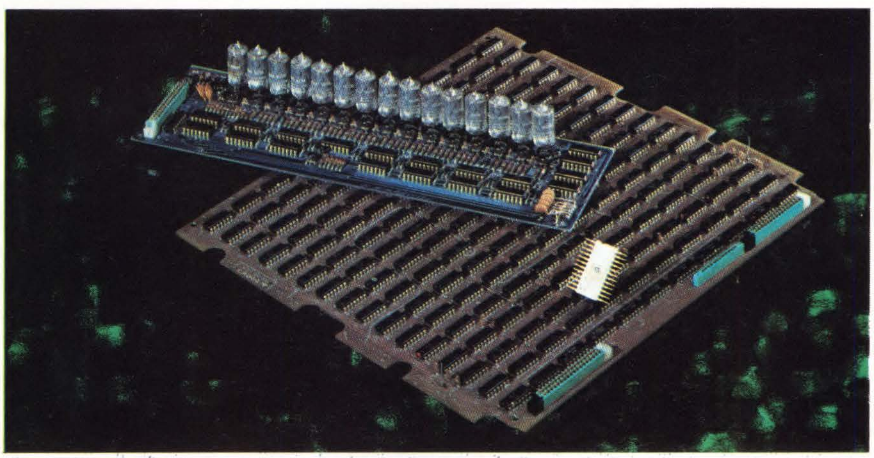
The control ROM chip contains the ROM which issues the basic control sequences that operate the calculator. There are 128 ROM words of 15 bits each. Each word contains a control bit pattern causing specific gating or data movements associated with a program step to take place. In addition, a portion of each word specifies the address of the next program step within the ROM.

The control logic chip contains counters that control shifting and accumulate digit counts during multiply and divide operations. ROM address sequencing control is provided by this chip.

The register chip is composed of three 64-bit shift registers, one 4-bit shift register and register selection gating logic. There are three 64-bit registers: (1) the accumulator register, (RA), (2) the input register, (RI), and (3) the multiplier/quotient register, (RQ). Each register has individual clear and right or left shift capability. The input register receives keyboard figures and acts as one input to the adder on the arithmetic chip. The accumulator accepts arithmetic outputs and the RQ register manipulates multiplier, divisor and quotient digits.

In addition to full BCD adder/subtractor and complementing units, the arithmetic chip contains sign and overflow flip-flops, a digit timing register, and synchronization circuits for the keyboard generated "clear" function.

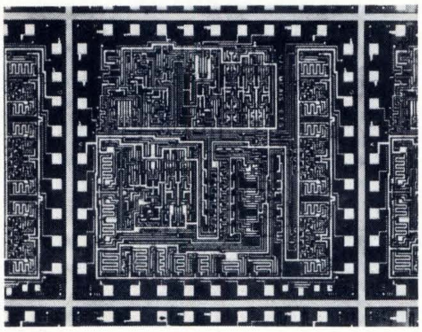
The output chip supplies signals for the BCD digit value to drive the display, as well as a signal for the decimal point display. Eight anode selection signals are sequentially activated to select one of eight positions for display. The calculator has the arithmetic capability to accumulate sums and products up to 16 digits. The 16-digit positions are viewed eight digits at a time by selecting an upper half register (most significant half) or a lower half register, (least significant half). In the upper half register, no decimal point is displayed, and leading zeros are suppressed. In the lower half register, leading zeros are suppressed until the decimal point position is reached.



One of six MOS/LSI chips used in the new calculator is compared to the 8-layer, 11- by 11-inch printed-circuit board predecessor that housed 176 discrete ICs. Complexity of display board used in the initial calculator also is shown. Use of LEDs has greatly simplified display board driver circuitry.

Ceramic LSI Packages

Simplified, room-temperature ceramic packaging methods for 36-pin LSI are reportedly being used by Toshiba in the production of electronic desk-top calculators. Pin spacing is EIA standard at 600 mils, and the multi-layer alumina package is claimed to have good hermeticity and high heat conductivity, while maintaining perfect isolation and maximum power. Previously, the maximum pin number that Toshiba had been able to package ceramically was 24.



'No Man's' Space

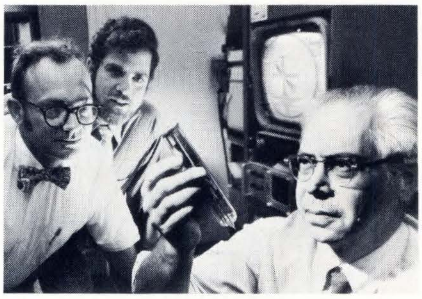
RCA is studying a new satellite, Atmosphere Explorer, to fly an orbit with a low point of 75 to 93 miles. This "no man's land", too high for observation by aircraft and too low for spacecraft, is the thermosphere where most of the sun's ultraviolet radiation is absorbed.

Sensitive Mike

An ultrasensitive microphone so sensitive it can "hear" the sound made by air molecules striking it was used recently at the David Sarnoff Research Center to evaluate theoretical predictions on the amount of sound caused by air molecules. Dr. Harry F. Olson's measurements show that the sound caused by the air molecules striking the ribbon diaphragm of the microphone was -6 dB below the threshold of hearing, which means that the microphone is more sensitive than the human ear.

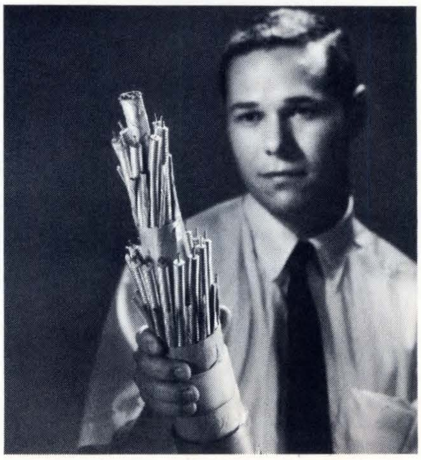
Tiny Pyramids

A new type of television camera pickup tube that offers high sensitivity and long life has been developed at the General Electric Research and Development Center. Application may be in "picture phones", where its sensitivity will permit it to operate in normal room lighting. The "Epicon" camera tube target consists of an array of millions of silicon semiconductors, tiny pyramids grown through the silicon dioxide layer, leaving only a small portion of the oxide layer exposed protecting it from electron influx. High temperature tube bake-out prolongs the life of the tube.



Cabled Coax

A 22-tube coaxial cable ultimately will carry up to 90,000 telephone calls simultaneously. In the new L5 cable system being tested by Bell Labs., basic repeaters spaced at 1 mile intervals will use hybrid thin film circuits for the first time in long haul communications.



Airborne Dialing

Newest user of the RF spectrum is "Jetphone", solid-state air/ground radiotelephone capable of automatic channel select and direct dialing service. A Motorola electronic package also provides manual channel selection, conversational quality, full duplex (no push to talk), compliance with Bell System specifications, compatible with pending automatic and existing manual ground stations.

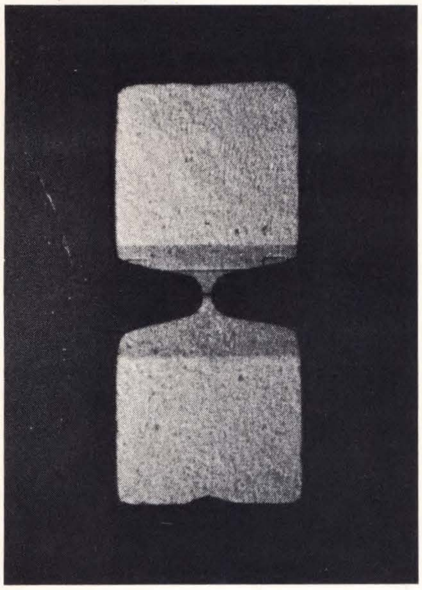
Around the Corner

Flexible imagescopes are helping helicopter crews with after-dark military missions. These fiber optic transmission devices, developed by Bendix Mosaic Fabrications Div. in Sturbridge, Mass. are part of the INFANT (Iroquois Night Fighter and Night Tracker) system. It works even in the absence of moonlight and starlight, with xenon searchlights to generate infrared light for illumination.

Tube Stores 'Snapshots'

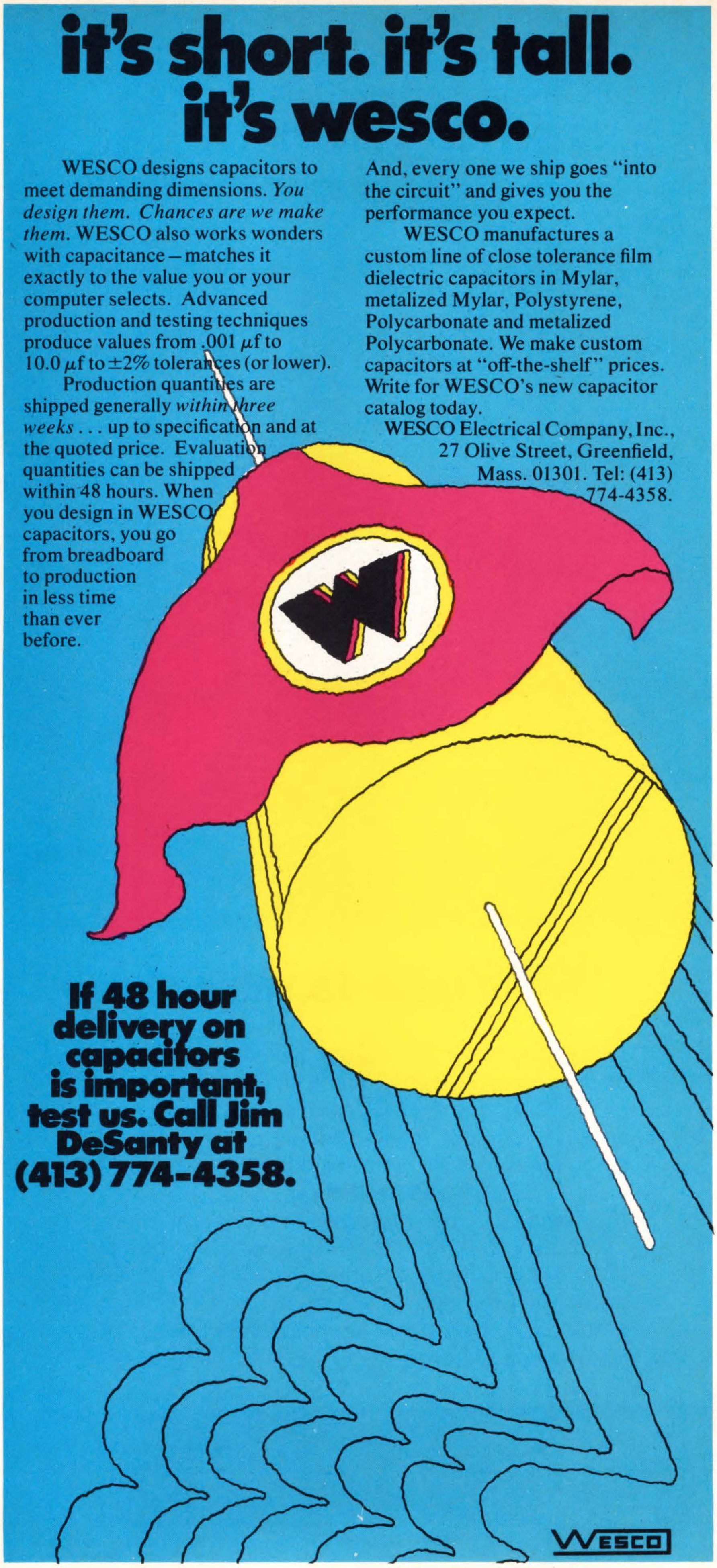
A small, vidicon-type device that can take and store single electronic "snapshots" is a new RCA development. The still picture, electronically stored in the tube, eliminates the need for an external storage medium such as film or videotape. It can be relayed to a TV monitor immediately or kept intact within the tube for several days. Initial beneficiaries are seen as closed-circuit television systems designed for use in data processing, business, education, defense and space.

Stress Sensitivity

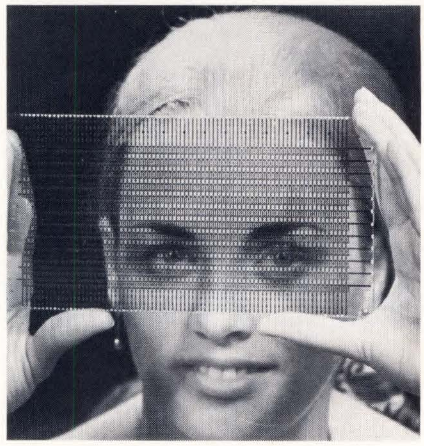


A junction-type strain transducer of new structure and principle claims more than 10 times the sensitivity of conventionally structured devices. A semiconductor with high specific resistivity is employed as a substrate, a rectangular thin plate silicon shaped and formed laterally with a sharp notched section at the midddle (see photo). Responding to both negative (tension) and positive (compression) stresses the structure's higher sensitivity makes it suitable for applications as a microphone and a phone-pickup. Other applications such as telephone transmitter and desk calculator keyboard elements are expected.

Matsushita Electric's new strain transducer is 1.8 mm in length, 0.8 mm in width, and 0.04 mm in thickness. It is fabricated so that n-type material is at one side and p-type is at the other side. Part of the n-region near the center is left with high specific resistivity. Total structure, therefore, is p-region (p^+) at the left high resistive-region (n) at the center and n-region (n^+) at the right.



Card Reader Is 4- by 8-Inch IC



Light-sensitive thin-film circuit developed by RCA for electronic reading of stationary punched cards is a form of integrated circuit on a glass substrate. Unit shown is laid out in 12 rows of 80 elements to match the 960 holes on a computer card. Each element in the sensor array consists of a "lateral-flow" photoconductor in series with a thin-film Schottky diode connected to mutually perpendicular address strips. Diode action results from dissimilar contacts to the photoconductor. Four sets of thin films are vacuum-deposited, as in smaller IC fabrication. Light source passes illumination through punched-card holes, is detected by photosensitive elements. Developers expect initial application as card reader for computer input, but point to exotic uses such as door locks in which a punched plastic card would act as the key and the photosensitive array would act as the tumblers of the lock.

Laser Heat Makes Photomasks

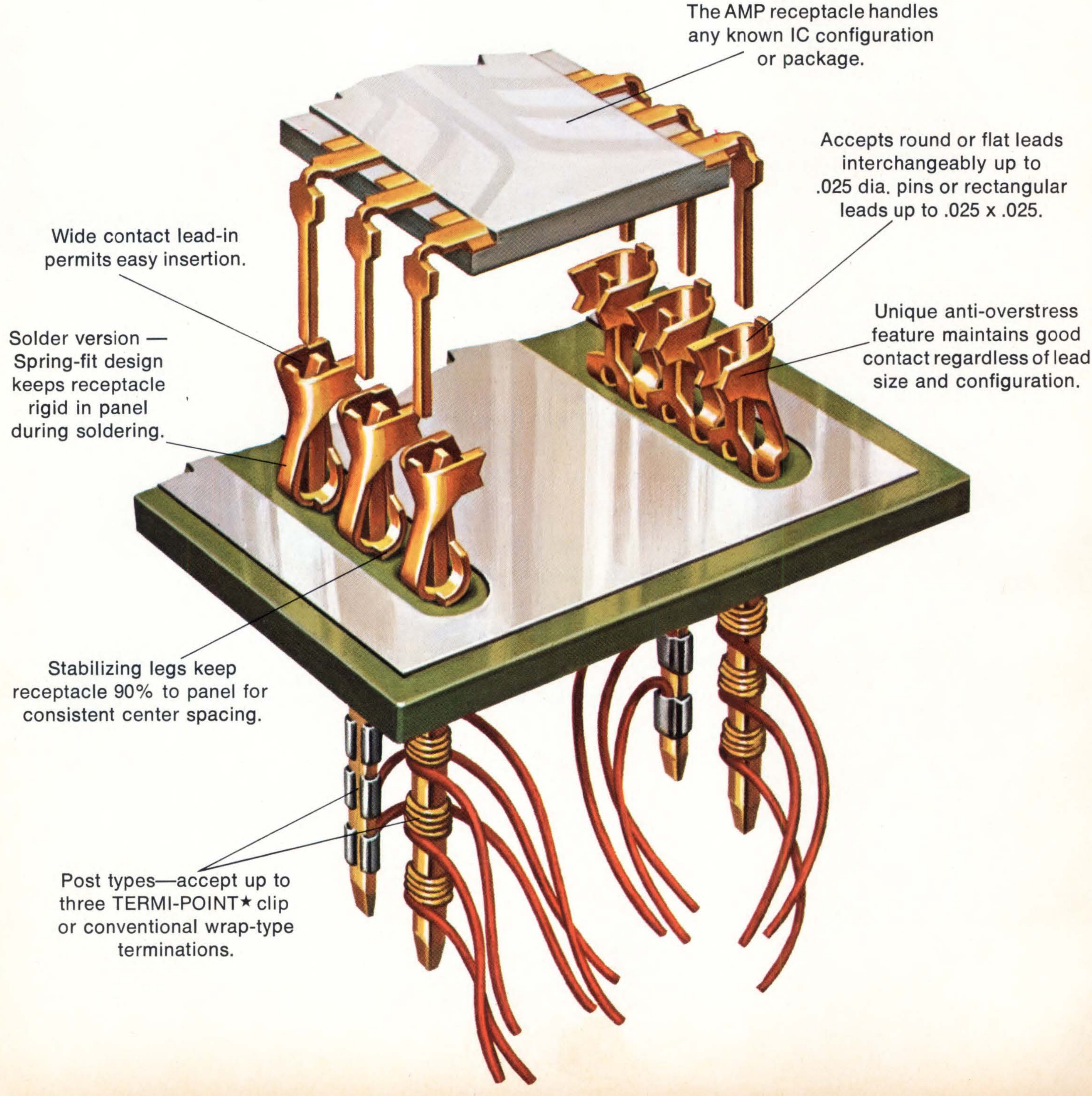
A powerful pulse of thermal energy, lasting only a few billionths of a second, can evaporate a metal image from one surface and precisely deposit it on another. The experimental technique, which uses a laser's heat rather than its light, was developed at IBM's components division in East Fishkill, N.Y. Technique of mass transfer permits direct and simultaneous production of both positive and negative photomasks, a time-consuming process normally requiring several image-reversing steps.

A glass plate, coated on one side with 1000Å of chromium, is sandwiched in a vacuum frame between a master mask and a clear glass plate. This assembly is then aligned at right angles to the optical path of a ruby laser which emits a 1-3J pulse of collimated radiation lasting 15 ns—just below the thermal diffusivity of the chromium.

When the beam passes through the windows of the master mask, it sublimes metal from the first glass plate according to the pattern prescribed on the master mask and deposits it on the second glass plate, thus making the first one a positive photomask and the second one a negative photomask. Several metals of sub-micron dimensions can be transferred by this method. At least a hundred such photomasks can be made from the same master mask without any distortion of the images, some only a few microns wide, say IBM spokesmen.

AMP IC receptacles difference in panels

A different kind of IC receptacle.



are where the starts.

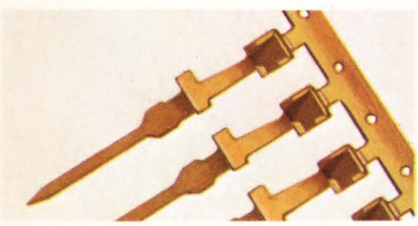
We don't stop there.

We've designed greater reliability into the critical receptacle portion of your panel designs, but that's only *part* of the difference in AMP's complete packaging panel capabilities. No other company offers the flexibility that AMP does in panels. We offer a tried and tested panel building technique and AMP's one-house responsibility to back it up.

Tell us what you want.

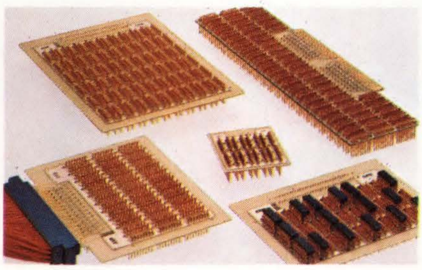
1. You build the panel.

If your requirements dictate that you build the panels, we don't just supply you with loose receptacles and let you tackle your production problems alone. The AMP IC receptacles are supplied with a carrier strip and special insertion tooling for high speed assembly to the board or panel. We've lived with panel production problems and we'll share the resulting know-how with you.



2. We build the panel.

Obviously, the same time tested know-how can be put to work in our plant to build standard or custom panels for you. The placing of the IC receptacles can be as random or uniform as you need. Remember, our receptacle can handle any IC configuration or package. Pictured below are several of the panels produced for our customers.



3. Either of us wire the panel.

For point-to-point wiring, AMP offers two basic types of panels. One for use with the versatile termi-point wiring technique and another for use with the conventional wrap-type techniques, for use in your plant or ours.

And the price is right.

Forget the usual claim that something better always costs more. The advantages of the AMP IC receptacle are available at a competitive, low per-unit cost, *plus* there are additional savings in our assembly technique.

For more information on the difference in AMP IC receptacles or our panel capability in general, write:

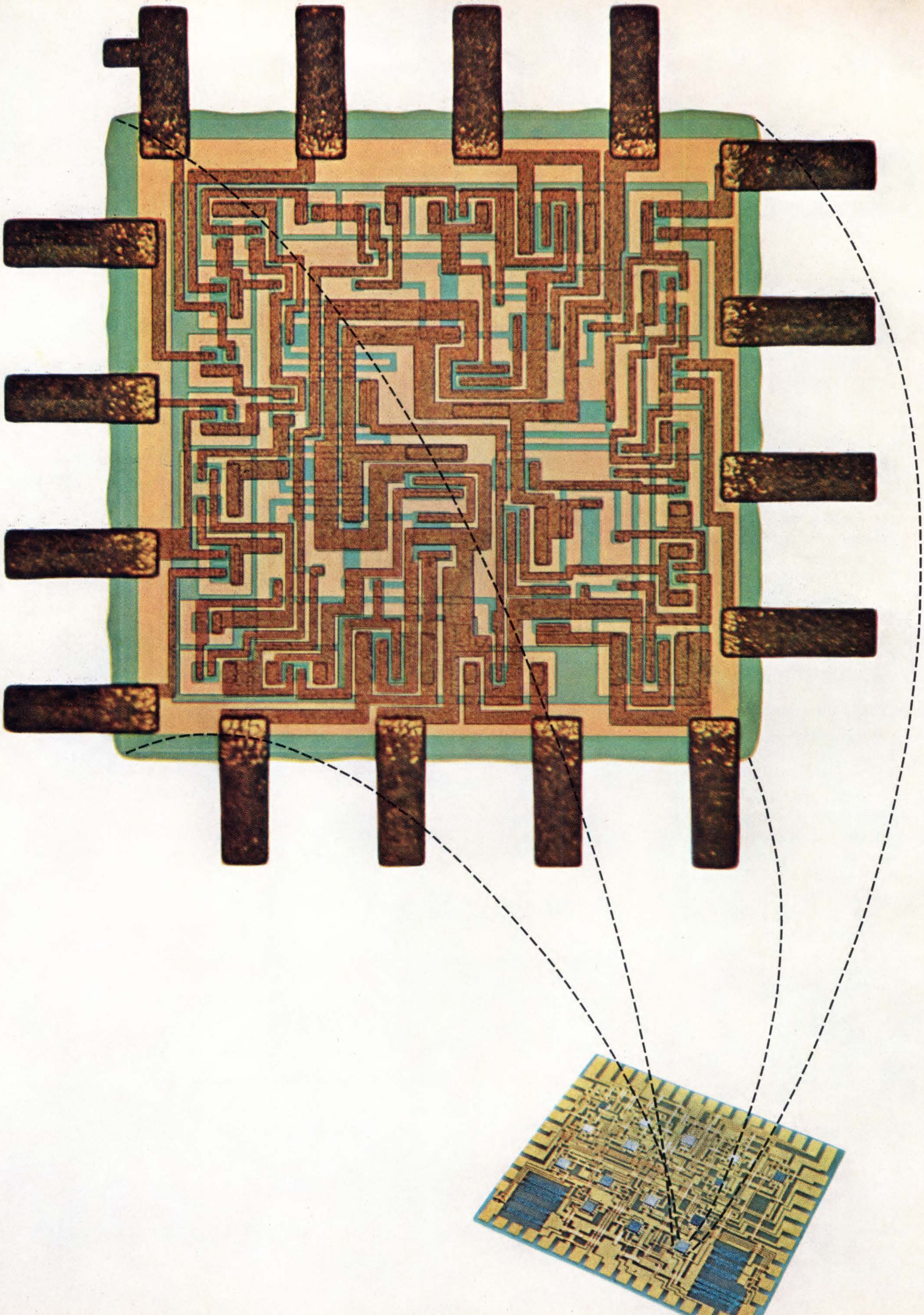
AMP Incorporated, Industrial Division, Harrisburg, Pa. 17105.

★Trademark of AMP Incorporated

See us at booth #1311
Fall Joint Computer Conference
Nov. 17, 18, 19.

AMP
INCORPORATED

CIRCLE NO. 17



Circuits and synergy

To fill a variety of communications needs, Bell Labs and Western Electric have worked together to develop a special kind of integrated circuit. Based on two compatible and complementary technologies—silicon and tantalum—this "hybrid integrated circuit" is hundreds of times smaller and more reliable than circuits using discrete solid-state components.

The silicon portions of the circuit contain active components such as diodes and transistors; some low-precision resistors and the necessary interconnections are also formed on the tiny silicon chips. Hundreds of these chips are fabricated on one silicon slice. Tiny gold conductors—"beam leads"—are formed on each chip at the same time. Then the chips are separated and the beam leads bonded to tantalum thin-film circuits. Typically no more than one or two square inches, tantalum circuits contain precision resistors, capacitors, and interconnections etched into the metal film, previously deposited on glass or ceramic substrates.

Hybrid integrated circuits open new opportunities for circuit designers in many areas of communications systems engineering—telephone equipment, transmission, switching.

In this hybrid integration technology, design and manufacturing are intimately related. Designer and maker must work closely together. The Bell System fosters this concerted action—this synergy—with Bell Labs, for research and development, and Western Electric for manufacturing and supply. At several plants Bell Labs and Western Electric engineers work together in Process Capability Laboratories, speeding new designs into manufacture.

Here are a few examples of their teamwork.

The tantalum portion of a hybrid circuit starts as a 2000-Angstrom layer of tantalum, deposited on glass or ceramic. This process, invented at Bell Labs, was first carried out in a vacuum under bell jars. Western Electric designed and built "open ended" machines. Now, deposition takes place as the glass or ceramic chips move through the machine on a chain.

For highest precision, newly formed tantalum thin-film resistors require adjustment. This is done by removing, electrochemically, just the right amount of tantalum to raise the resistance to the required value. Bell Labs devised the process; Western Electric computerized and automated it.

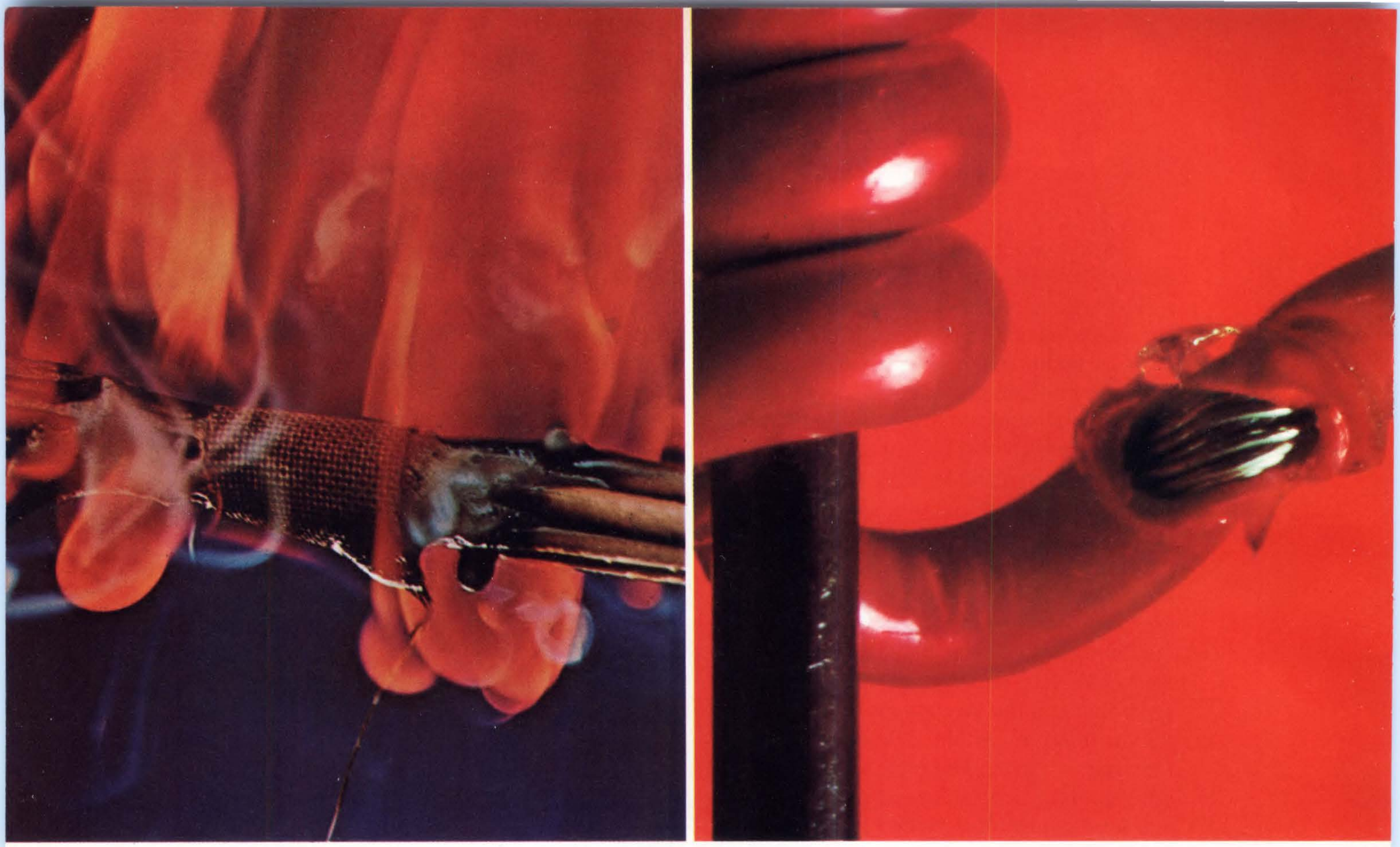
Silicon circuits are sensitive to impurities such as sodium ions in the air. So, they used to be sealed into expensive evacuated cans. But now, a gold and silicon-nitride shield gives the required protection at low cost. Originated by Bell Labs, it was put to work by Western Electric.

Making connections to integrated circuits once called for individual attachment of fine gold wires. Then Bell Labs came up with "beam leads": gold conductors plated into place on silicon circuits. In addition to being conductors, the leads also give mechanical support. Western Electric developed methods for bonding them to circuits.

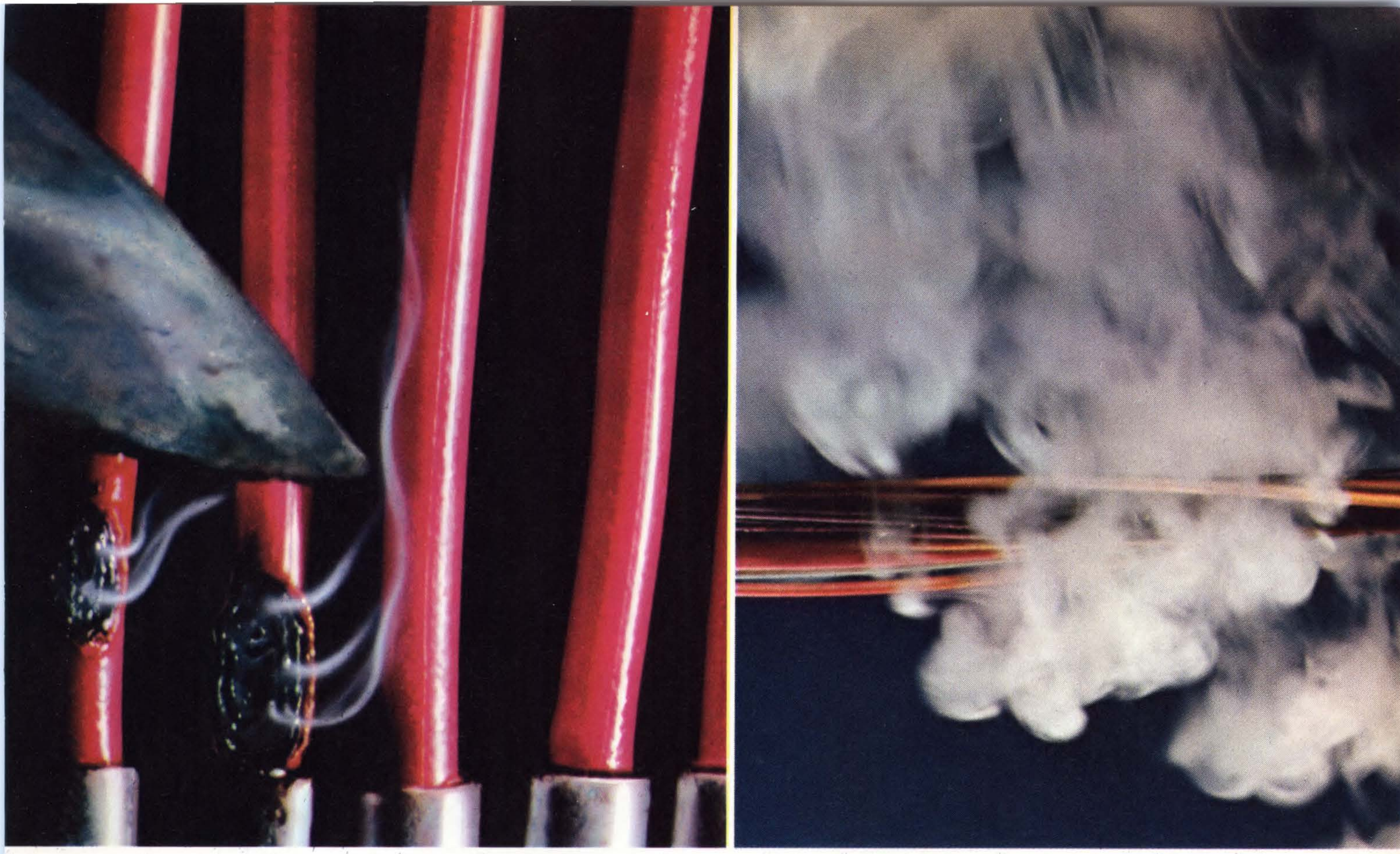
Beam leads are fabricated as part of the silicon circuit but their free ends must be attached to other circuitry. Bell Labs and Western Electric have developed thermocompression bonding techniques for this job. With the proper combination of time, temperature, and pressure all leads on the silicon circuit are bonded simultaneously to a thin-film circuit.

In the future, we hope to get more circuitry into less space and to find new functions for the technology. The circuit shown here, for instance, is one of some 200 logic "building blocks" for use in private branch exchanges, data sets, and other customer telephone equipment. It could not have been built with "discrete-component" technology. And we will not stop with silicon and tantalum. For other jobs, other materials may be better. Bell Labs and Western Electric are working together to find and apply them.

Bell Labs
Western Electric



In a world where things



like this can happen–

it's a good thing there's TEFLON.

Wire insulation of TEFLON: You can install it and forget about it. You can forget about the hazard of flammability, the hazard of embrittlement or stress cracking under thermal aging, the hazard of solder-iron damage during installation, the hazard of heavy smoke emission under electrical overloads.

You can count on this unbeatable combination of protective properties... and on superb electrical properties that remain unchanged over a wide range of temperatures and adverse environments. You can count on unsurpassed resistance to corrosives and chemicals. In composite constructions you can get whatever extra resistance to cut-through and abrasion you may need.

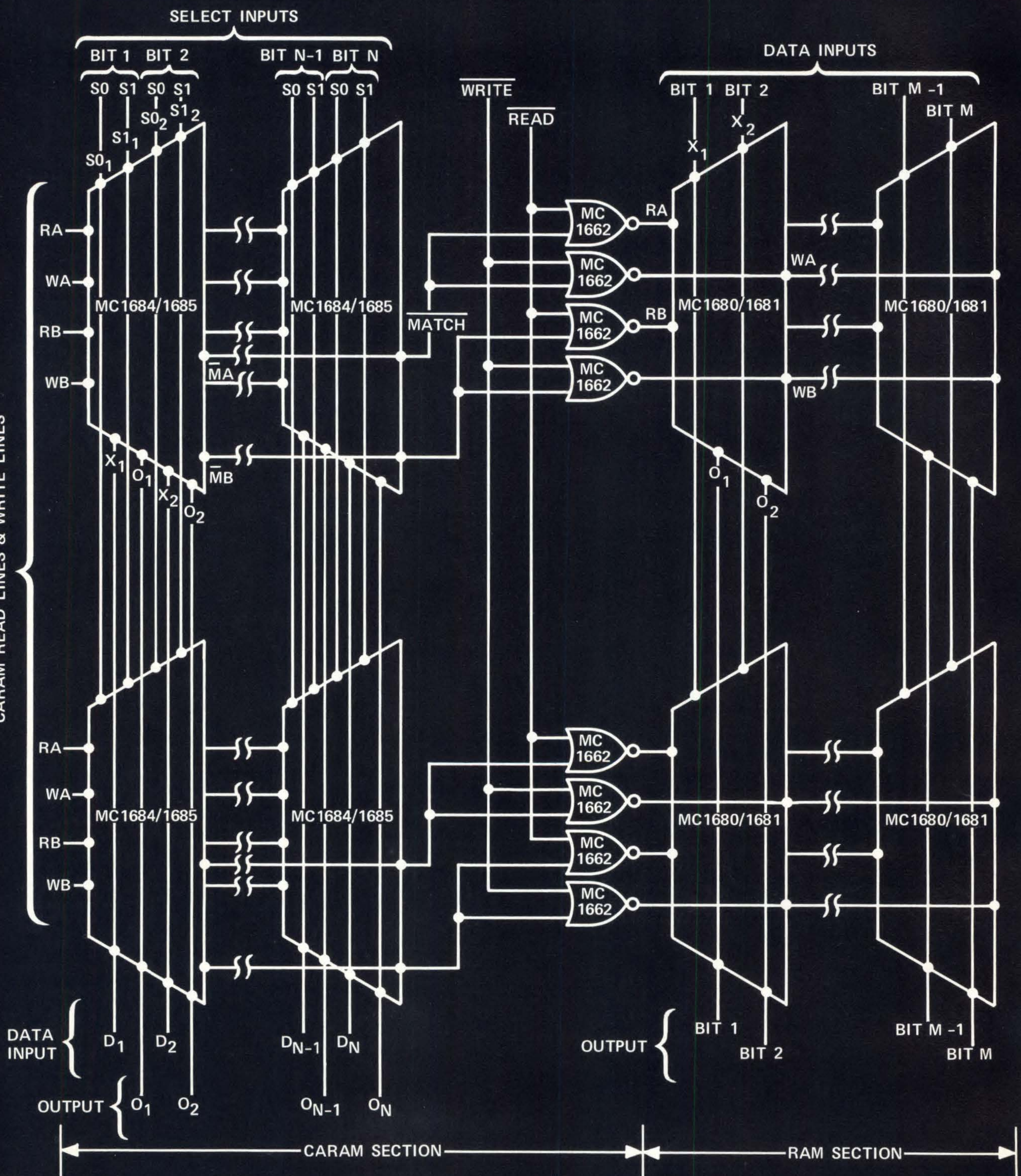
Consider insulation of TEFLON for any electrical, electronic or aerospace application that calls for reliability and dependable performance. Ask your wire and cable supplier about the type and construction that best meet your needs. For specific information, write us, mentioning the application you have in mind. Address: Du Pont Company, Room 8745L, Wilmington, Delaware 19898.

DU PONT
REG. U.S. PAT OFF

TEFLON®
fluorocarbon resins

CIRCLE NO. 12

FOR A FLEETING MEMORY . . .



CAM/RAM BUFFER MEMORY

. . . MECL III OFFERS THE FASTEST

Picture a computer with limitless storage capacity and instantaneous retrieval. Impossible? Today, yes — but new technologies are providing more rapid access to data, and performance of high-speed memory functions outside the main storage memory are paving the way to the ideal computer. MECL III now introduces three basic memories to meet state-of-art requirements for high-speed buffers and applications requiring rapid storage and transfer of data.

The MC1684 (High Z)/MC1685 (Low Z) Content Addressable Random Access Memory performs the read-write (scratch-pad) function *plus* the content addressable (interrogate-match) function. In other words, information may be written-in, read-out and the memory may be interrogated to check its contents. Typical read, write and search delays are 2.5-3 ns, 4 ns and 2.5-3 ns, respectively.

The MC1680 (High Z)/MC1681 (Low Z) Random Access Memory is sometimes called a decoded scratch-pad memory. Data can be entered or read out of the memory from either of two words simultaneously. Recommended for ultra-high performance applications, the MC1680/1681 features typical 2.5 ns access times and a write delay of 3 ns. Computer interrogation is speeded through application of the MC1682 (High Z)/MC1683 (Low Z) Content Addressable Memory. Sometimes called an associative memory, the MC1682/1683 features a search (interrogate) delay of 2.5-3 ns and a write delay of 4 ns, both typical values.

As illustrated, the MC1684/1685 CARAM and MC1680/81 combine to form a very high speed buffer memory. When a word is required from the mass storage memory, it is placed in the RAM portion of the buffer for future access. The word's address in mass storage is placed in a content addressable memory tied to the random access section thereby allowing words to be addressed by their mass storage location in one cycle time of the buffer memory.

As the address of the desired word is presented to the content addressable section, the CAM will indicate (in one cycle time) if the address is in the CAM and if the desired word is available in the buffer. If the word is present, the desired read and/or write function can be performed at buffer RAM speeds. If the word is not present it must be brought from the slow mass storage through 'push-down pop-up" techniques. Through the use of the CAM/RAM Buffer Memory, the effective access time is a function of the memory access sequencing and not the mass storage access time.

For further details on these high-speed memories write to Motorola Semiconductor Products Inc., P. O. Box 20912, Phoenix, Arizona 85036. Evaluation devices are available at your nearby Motorola distributor. MECL III provides the fastest memory functions available today. Design in and THINK FAST!

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The Digitest 500 gives you five functions and 17 ranges to choose from, five times the accuracy of the conventional VOM and overrange up to 100%.

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Take advantage of this limited-time offer now! Use the convenient reply card you'll find attached . . . for instant action.

Honeywell

CIRCLE NO. 18

THE AUTOMATED FACTORY —NECESSITY, NOT LUXURY

The electronics industry will be transformed almost beyond recognition by the end of the 70s by integration of design, tooling, production, test and shipment into one automated process, says Arthur S. Klaben, Project Director of Theta Technology's Electronic Manufacturing study program.

By 1980, annual sales of electronic manufacturing equipment in the U.S. will reach $2 billion, and 3/4 of this will be for advanced technology processes and equipment. Eighty percent of this equipment will be part of integrated, automated manufacturing systems or subsystems; therefore, producers of individual equipment components will find their fractional share of the market less than half its present value.

Labor and material costs will continue to rise and must be offset by accelerated improvements in productivity. Skilled manpower will be in chronic short supply and will be the limiting factor on production levels. Foreign competition will continue into other than consumer market areas if the U.S. electronics industry does not make full use of advanced automated manufacturing systems and processes to compete more effectively.

ICs and automation will not provide a magic cure to foreign competition, because foreign firms are automating more rapidly and using ICs in their products more extensively than are domestic firms.

Penetration of U.S. markets by foreign competitors need not be a one-way street, however. The total electronics sales market in Europe and Japan in 1980 may top the $52 billion predicted for the U.S., and the market for electronic manufacturing equipment overseas will nearly equal that in the U.S. Nearly 1/4 of this foreign equipment market can be captured by U.S. manufacturers if they are ready. One point that should be recognized by U.S. equipment producers who wish to serve these foreign markets is that they must offer and service complete manufacturing systems rather than individual component equipment. **Production results are what is wanted—not just equipment.**

Closer to home, a lesson might be learned from the Japanese emphasis on economy and reliability through standardization. In the IC assembly and packaging areas, the industry has fragmented its efforts, developing a wide variety of self-defeating methods with only marginal advantages. What the industry requires now is a limited number of versatile and reliable processes. This would accelerate the IC market at more competitive costs than a never-ending search for the technically satisfying "ultimate" process.

The basis of automated manufacturing systems rests on computers, both large and mini. Sales of dedicated computers, mostly mini, will reach $1.36 billion by 1974. Most of these will be associated with advanced manufacturing processes, automation and factory information and management systems. Programming costs are still a constraint on this industry segment.

Rapid growth is forecast for the automated test equipment market. With both product complexity and density growing (e.g., LSI), automated testing is the only possible approach, both physically and economically. To contain these costs, manufacturers are introducing more extensive testing in the early and middle positions of their production lines where process deviations and corrections are more quickly and economically established.

These are some of the conclusions reached in our comprehensive study and forecast just completed, titled "Electronic Industry Market for Advanced Technology Manufacturing Equipment, 1970-1980."

See Design Dataline p. 78 for details on the complete report.

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CIRCLE NO. 19

MONOLITHIC MAGNETIC DOMAIN MEMORY IS FOR REAL

A new technique using movement of magnetic domains in thin magnetic films promises to revolutionize many aspects of the memory business. Because it lends itself to simple batch fabrication processes and requires little electronics, it will be economical as well.

ROY W. FORSBERG, Boston Regional Editor

Design Features

Domain tip propagation logic is the proper name of a new memory technology, first shown to the public at the 1969 Fall Joint Computer Conference by Cambridge Memories, Inc., Newtonville, Mass. They call it DOT for short, standing for DOmain Tip. But just what is a magnetic domain memory and how old is it?

DOT is the outgrowth of study programs and research sponsored by the Air Force Cambridge Labs. at Hanscom Field 7-8 years ago. During the ensuing years, work fluctuated on this technology because of materials and fabrication problems and, perhaps, because its applications potential was not fully appreciated. With an eye toward the mass memory storage market, Cambridge Memories attacked and solved materials and fabrication problems. The key to success was found in low-cost, reliable, batch fabrication processes. Devices manufactured by these processes have wide operating margins and show no material changes in long-term like tests. First application will be shift registers up to 2000 bits long.

What Are Magnetic Domains?

Magnetic domains are tiny magnetic spots (**Fig. 1**) generated within a channel of magnetic material and

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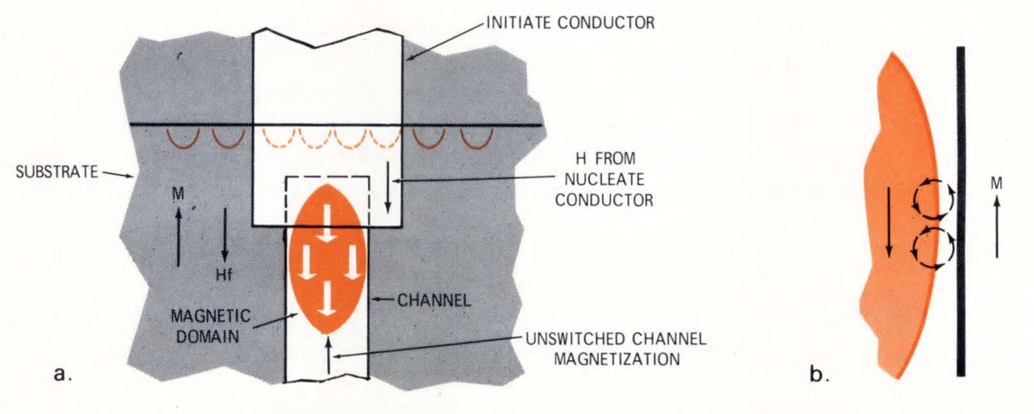

Fig. 1—**a. How a Magnetic Domain is Formed (nucleate).** Shown is a portion of the substrate, start of a channel, nucleate conductor, and one magnetic domain. The magnetic film was formed on the substrate in an ac field so that all magnetic particles are oriented in one axis, thus establishing an easy axis for further magnetization. Permanent background magnetization (M) is established prior to final device test by applying a high magnetization field pulse (50 Oe) to the entire substrate. A combination of high coercive forces and lower strength fields for propagation and erase (14 Oe) prevents any further changes in particle orientation outside the channel. During the nucleate cycle, a field pulse is applied to the entire substrate along with a slightly stronger pulse to the nucleate conductor. The field pulse is not of sufficient strength to overcome low coercive forces within the channel and nucleate a domain, but it is strong enough to propagate one, once it has been formed. However, fields under the nucleate conductor overcome the channel's low coercive forces and cause magnetic particles to become reoriented in a direction opposite to background magnetization outside the channel and unswitched magnetization within the channel. The resulting magnetic spot, called a magnetic domain, can be shifted along the channel and detected at will.

The channel does not extend to the edge of the substrate because the film coercive force is low there, and small residual domains could combine into a larger one during a propagate pulse, thus giving a false input.

b. Enlarged section of a domain wall. Since magnetic particles cannot change direction abruptly, there is a transition area of changing magnetization directions that makes up the domain wall. It is the friction of this wall that keeps domains from collapsing.

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(Continued)

propagated along this channel in a predetermined manner. The DOT technique controls propagation of domain tips within a low coercive force channel imbedded in a magnetic film of generally high coercive force (**Fig. 2**). Channels can be formed into many configurations so that they can act as diodes, can jump domains from one layer to another, cross one channel over another, perform logic functions and fan out to amplify the signal (**Fig. 3**). A zig-zag channel shaped like a string of diodes (**Fig. 4**) incorporates part of the shifting logic into the magnetic film, simplifying shift register operation.

In order to perform these functions, a propagation path must be produced in a magnetic film so that domains entered into the channel can propagate only in one direction along that channel (**Figs. 5, 6, 7, 8**). One advantage of this type of technology is that you can make domains fan out to produce more flux so that readout signal strength is as much as needed. (One mV is typical with a fan-out of five). This is in contrast to other magnetic memories, where as you try to make higher and higher density devices, the output signal strength diminishes.

What Can It Do?

The magnetic domain memory certainly won't compete with bipolar integrated circuits where speed is an important consideration, because propagation velocities are much lower, similar to thin-film technology (about 10^5 cm/s or 80 mils/μs). However, a DOT memory should be fast enough (1 MHz) to satisfy 95% of buffer memory applications which currently use MOS devices. Among DOT's advantages over MOS devices are: they are nonvolatile – if power fails, the memory will retain its content indefinitely; standby power is zero; and little power is needed during operation. Circuit design tricks such as parallel operation can make a DOT memory look faster than its maximum speed actually is.

Logic elements are made the same way as the channels, so logic, selection and decoding can be performed right in the memory structure. These devices, having very little electronics and very few interconnections, should lead to low-cost memories in terms of block organization.

Another feature of DOT devices is wide operating margins, about two or three times that of ferrite cores. The lower margin limit is the minimum field required to move or shift a domain, while the upper limit is the nucleation level. If the upper limit is exceeded, you will spontaneously produce information and get domains you don't want. The intrinsic nature of the material allows very small stable domains to be produced.

DOT devices are monolithic, formed on a single substrate made by simple batch fabrication processes (evaporating aluminum and polycrystalline magnetic films on glass). The process, having much wider tolerances and using only two masks, one for the channels and the other for control conductors (e.g., write, sense, hold, erase), is less critical than for semicon-

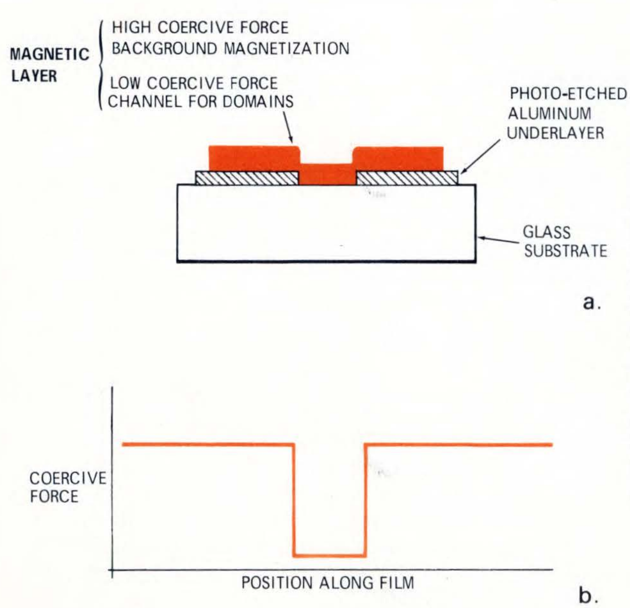


Fig. 2 – **a. Channel construction.** The entire substrate uses conventional batch fabrication processes. A layer of aluminum is evaporated on a glass substrate and etched by common photo-lithographic techniques. Photo-mask design determines the channel's shape and layout, which in turn depends on circuit functions desired. A layer of magnetic material is then evaporated over the etched aluminum.

b. This magnetic film exhibits a high coercive force in all areas surrounding the channel, and a very low coercive force within the channel. It is this difference in coercive forces that allows a domain to be formed within a channel, but not outside, and restricts the domain within the channel walls.

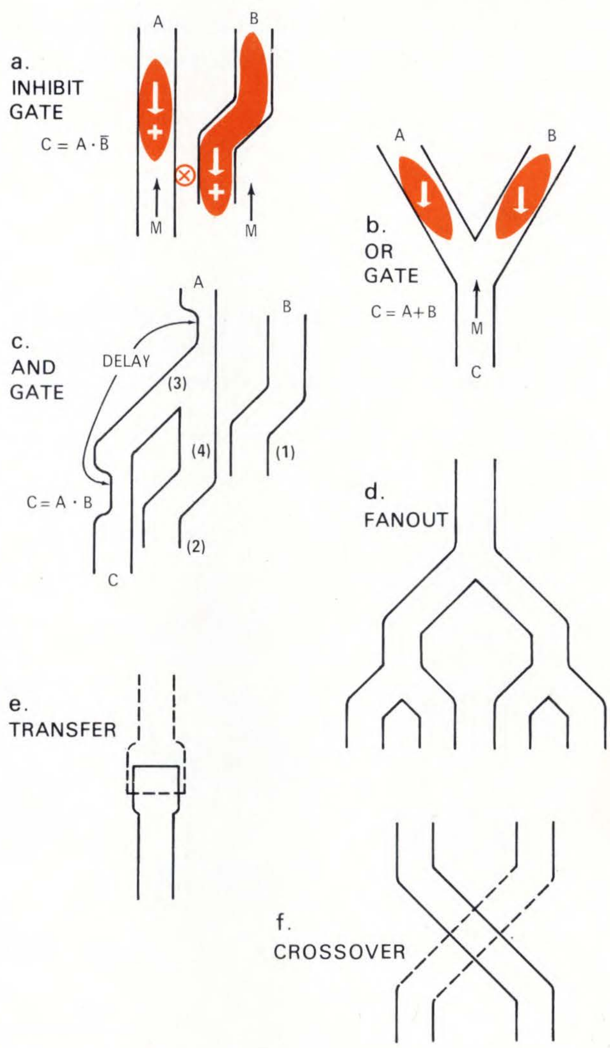


Fig. 3 — **Functions performed by magnetic domains**

a. Inhibit gate—At 'x' both domains repel each other, thereby allowing no output if B is true.

b. OR gate—Even if A and B are both true, they will not totally repel each other and one will get through to give an output at C.

c. AND gate—Domain A is always delayed so that it arrives after B, and the portion of A in the C leg is further delayed. These constraints, along with inhibit functions, make the AND gate work. If B alone is true, it will stop at (1) and there is no output at C. If A alone is true, it splits at (3) and the domain at (2) inhibits the one in the C leg, preventing an output at C. When A and B are both true, domain B inhibits the split domain A at (4) so that domain A in the C channel can propagate and become the output C.

d. Fan-out—This is provided at all read-out points. Fan-out capability is unlimited for amplifying domain signal flux.

e. Domain Transfer—When complex circuit functions like logic networks must be laid out in multi-layer substrates, the transfer function allows domains to jump from one layer to another much like a through hole in PC boards or vias in hybrid substrates. Notice that the actual transfer point is wider than the rest of the channel.

f. Crossover—Provided in multi-layer construction along with transfer in order to cross channels.

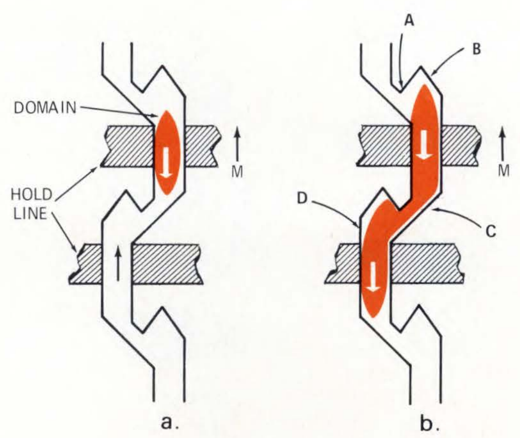


Fig. 4 — **The magnetic domain diode.**

a. The channel section shown is a diode. This shape allows domains to move in one direction only during propagation pulses.

b. Domains follow paths of least resistance and cannot make abrupt direction changes. During propagation pulses, domains will grow in all directions allowed by hi-coercive force channel walls. They are restricted in growth backward by the dead-end at B and narrow channel at A, but meet little resistance at C and D because of gradual direction changes (C) and increased area (D).

(Continued)

ductors. Storage density is high at about 4000 bits/in^2 right now, with future goals of 8000 to 16,000 bits. Output amplification is unlimited using fan-out techniques, thus requiring little electrical amplification. Magnetic domain memories also appear to be insensitive to radiation, temperature, shock and acceleration.

Applications:

Besides a shift register, DOT can perform such functions as decoding, arithmetic, digital logic, storage, counting and timing. It can be built as a random-access memory, read-only memory and associative memory, all with nondestructive readout. By combining about 1000 substrates and sharing associated electronics, it is possible to build a mass storage device which would end up looking like a magnetic disc memory, except that it is not mechanical (no moving parts) and it has much shorter latency time. It would give immediate access to a block of information and work at high data rates, faster than current disc memories.

Because inputs and outputs can be either parallel or serial, an electrically alterable ROM could be built easily, with little modification of the basic memory construction (**Fig. 9b**).

Other applications such as an automatic telephone dialer could be built easily and inexpensively (**Fig. 9a**). ▭

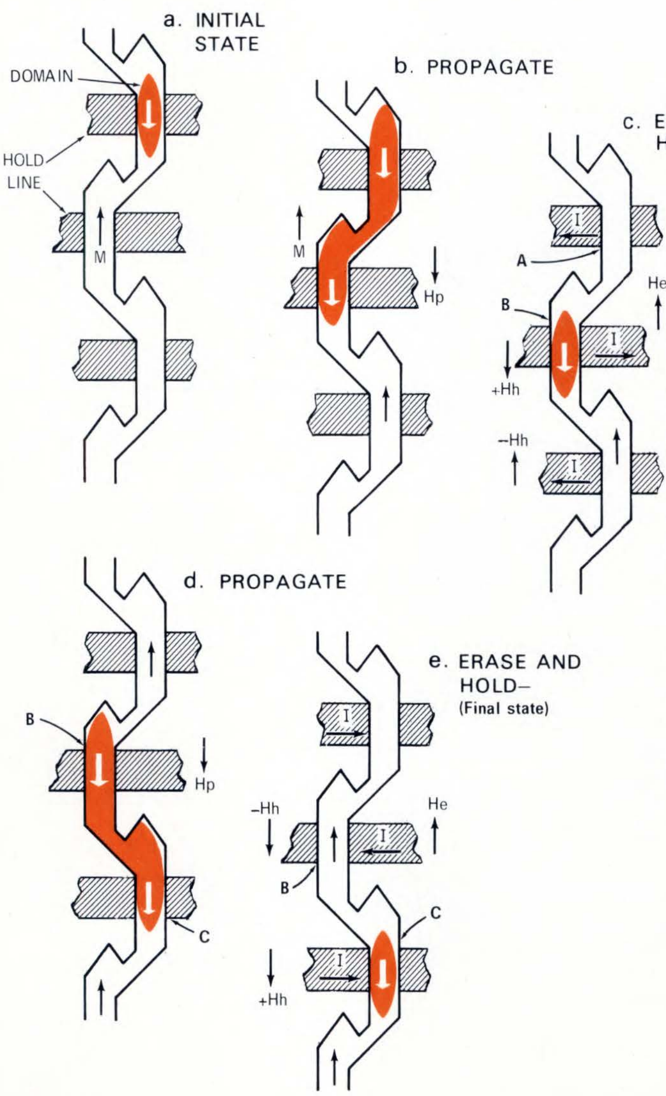


Fig. 5 – **Propagation sequence during one shift cycle.**
a. Domain already in channel. Hold line shown in three places is one continuous loop (**see Fig. 6**) so that each adjacent line is opposite in field polarity when the entire line is pulsed.
b. Propagate field pulse applied (Hp). The domain tries to grow in all directions but must grow as shown because of channel restrictions.
c. Erase (He) and hold (+Hh) pulses are applied simultaneously (**see Fig. 7**), He being opposite in polarity to Hp. The domain at A is erased because its polarity and the combined He and Hh are different. The domain remains at B because He and Hh cancel each other.
d. Second propagate pulse grows domain again to bring it to its final shift position (C).
e. This time the applied hold (Hh) pulse is negative to hold the domain at C, otherwise it would return to B. At C, Hh and He cancel allowing the domain to remain while at B, Hh and He combine to erase it. This completes one full shift cycle.

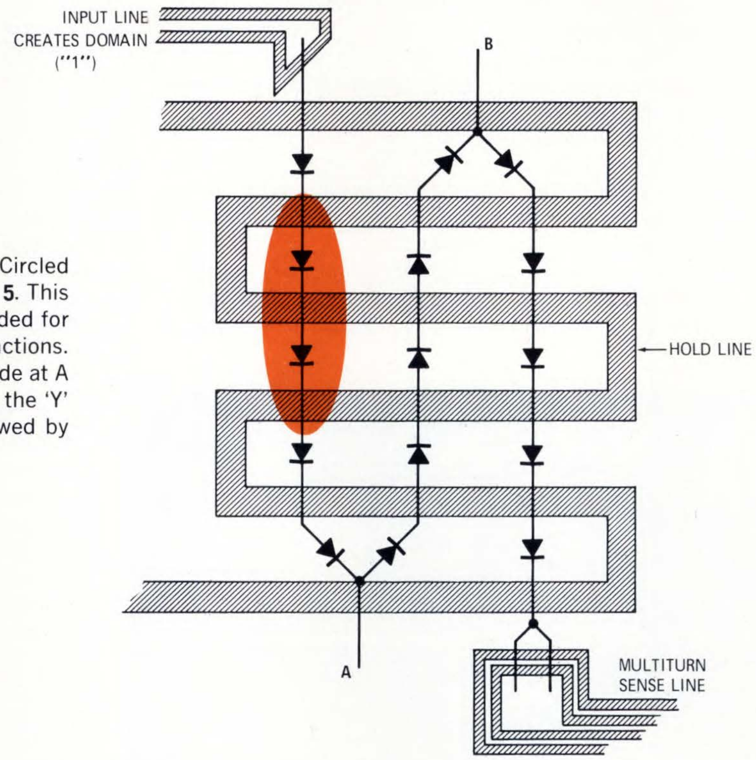


Fig. 6—**Electronic equivalent of DOT circuit.** Circled area represents circuit section used in **Fig. 5**. This circuit is a simple one that could be expanded for greater capacity or to perform logic functions. Note how an abrupt direction change is made at A and B. The growing domain fills the tail of the 'Y' and then propagates in the direction allowed by the diode.

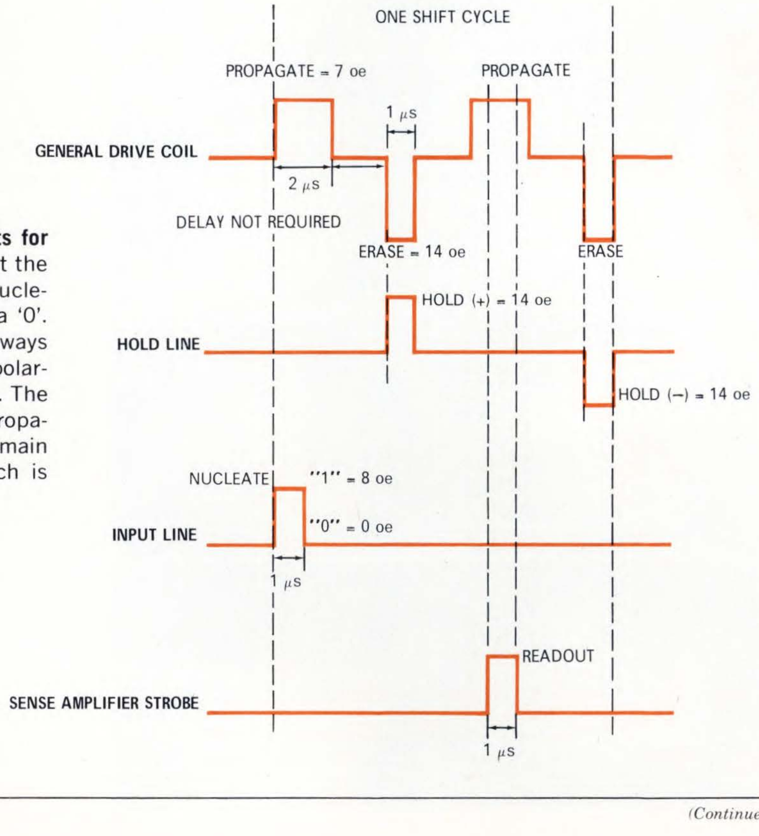


Fig. 6—**Timing diagram and field requirements for diode shift register.** The input line is pulsed at the start of a cycle if a "1" is to be entered. This nucleates a domain. There is no input pulse for a '0'. Note that propagate and erase pulses are always plus and minus respectively while hold pulse polarity alternates so that the domain shifts along. The sense amplifier is strobed during every other propagate pulse to check for the presence of a domain which represents a '1' or the absence which is a '0'.

(Continued)

Domain Memory (Cont'd)

DATABANK

1. K. D. Broadbent, *Transcript—Institute of Radio Engineers on Electronic Computers*, EC-9, No. 3 pp. 321-323 September 1960. Describes a magnetic thin-film shift register using domain wall displacement in a magnetic thin film by means of a 3 ϕ conductor system.

2. H. Rubinstein, T. L. McCormack, H. W. Fuller—*Proceeding from Solid State Circuits Conference 1961*, p. 64. Describes a technique for controlled positioning of domain walls corresponding to binary information in a magnetic thin film and a method of reading out this information.

3. R. J. Spain, H. I. Jauvtis, H. W. Fuller—*Journal of Applied Physics* Vol. 36, Part 2, p. 1103 (1965). Describes new thin-film shift register designs based upon sidewise domain wall motion.

4. R. J. Spain, H. I. Jauvtis—*Journal of Applied Physics* Vol. 37, p. 3584 (1966). Describes the application of domain tip propagation in thin films for construction of a shift register device, and performance of logic using such techniques.

5. R. J. Spain, M. J. Marino, H. I. Jauvtis—*Proceedings from Spring Joint Computer Conference*, Vol. 30, p. 491 (1967). Describes a Push-Down List memory (PUDL) based on DOT shift registers.

6. A. J. Perneski, A. H. Bobeck, R. F. Fisher—*1967 Intermag Conference*, Amsterdam, April 1969. Describes shift register devices based upon "bubble" techniques in ortho-ferrites.

7. R. J. Spain, *NEREM Record* 1969, Vol. 11, p. 184. Discusses and compares different types of monolithic sequential magnetic memories.

8. *EDN* Sept. 15, 1969 p. 18-19. Describes different types of "bubble" techniques in ortho-ferrites.

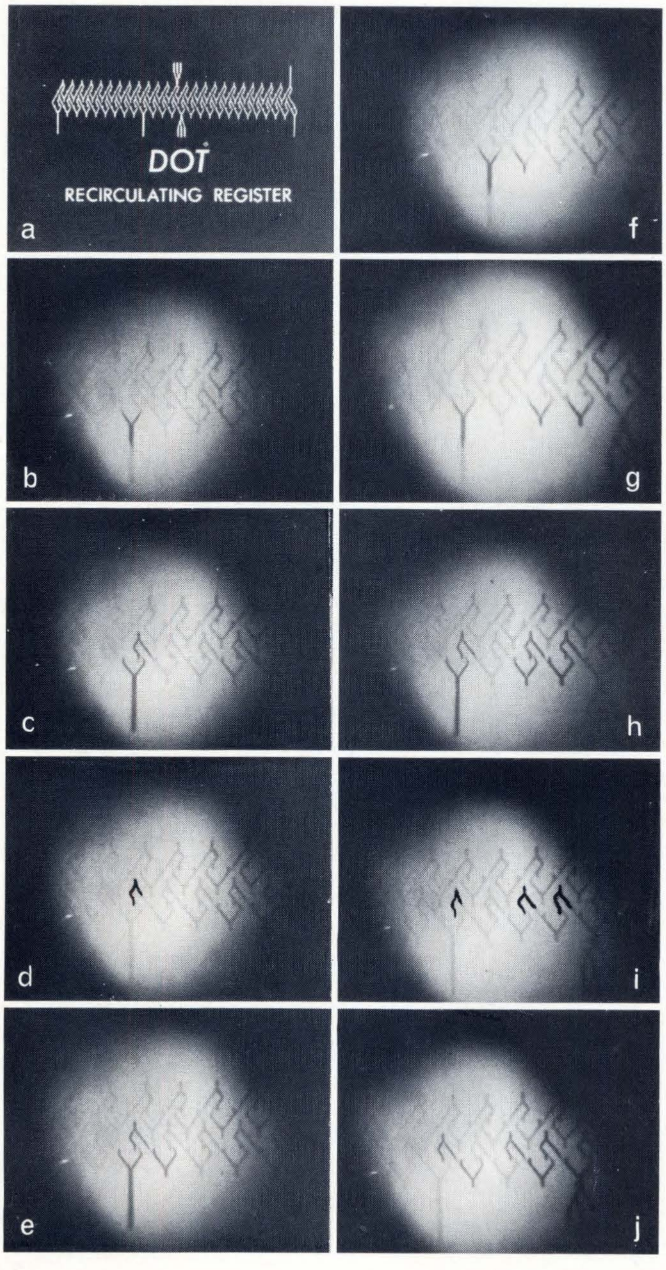


Fig. 8—**Movement of magnetic domains through a recirculating shift register.** These photos were taken through a microscope using polarized light (Kerr effect) to make the domains visible. Domains will move in a horizontal direction vs vertical directions previously illustrated. Hold lines are beneath the substrate and not seen so that these photos could be taken.

a. Four possible input positions and two output sense positions are shown in this shift register. The remaining photos show only the section directly above and a little left of the word DOT.

b. First domain having been nucleated at the input just to the left of the word DOT is being held in its intermediate position during the initial erase and hold (+) pulses of cycle 1.

c. Second propagate pulse of cycle 1 grows domain in all directions allowed by channel geometry. Note that the domain is changing direction at the diode top.

d. First domain during erase and hold (−) pulses is in its final position at end of cycle 1.

e. Nucleation of second domain. Note from timing diagram, **Fig. 7**, that nucleate pulse coincides with propagate pulse and that domain No. 1 has grown to a new position at start of cycle 2.

f. First and second domains are in intermediate positions during erase and hold (+) pulses of cycle 2.

g. Photo skips to the erase and hold (+) pulses of cycle 4 showing three domains, representing binary 1, 1, 0, 1, held in intermediate positions.

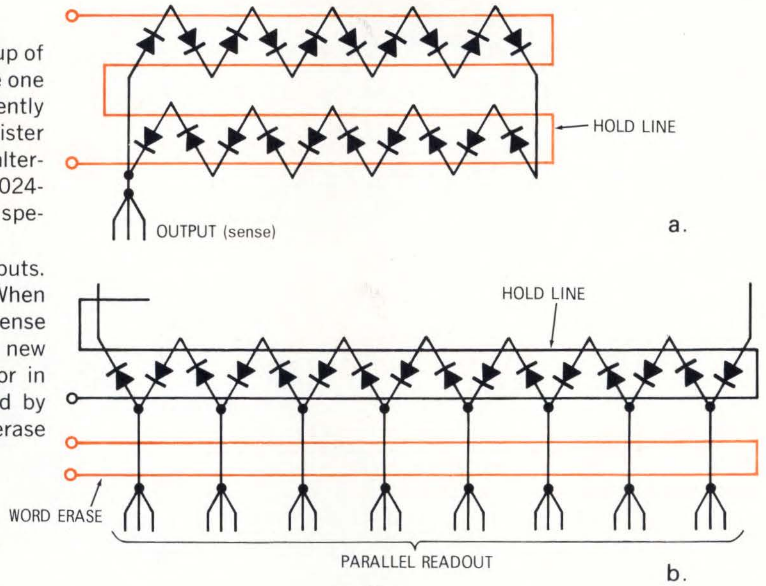
h. Domains grow up and right during second propagation pulse, cycle 4. None have reached the sense amplifier so it will read no output as it is strobed on this cycle.

i. Domains in final positions of cycle 4 during hold (−) and erase pulse.

j. Start of cycle 5. Domains have grown down and right with first domain just entering the sense amplifier. It will not be sensed until the second propagation pulse of this cycle (**per timing diagram Fig. 7**). Next pulse is hold (+) which holds domains in lower channel positions as in photo **b**. The second propagate pulse will regrow domain 1 shifting it up and right, and also back into the sense amplifier since there is no blocking diode (see photo **c**). Note that a '0' is now being entered in the input line as opposed to a '1' shown under the same conditions in photo **e**.

Fig. 9—**a. Automatic telephone dialer** is made up of a series of recirculating shift registers like the one shown, with a separate phone number permanently written into each register. The proper register would then be selected by a pre-set code. An alternate method would be to code numbers in a 1024-bit shift register, but this method requires a special comparison circuit.

b. Electrically alterable ROM with parallel outputs. Only output stages of the memory are shown. When all eight domains of an 8-bit word are in the sense amplifiers, the word erase line is pulsed. A new word can now be written in, either serially or in parallel. The entire memory could be cleared by interrupting the hold pulse during a regular erase pulse.



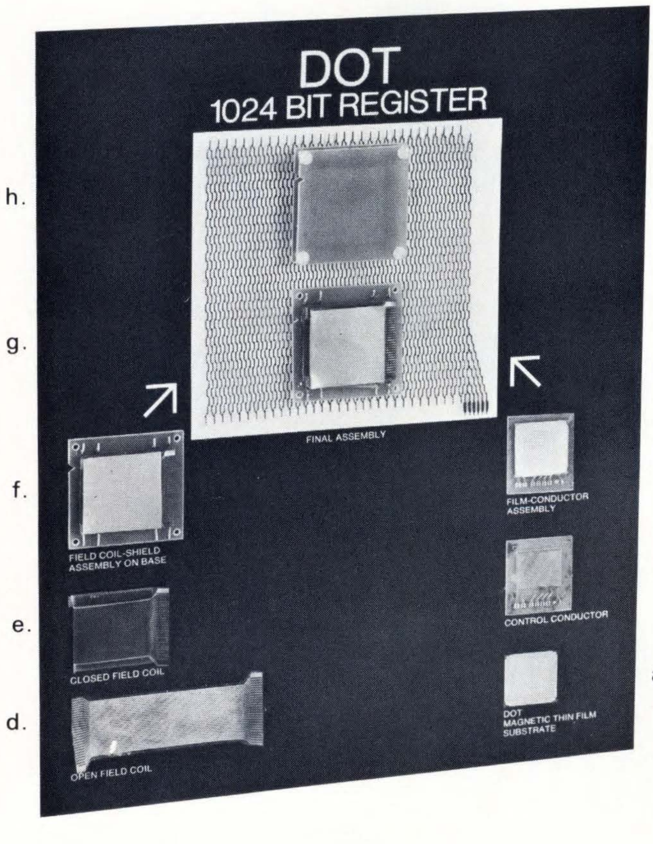


Fig. 10—**Assembly of Shift Register.** The magnetic thin-film substrate (**a**) with channels already formed in it is mounted on PC card (**b**) containing control conductors, and the two are bonded together (**c**). The film-conductor assembly (**c**) is placed within the open field coil (**d**), and when the ends are bonded together (**e**) the conductors meet to form one continuous coil wrapped around the film conductor assembly. A magnetic shield is added to (**e**) and both are mounted and bonded to the base card (**f**). Wire connections from base pins to control, field, nucleate, and readout conductors are made (**g**), and finally a protective cover is added (**h**).

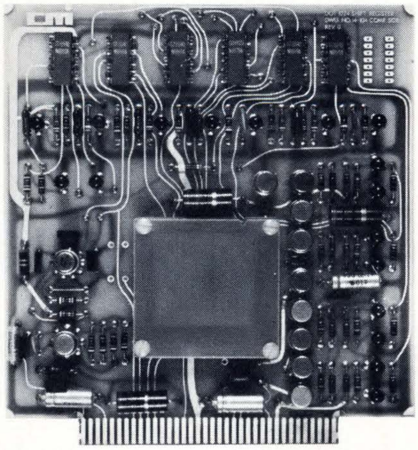


Fig. 11—**Complete shift register with associated electronics.** Shift register assembly from **Fig. 10** mounts on 6- by 5-1/2-in PC card containing all necessary electronics (timing, buffers, logic, drive, and sense). Base pins fit holes on master PC card and entire assembly is then soldered in one operation.

FOR A FREE REPRINT OF THIS ARTICLE, **CIRCLE NO. L61**

PLASTIC ICs ENTICE MILITARY

Can economical plastic-encapsulated ICs meet military requirements? Recent reliability tests show that the silicone-plastic package holds promise.

EUGENE R. HNATEK, National Semiconductor Corp.

Although the plastic-encapsulated IC has found a comfortable niche in the commercial/industrial marketplace, the military has been reluctant to accept it. Until now, the military standoff was well justified. There just wasn't enough reliability test data to warrant using plastic ICs—and the few early tests that were performed showed that the plastic package was not moisture resistant.

Why should the military be interested in plastic-encapsulated ICs? One good reason is cost—plastic packages are much less expensive than hermetic types. More important, however, are the results of recent reliability tests. These tests, discussed in the ensuing paragraphs, show that the plastic package, specifically silicone, holds promise of fulfilling many military applications.

Evaluating Plastic Protection

About two years ago, the reliability and economy of plastic-encapsulated ICs came under intense scrutiny by the military and other Government agencies. Since then, there has been a growing effort by the military and IC vendors to characterize the reliability of plastic packages. Rome Air Development Center (RADC) has been the leader in the IC reliability drama, with semiconductor firms playing important supporting roles. As the drama unfolded, RADC played the devil's advocate—while semiconductor firms ardently conducted

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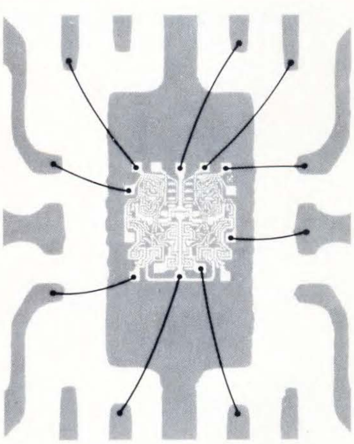


Fig. 1

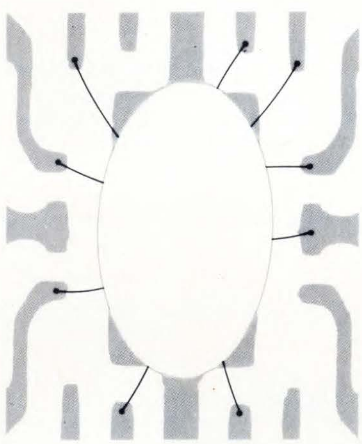


Fig. 2

Fig. 1.—**Interlocking mechanism** designed into the gold-plated Kovar lead frame adds strength to the ICs lead bonds by preventing lead movement during any device handling operation.

Fig. 2—**Silicone-polymer conformal coating** surrounds IC to enhance protection against hostile environments.

(Continued)

reliability tests on plastic packages. One of the firms, National Semiconductor Corp., has just completed a series of reliability tests on ICs packaged in epoxy and silicone plastics. With these test results, they hope to convince the military to accept the silicone-plastic package.

Before looking at these test results, let's first consider what an IC package must accomplish. Basically, the ideal package will protect the IC from a hostile environment, dissipate internally-generated heat—and provide a means for connecting the IC to the outside world. As far as these last two requirements are concerned, there's not much difference between the plastic-molded package and its hermetic counterpart. Both types dissipate heat and provide for external connections. When it comes to protecting the IC, however, the hermetic package with its internal cavity has had an historical superiority over the plastic package. To overcome this inadequacy, plastic-encapsulated ICs have had to incorporate an added measure of protection.

In evaluating plastic packages at National Semiconductor, the standard gold-plated Kovar lead frame with individual locking mechanisms was used (**Fig. 1**). As an added measure of protection, two types of silicone-polymer were used to coat the IC (**Fig. 2**). This conformal coating also serves to isolate the IC from the lead frame. After the conformal coating cured, the units were molded in epoxy or silicone—and were finally subjected to a series of mechanical and electrical stress tests. Results of these tests, performed on a sample of 900 devices, are summarized in **Table 1**.

For comparison, **Table 2** depicts the test results separately garnered by RADC. The RADC tests were performed on a sample of 2500 devices which included phenolic as well as epoxy and silicone packages.

Silicone Is Superior

As **Tables 1** and **2** show, silicone provides better moisture resistance and better mechanical properties than epoxy or phenolic. The salient features of the superior silicone package are:

a) *Gold-plated Kovar lead frame with internal-locking design* to provide strength for the finished device.

b) *Inert silicone-polymer conformal coating* that completely surrounds the semiconductor die. Apart from enhancing the protection of the die, this conformal coating also provides a close thermal match with the outer transfer-molded plastic—and further acts as a

	PERCENT OF DEVICE AND PARAMETER FAILURES	
	EPOXY	SILICONE
Temperature Cycle: −65 to 150°C (30 min each temperature), 50 cycles	19	10
Thermal Shock: 0 to 100°C (1 min at each temperature extreme), 50 cycles	11	6
Pressure Cooker, D1 water at 100°C, 15 psi, 1 h/cycle	16	4
Moisture Resistance: Mil-Std-202C, Method 106	27 (30 cycles)	10 (50 cycles)
Life Tests after 240h	58	44
***Storage at 200°C**	50	41
***Operator HTRB at 125°C**	24	14

The above test results were obtained on a sample size of 900 devices. Looking in depth at a sample size of 100 devices gives a more definitive picture of the failure modes as follows:

	EPOXY	SILICONE
Temperature Cycle −65 to 15°C, 50 cycles	19 opens, greatly increased leakage	10 opens, constant leakage
Thermal Shock 0 to 100°C, 1 min at temp extreme (liquid to liquid)	11 opens, large leakage increases	6 opens, steady leakage
Pressure Pot, D1 water at 100°C and 15 psi, 1h each cycle (sample size: 50 each type)	8 excessive leakage failures	2 excessive leakage failures
Moisture Resistance, Method 106, Mil-Std-202	50 opens, 22 leakage failures	No opens, 10 leakage failures
Life Tests after 240h (samples size: 50 each type) **Storage at 200°C**	10 opens, 19 parameter failures	10 opens, 11 parameter failures
High Temperature Reverse Bias Operating test at 125°C	3 opens, 9 parameter failures	3 opens, 4 parameter failures

	PHENOLIC DTL (%)	EPOXY DTL (%)	SILICONE DTL (%)	SILICONE DTL (%)
Life Test: relative humidity, reverse bias at 1500h and 150°C	7.8	4.0	2.0	0
Pressure Pot: percent of weight gain	1.02	0.88	0.08	0.13
Pressure Pot: 24h	4.2	96.0	4.0	0
Thermal Shock: 240	4.6	62.5	4.0	0
Moisture Resistance: 168h 85°C, 85% relative humidity	1.0	0	0	0
Sample size: 2500 units.				

NOTE: Early package design problems, which have since been corrected, caused the difference in failure rates between the silicone DTL devices of LOT A and LOT B. The reliability figures of redesigned silicone DTL package now compare with those listed for LOT B.

mechanical buffer between the lead wires and the rigid package body.

c) *Transfer-molded silicone* body (Dow Corning 306) that provides outer protection, dissipates internally-generated heat and adds the necessary mechanical strength to the finished package.

Though silicone by itself presents a moisture-absorption barrier, the die receives its important moisture-resistant protection from the silicone-polymer conformal coating. Even when a certain amount of moisture penetrated the outer silicone body, it never reached the die area because of the internal protective coating. Moisture-resistance stress tests, both biased and passive, have proved this point, and the pressure-pot test series backs up this conclusion. As for mechanical integrity, the test results have proved the advantages of incorporating an adequate locking mechanism into the lead frame design. With the internal locking mechanism, the failure mode for opens has become negligible.

When the salient features of the silicone package are combined with in-line screening (visual inspection, wire pull and 100% temperature cycling)—the final product has reliability characteristics that should make it suitable for a host of military applications.

Because of silicone's superior performance during reliability tests, National Semiconductor now extensively offers the silicone-molded package for all of its ICs. **Tables 3** and **4** depict additional test results for several of National's digital ICs that were housed in silicone dual-in-line packages. In addition to these results, National Semiconductor has a 95% humidity test in process with an accumulated operating time that exceeds 4000 hours—without a single silicone package failure.

Salt Spray—The Achille's Heel

During the IEEE Reliability Physics Symposium (April, 1970), RADC proposed a set of tests for plastic-encapsulated ICs (see box).

These tests could catalyze military acceptance of plastic packages for all but the highest reliability applications such as Apollo or Minuteman. Although these tests are a step in the right direction, they are somewhat less than realistic. A case in point is the requirement to withstand a salt-spray environment —which just happens to be the "Achille's heel" of the silicone package. It seems unreasonable to make a blanket salt-spray requirement when there are many military applications that never get near the ocean.

It appears that the RADC criteria have been so structured that no single plastic package can meet them all. Silicone does well on everything but the salt-spray environment. And, although epoxies and phenolics can pass the salt spray requirement, they fail the moisture resistance and pressure cooker tests. A more realistic approach would take into account the specific application of the ICs. Rather than establish a rigid set of criteria for *all* military programs, it would seem more practical to select only those criteria essential to a *specific* program.

Because of the recent reliability tests, many users are beginning to consider the more realistic approach. McDonnell Douglas, for instance, has been evaluating plastic ICs for use in the F-15 program. Though the firm is using these ICs on prototype jets, acceptance

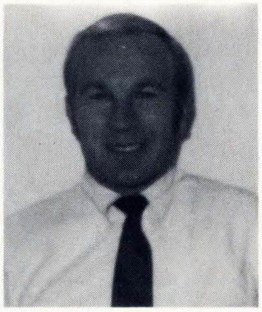
(Continued)

for production units will depend on military approval. □

Databank

1. *Can Plastic Encapsulated Microcircuits Provide Reliability with Economy?* Paper presented at the April, 1970 IEEE Reliability Physics Symposium by J. B. Brauer, V. C. Kapfer and A. L. Tamburrino (RADC Reliability Branch).
2. *Reliability Evaluation of Plastic Integrated Circuits.* (RADC TR 69-451, Feb. 1970) prepared by Delco Division of General Motors Corp.
3. *Test Methods and Procedures for Microelectronics* (MIL-STD-833).
4. *General Specification for Microcircuits.* (MIL-STD-38510).
5. *Plastic IC's Get Foot in Military Door* by L. Curran, Electronics, May 11, 1970.

Eugene R. Hnatek is the Military Product Manager at National Semiconductor Corp. Before joining National, he served as a Senior Design Engineer and Project Manager for Lockheed Missiles and Space Co. Holding both BSEE and MSEE degrees, Mr. Hnatek has authored numerous technical papers, and his first book, *Solid-State Power Supply Design*, will soon be published.



TEST	SAMPLE SIZE	TEST HOURS	FAILURES	TOTAL DEVICE TEST HOURS	COMMENTS
Storage life at 150°C	50	1000	0	50,000	No parameter drift
Storage life at −55°C	50	1000	0	50,000	Product very stable
Operating life at 125°C	26	250	0	6,500	No noticeable change
Operating life at 25°C	10	1000	0	10,000	Excellent parameter stability
Totals	136		0		

TEST	SAMPLE SIZE	MAXIMUM STRESS LEVEL	FAILURES	COMMENTS
Pressure Pot: D1 water at 15 psi and 100°C	11	13h	0	No parameter drifts
Pressure Pot: D1 water at 15 psi and 100°C	100	13h	1	One lead opened
Thermal Shock: 0 to 100°C. 1 min at each extreme	9	130 cycles	1	One lead open at 70 cycles
Thermal Shock: 0 to 100°C. 1 min at each extreme	100	10 cycles	0	No noticeable drift
Temperature Cycle −55 to 150°C. 30 min at ea. extreme	8	130 cycles	0	No significant drift
Temperature Cycle −55 to 150°C. 30 min at ea. extreme	100	20 cycles	3	One device shorted. Two devices, parameter degradation failures
Moisture Resistance/Method 106	50	10 cycles	0	No change detected
Moisture Resistance/Method 106	50	10 cycles	0	No parameter or catastrophic failure
Salt Atmosphere/Method 1041.1	50	24h	0	Mechanically and electrically unchanged
Totals	478		5	

GROUP A - 100% SCREENS

Screen	Class B Method	Class B Conditions	Class C Method	Class C Conditions
Internal visual before encapsulation[1]	2010	Test Condition B	2010	Test Condition B
Stabilization bake	1008	24h minimum, Test Condition C, 150± 25°C	1008	24h minimum, Test Condition C, 150± 25°C
Temperature cycling	1010	Test Condition C	1010	Test Condition C
Burn-in test	1015	168h at 125°C	not required	
Final electrical tests		▸ Static tests • at 25°C • at max, min operating temp[2] ▸ Functional tests ▸ Dynamic tests at 25°C		▸ Static tests • at 25°C • at max, min operating temp[2] ▸ Functional tests at 25°C
Qualification or quality conformance inspection	5005	per applicable document	5005	per applicable document
External visual inspection[3]	2009			

1 To be accomplished prior to encapsulation with all applicable criteria of Method 2010.
2 Test is required to establish continuity of microcircuit bonds and connections at specified temperature extremes. Detail specification shall contain sufficient static tests for screening to establish continuity from all used external leads to the die or substrate. An alternative to using static parameter tests for this purpose can be a continuity test (threshold) program which establishes continuity from all used externa leads to the internal microcircuit elements.
3 Unless otherwise specified, external visual inspection need not include measurement of physical dimensions.

Cautious Approval . . .

At the last IEEE Reliability Physics Symposium (April 7-10, 1970, Las Vegas), RADC recommended a set of standard screening requirements and environmental qualification tests in their paper entitled *'Can Plastic Encapsulated Microcircuits Provide Reliability with Economy?'* During the presentation, Joseph Brauer, RADC chief of solid-state applications, said: "If these recommendations are accepted by the Services, it amounts to a *cautious approval for military use of those plastic devices which can pass* an admittedly stringent set of requirements. It is recognized as a *calculated risk* based on substantial high stress-test results and extensive failure analysis—but on a negligible amount of documented field experience. And it is not a blanket approval or testimonial to the goodness or acceptability of *all* plastic devices any more than was indicated by the publication of standard screening qualification procedures for hermetic devices. We have seen devices in both categories which were mistakes in design, materials, process, or package, and shouldn't even be used in the toy market. It does mean we are recommending that the statutory ban against plastic devices be lifted and that we provide a method for them to qualify against military performance and environmental requirements."

Of the proposed tests shown below, Brauer asserted, "Class A applications will certainly not even be considered until substantial favorable experience is gained in Class B applications. Even Class B and C applications must be regarded as potential tradeoffs between cost and risk. Recognizing this, my committee has recommended that a safety factor be applied by assuming that plastic failure rates will be at least four times greater than those commonly achieved with the equivalent dual-in-line hermetic device."

RADC-proposed Tests for Plastic ICs. Numbered test methods (2010, 1008, etc.) refer to MIL-STD-883. Those methods labeled 10XX are new and await number assignment. Numbers listed under "LTPD" (Lot Tolerance Percent Defective) in Groups B and C refer to a MIL-STD-883 table that tells how many defective parts are allowed in a lot.

GROUP B - SAMPLING EACH LOT

Test	Method	Conditions	Class B LTPD	Class C LTPD
Subgroup 1 ▸ Visual and mechanical ▸ Bond strength	2008 2011	Test Condition B, per documented design and construction Test Conditions B,C,D, or F, as applicable	1 device, no failure 7	1 device, no failure 10
Subgroup 2 ▸ Marking permanency ▸ Physical dimensions ▸ Lead fatigue	2008 2008 2004	Test Condition B, par 3.2.1 Test Condition A Test Condition B	4 devices, no failures 15	4 devices, no failures 20
Subgroup 3 ▸ Radiography[1] Solderability	2012 2003	One view, normal to die or substrate criteria as specified temp, 260± 10°C, with age	15 15	20 15
Subgroup 4 ▸ Salt atmosphere ▸ End-point electrical parameter	1009	Test Condition B as specified in procurement document	15 15	15 15
Subgroup 5 ▸ Biased moisture life ▸ End-point electrical parameter	10XX	85°C at 85% relative humidity with min power bias for 1,000h min as specified in procurement document	10	15

Subgroups 1, 2, and 3 may use electrical rejects. Subgroup 4 samples may be used in Subgroup 5 tests. Radiographic acceptance criteria include precautions against lead frame shift, foreign particles, lead dress, and encapsulant voids.

GROUP C - PERIODIC SAMPLING

Test	Method	Conditions	Class B LTPD	Class C LTPD
Subgroup 1 ▸ Steady-state reverse ▸ End-point electrical parameters	1005	Test Condition A, 160h at 150°C, min as specified in procurement document	7	15
Subgroup 2 ▸ High-temp storage ▸ End-point electrical parameters	1008	150°C min, 1000h min storage as specified in procurement document	10	15
Subgroup 3 ▸ Thermal shock ▸ Temperature cycling ▸ Monitored temp cycling	1011 1010 10XX	Test Condition B for a min of 15 cycles Test Condition C for 10 cycles 1 cycle ranging from −65 to +150°C	10	10
Subgroup 4 ▸ Moisture resistance or biased moisture life ▸ End-point electrical parameters	1004 or 10XX	With min power bias for 3024h as specified in procurement document As specified in procurement document	15	None

Single sample may be used for all subgroups. Tests within any subgroup must be conducted in the order shown, initial device qualification shall be to tighten inspection levels as defined in Appendix B of Mil-M-38510 and Mil-S-19500.

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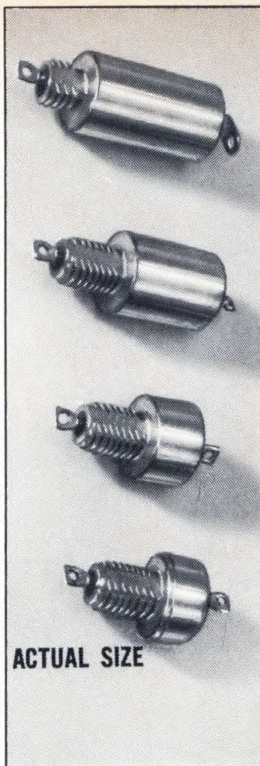

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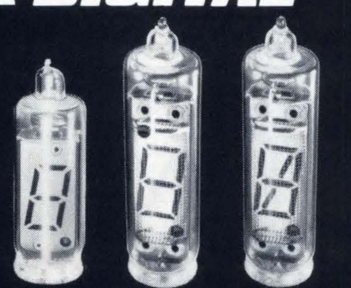

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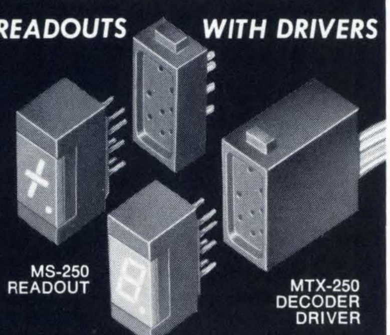

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CIRCLE NO. 26

Build a Sawtooth Generator With Three ICs

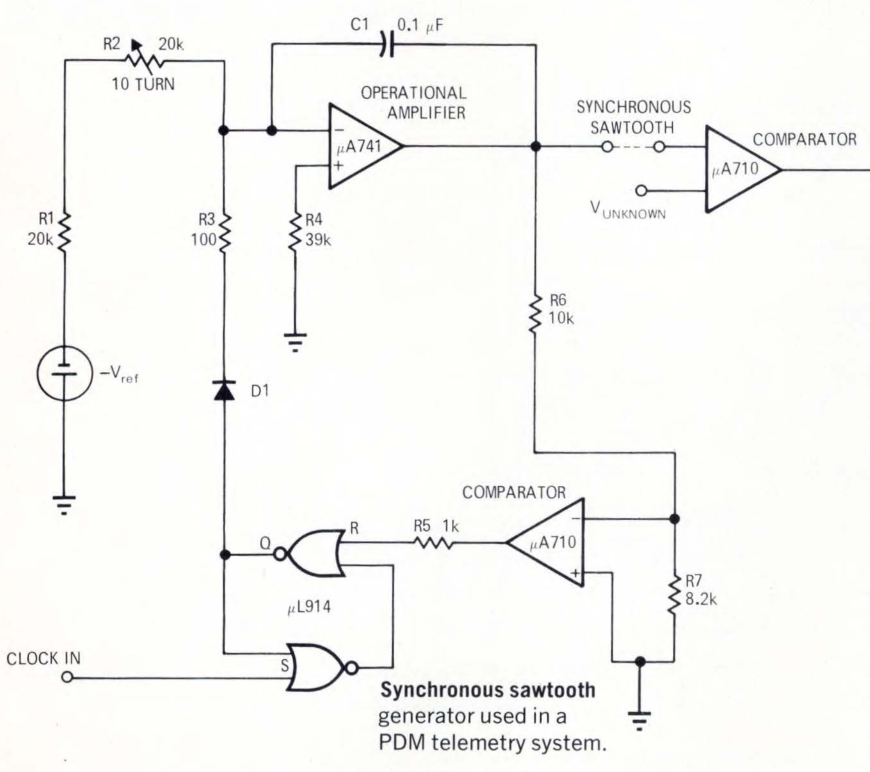
Only three inexpensive active components form a sawtooth generator with a very linear ramp that is set accurately to zero by a clock pulse.

JOHN SPRINGER, Fairchild Semiconductor

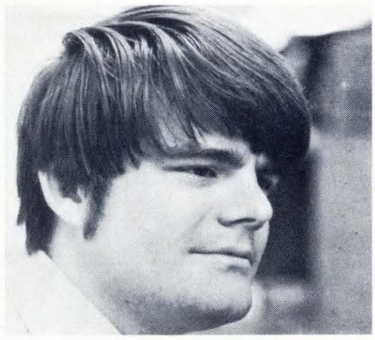
Comparing the ramp from a sawtooth generator with an analog voltage is a popular technique for forming pulse duration signals during an analog-to-digital conversion. In the circuit shown, each clock pulse initiates a new output pulse. When the ramp exceeds the analog value, the pulse is terminated.

Components R1, R2 and C1 form an integrating network around the operational amplifier. Varying the value of resistor R2 adjusts the current to the summing point and thus varies the slope of the ramp output. The integrator generates a positive-going ramp until a positive pulse is received on the clock input. This pulse sets the R-S flip-flop formed by the cross-coupled NOR gates. When Q goes high, current is forced into the summing point through D1 and R3, and the integrator output is driven rapidly toward ground. The comparator detects the point at which the ramp reaches ground and resets the flip-flop, thereby stopping the discharge. Voltage divider formed by R6 and R7 prevents the voltage across the comparator inputs from exceeding the breakdown potential of 5V.

The stability of the reference voltage (V_{ref}) determines the reproducibility of the ramp. For most applications, this voltage is set with a zener diode or two forward-biased switching diodes. Capacitor C1 should be metallized polycarbonate for low leakage current. ▭



Synchronous sawtooth generator used in a PDM telemetry system.



John Springer got his M.S. from Oregon State University and promptly went to work for Fairchild Semiconductor as a digital applications engineer. He's a member of IEEE and the American Chemical Society with a special inclination toward chemical and biomedical instrumentation.

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Digital Technique Generates Audio Frequencies

Frequency generator develops 16 separate audio-frequency codes under control of a digital word.

LEONARD E. MILLER, U.S. Naval Ordnance Lab.

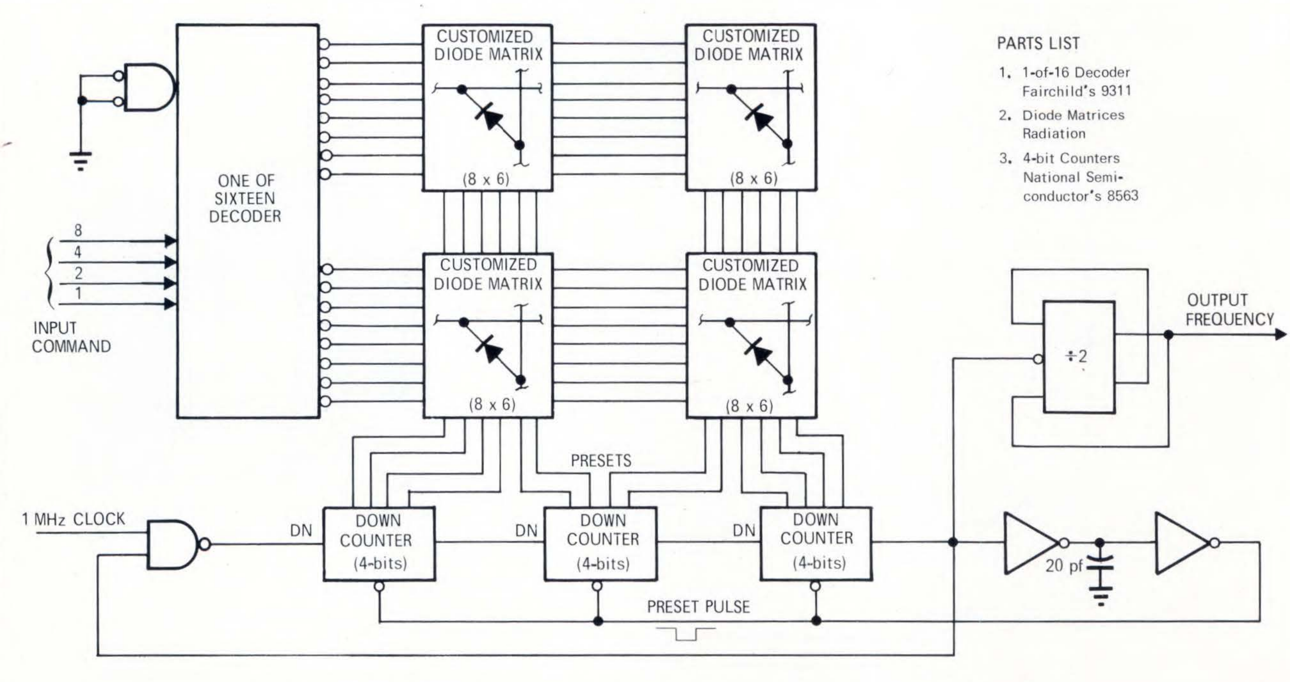
A 12-bit down counter driven by a 1-MHz clock is the heart of the frequency generator illustrated. Programmed with a 4-bit word, this circuit produces 16 different predetermined code commands at frequencies between 122 Hz and 500 kHz. This design intermixes ICs and uses multilayer printed circuitry to conserve board space.

The binary number corresponding numerically to the period, in microseconds, of twice the desired frequency is preset into the counter. Each time the count reaches zero, the number is re-entered. Simultaneously, a pulse (preset) toggles a flip-flop whose output generates the square-wave version of the desired frequency.

Combined actions of a one-of-sixteen decoder and several monolithic diode matrices produce the appropriate number to be entered into the counter. Four customized 8 x 6 diode matrices are sufficient. These matrices are patterned by "burning out" the unwanted diodes. Also, juggling the rows and columns of the matrix truth table reveals that one 5 x 8, one 4 x 10 and two 8 x 6 matrices could be used in the frequency generator shown.

The decoder outputs provide current-sinking through the diode matrices for the counter preset inputs. An input command applied to the decoder selects one of these outputs. This in turn applies zeroes to the appropriate preset terminals. □

Leonard E. Miller is an electronic engineer with the U.S. Naval Ordnance Lab., Silver Spring, Md. Mr. Miller is a member of IEEE. He received a B.E.E. from Rensselaer Polytechnic Institute and a M.S.E.E. from Purdue University.



Programmable frequency generator provides sixteen separate AF coded commands.

DC Feedback Stabilizes Bias On FET/Bipolar Pair

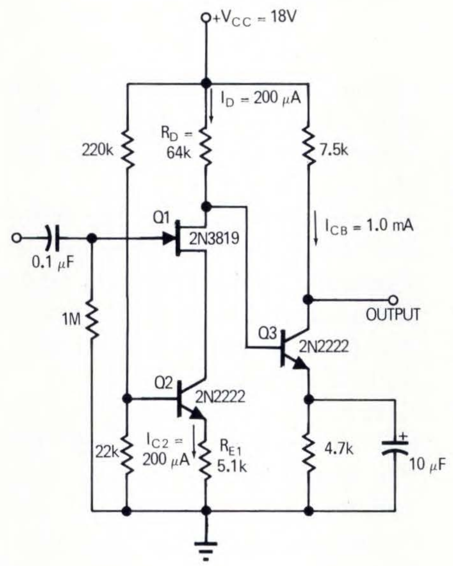
Simple voltage-feedback loop stabilizes bias on direct-coupled FET and bipolar stages.

H. T. RUSSELL, Texas Instruments Incorporated

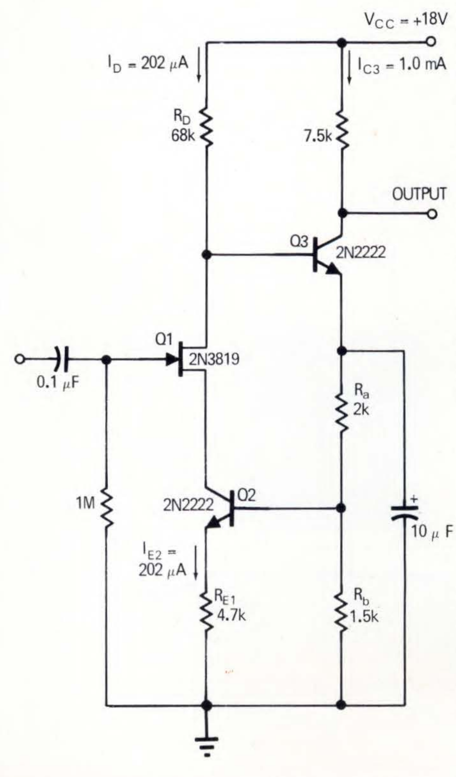
Direct coupling a FET to a bipolar transistor involves the problem of how to make the FET bias the bipolar correctly. This problem results from the fact that current through the FET depends on the device parameters (I_{DSS}, V_P) and source resistance. Correct dc coupling to the bipolar requires that the FET be biased properly.

There are several methods of biasing a FET independently of its parameters. Supplying the source terminal with a constant current is one method. A constant current forced through the drain sets the bias voltage at the base of the bipolar. However, drift in the constant-current source shifts this voltage and "unbiases" the bipolar.

A possible solution to this problem is to make the constant-current source dependent on the bipolar bias current. By choosing proper resistor values, dc voltage feedback from the emitter of the bipolar can be made to control the constant current value. Since this current nearly equals the FET drain current, the base-bias voltage of the bipolar is set at its desired value. Any change in drain current causes an opposite change in the constant-current value, thus stabilizing the bipolar. ☐



Unstable biasing method for FET Q1 direct coupled to bipolar transistor Q3. Constant-current source Q2 properly biases FET Q1 independently of its parameters I_{DSS} and V_P. Constant-current source Q2 determines FET drain current I_D and sets bias voltage at Q3 base. However, drift in Q2 collector current I_{C2} shifts base-bias voltage causing instability.



Stable Biasing Method incorporates dc-voltage feedback from Q3 emitter to base of constant-current stage Q2 to maintain stable bias voltage at Q3 base. Any change in Q2 collector current is reflected as an opposite change in Q3 collector (and emitter) current. Voltage divider R_a, R_b adjusts Q2 base voltage to restore the original current value. Feedback method maintains stable bias on Q3. Design equation for Q3 collector current is:

$$I_{C3} = \frac{V_{CC} - V_{BE3} + \frac{R_D}{R_{E1}} V_{BE2}}{R_a + R_b \left[1 + \frac{R_D}{R_{E1}}\right]}$$

Collector current thus is a function of resistor values and completely independent of FET parameters. I_{DSS} value ranging from 3 to 20 mA has negligible effect on Q3 collector current.

Howard T. Russell (M.S.E.E.), an applications engineer at Texas Instruments Incorporated, Dallas, Texas, designs audio and low frequency circuits. He previously designed FET circuits at Fairchild Semiconductor.

Customer Engineering Clinic

MIL Spec Capacitors Short During Soldering

D. D. CUOZZO, Hazeltine

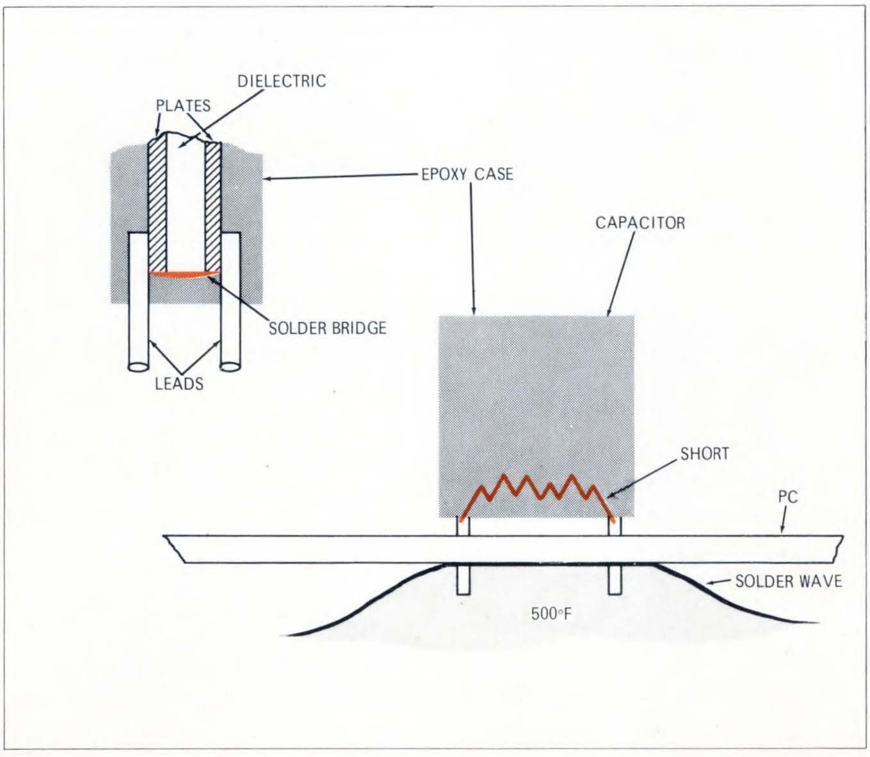
Problem: Ceramic capacitors failed in large numbers during a fast turn-around production run. Rejection rate was 80% at the printed-circuit-board level. This caused a "panic", since a tight delivery schedule had been imposed by the military customer.

Discussion: Inspection of failed boards disclosed the primary point of failure to be the CKO5 ceramic capacitors that were used in fair numbers. Inspection of failed CKO5 capacitors revealed that the two electrode plates on either side of the ceramic dielectric had shorted inside the epoxy case. It appeared that the solder used by the capacitor manufacturer to connect the leads to the plates had spread out and bridged between the plates. The solder had flowed right across the edge of the dielectric.

To determine whether the capacitors were being received in this condition, 200 CKO5s of different values and randomly selected from incoming inspection were tested electrically. All were found good.

Investigation then turned to the PC-board soldering operation. The 200 good CKO5 capacitors were mounted on PC boards and run through the production wave-soldering machine. An 8% fall-out occurred. This was at the 500°F temperature which was normal for the solder bath.

When the vendor was contacted, he said he assembled his capacitors according to the requirements of MIL-C-11015 and used a 430°F melting-point solder. MIL-C-11015 was consulted, and it verified that 430°F solder was indeed adequate for these capacitors.



Solution: The immediate corrective action was to increase the travel speed of the PC boards through the wave-soldering machine to minimize the heat conducted through the capacitor leads.

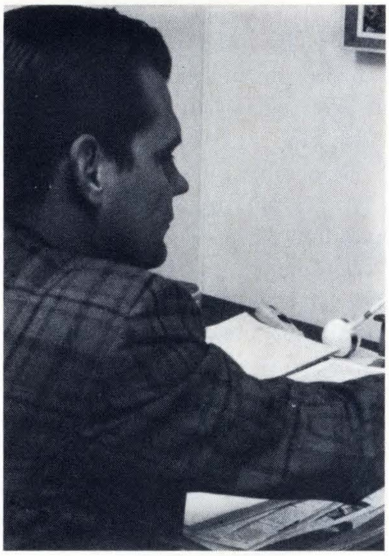
Long-term corrective action was to formulate specification control drawings for CKO5 capacitors that called out a 550°F minimum melting point (internal) solder.

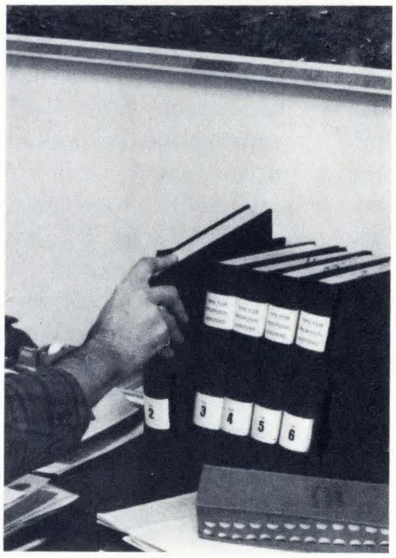
The Department of the Navy was advised of the problem with the suggestion that the MIL Spec be revised to require higher-temperature solder. (This change will be under consideration at the next MIL-C-11015 Specification Coordination Meeting.) ▭

EDN will pay $50 for any problem-solution article accepted for publication.

Next Issue's Problem

Our July 15 Clinic asking for solutions to the problem of simultaneously testing two zeners resulted in an avalanche of answers—more than 900 were received! Next issue we will name the winner and runner-up, and will give the circuit finally used.





Twelve Tips For Proposal Writers

Contract awards are often won by companies that submit the least undesirable proposal. This is hardly a positive way to do business with anybody, let alone the government.

CHARLES E. ANDERSON, Reflectone, Inc.

There are many improvements that industry can make to increase the quality and yield of proposals. One of the most significant steps is to help the proposal writer himself, since it is at this ground-zero level that communication between a company and the government begins to take shape . . . or starts to break down.

As an engineer, some portion of your professional life will be devoted to writing technical and management proposals. In these times, you help yourself best by helping your company. So help yourself to any or all of these dozen writing tips. They'll assist you to get off to a better start—and finish— in your proposal writing efforts.

TIP 1 BEFORE YOU START

Treat a Proposal As a Sales Document— Anything that offers the services of your company to perform a specific task for a specific remuneration is a sales document. The ultimate sales document is a proposal—and, just because it **is** the ultimate, it must have three qualities. It must be clear. It must be concise. And it must be convincing.

Take another look at those three "Cs"—they may comprise the toughest set of criteria you've ever tried to meet. Certainly, if you come anywhere near this threefold goal, your proposal will be a stand-out in any competition.

Be warned: the term "sales document" has nothing whatever to do with "salesmanship" in the Madison Avenue sense. No huckster's spiel, no sweeping generalities or blind superlatives, no "blue sky" sales pitch can stand up to this triple test of clarity, conciseness and conviction.

Let's concede for the moment that you may be able to state and explain facts and ideas clearly, and that you have learned how to do this concisely. In a word, you can handle expository writing, the technique used to explain facts and ideas. But how on earth do you make

FOR A FREE REPRINT OF THIS ARTICLE, **CIRCLE L65**

(Continued)

it convincing at the same time?

There's a technique that professional writers call "argumentation" that you may have forgotten, even if you had ever run into it. Argumentation, exposition's cousin, is closely related to debate, and it is characterized by attempting to convince (sell) the reader on a specific point or set of points, or to persuade him to think or act as the writer desires.

Therefore, as you start your proposal activity, bear in mind that you will try to persuade the reader to adopt the facts and ideas behind your technical and management approaches. You will do this best by demonstrating to him that these approaches are not only sound, responsive and cost-effective, but also the best available.

Ways and means of doing this will be discussed under tips in the "writing" portion of this article.

TIP 2 **Understand Proposal Capture Strategy—**

We hear a lot these days about "game plan" and "game strategy"—which are nothing more or less than a formalized set of rules that state what you are going to do under a given set of possible circumstances. Your company, if it has properly assessed the procurement objectives of the customer and the strengths and weaknesses of the competition, has such a "game plan". Let's call it the proposal capture strategy here—the course of action that will win the contract for your company.

The proposal, to be optimally effective, should reflect and reinforce this theme, and, as a worst-case example, the proposal should do nothing to hinder or negate the proposal capture strategy. You and all other contributors should clearly understand this strategy, so that a unified, consistent argument is presented throughout the proposal.

Study the proposal outlines carefully. Thorough familiarity with them will give you the necessary insight into the company's capture strategy.

TIP 3 **Understand Your Assignment—**

All too often, engineers assigned to work on a proposal are handed a subject to write about, then left alone to develop their personal treatment of that subject. Nothing could be more disastrous.

The proposal manager should clearly identify the treatment of a given subject for you. Main points to be covered, length of the section, number and types of illustration and their content—all these should be worked out before you begin. If these aren't laid out for you, go to your proposal manager and discuss them with him.

Remember, it is the proposal manager's responsibility to formulate or, at the very least, approve the proposal message before the team starts on individual assignments. Don't start without this guidance; if you do, you'll waste precious time and perhaps duplicate a portion of someone else's work.

TIP 4 **Study the Documents—**

Before you can draft an effective, convincing response to a request for proposal (RFP), you must know the exact detailed requirements of the technical specification and the technical proposal requirements (TPR). Study these documents thoroughly, because the agency will measure responsiveness and relevance in terms of your understanding of the specific language of the customer's requirements.

Thorough study of the particular RFP enclosures will allow you to talk the customer's own language when you write the proposal. It's not only unfair, but also unrealistic to expect him to learn your language. After all, it's your firm that's seeking the contract.

AS YOU WRITE

TIP 5 **Follow Your Writing Plan—**

While even the best plans can go astray, in proposal work which is severely limited by time, there is no place for false starts or extensive rework. Even under the best of conditions, scant time is allocated for editing and review of drafts, so stick to the writing plan laid down for your effort.

Improvements in your writing plan may occur to you as you go along, but be sure to get your proposal manager's approval for them before you depart from the original plan.

Proposal planning, most essential when the writing must be hurried, is an iterative process and therefore must continue throughout the entire proposal preparation period. "Plan your work and work your plan" never fitted any task better.

TIP 6 **Incorporate References—**

To show tie-in, relevance and responsiveness, incorporate into your draft specific references to the particular paragraphs of the specification and technical proposal requirement to which your message is addressed. Some proposals are written as though these documents never existed, leaving the proposal evaluator with the burden of matching his requirements to responses.

Show continuity, unity and coherence within your proposal by incorporating references to other parts of the proposal which relate to your message. But first, go to these referenced paragraphs and read them carefully to be sure that you develop a maximum amount of continuity and coherence in your assignment. Be sure it all hangs together; don't just guess about the content of your referenced paragraphs.

Develop Your Topic Logically –

In writing your assignment, develop your argument logically. For example, start with the problem (or specification requirement), analyze it, assign a complexity factor to it, review the solutions available indicating the advantages and disadvantages of each, then select the best approach, giving your rationale for the selection and the benefits that will accrue to the customer if he can be induced to implement your selected solution or approach. Be sure to discuss the reasons for rejecting each of the possible solutions that you've considered. Knocking down unacceptable solutions goes a long way in selling yours – and unselling your competitor's if he has selected one you've shot down. Show your line of reasoning by employing some of the writing aids shown in the accompanying box.

TIP 7

100 CONNECTIVES TO HELP YOU WRITE WELL

RELATIONSHIP REQUIRED	CONNECTIVE TO USE		
Addition	again also and besides	equally important finally further furthermore	in addition last moreover yet another
Comparison and Contrast	after all but conversely however in comparison	in like manner likewise nevertheless notwithstanding on the other hand	on the contrary or similarly still whereas
Conditions	although because even though for if	in these circumstances nevertheless otherwise since	this being so though unless until
Exemplification, Repetition, Summary, Intensification	as has been stated as I have said as well as for example for instance here again in any event	in other words in particular in short in summary in brief indeed in fact	obviously of course that is to be sure to illustrate to sum up
Logical Conclusion	apparently certainly evidently	for all that notwithstanding of course	presumably therefore undoubtedly
Place	adjacent to beyond	here near	on the other side opposite to
Purpose	for this purpose to this end	toward this objective	with this goal
Result or Cause and Effect	accordingly because consequently for this reason	hence it follows that otherwise	therefore thus wherefore
Time	after afterward at length before	formerly immediately in the meantime later	meanwhile subsequently then

TIP 8 Summaries and Visuals Reinforce Your Text—

In argumentation (see Tip No. 1), one technique is to stop occasionally to sum up your argument. Provide the evaluator with the conclusion you wish him to take away with him when he concludes reading your section; don't leave it to him to decide what your main points were. His job is to read and evaluate the proposal, not to decipher, edit or interpret it.

Further support your text by including meaningful visual devices that summarize your main points. Add to these visuals a descriptive sentence or two so that they can stand alone as a text/visual entity. It should be possible, then, to follow the main points of the proposal by "reading" the illustrations, as easily as by reading the text—and the reader should be led to the same conclusion in both cases.

TIP 9 Write Clearly and Concisely, Be Readable—

Your proposal won't be separately scored on its writing quality, but the degree of communication you've established with your reader will certainly have an impact on his comprehension and subsequent acceptance of your argument. To this end, strive for clarity, conciseness, coherence, continuity, emphasis and vigor in your writing. Use the conversational "you", "I", "our company", "your agency". These are effective words that achieve personalized persuasion and argument. Use the force of the active voice ("we feel that the XYZ solution will benefit your agency for the following reasons . . .") rather than the dull, long-winded passive voice ("it is felt by this offeror that the customer will benefit by the XYZ solution because . . .").

Make your writing readable by paying attention to your writing style. Don't, for example, start every sentence with "the" as one proposal writer did in 16 out of 20 sentences. Change sentence length and structure to keep the captive proposal evaluator from falling off into sandmansville. This technique also materially strengthens clarity by making your paragraphs more coherent. Use the connectives shown in the box to compare, combine or contrast ideas and to smooth the entire flow of the sales message.

AFTER WRITING

TIP 10 Review Text and Artwork Thoroughly—

After your draft has been rough typed and your sketches turned into clean artwork, and after a suitable period of time has gone by for your initial efforts to cool to the point where you can apply some objectivity, thoroughly review your effort to insure that it presents your argument clearly, concisely and convincingly. While you're doing this, wear the hat of the proposal evaluator; play the devil's advocate; and above all, be honest with yourself. Rewrite your section if you have to, for effective writing most often requires several revisions—at least admit that one might be required. (Howard Roberts of Hewlett-Packard Co. had some wise words on this topic in an article in EDN, March 15, 1970, p. 97. Better re-read it.)

Don't, as so many engineers do, just proofread the draft for typographical errors. You wouldn't hesitate to revise a schematic drastically; don't hesitate to rip up mere words, either.

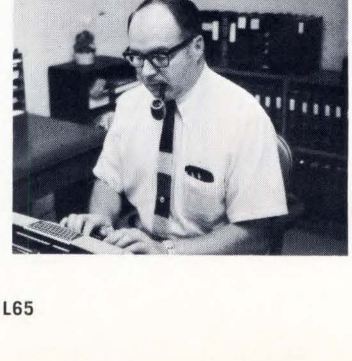
TIP 11 Compare Your Draft Against the Published Version—

This will help you determine what technical and editorial changes were made and why. Proposal editors generally don't make arbitrary changes to please their own journalistic or literary whims, and a good proposal editor will work with you to insure that he is not being arbitrary. Remember, a proposal editor usually has a better overview of the entire proposal than any individual writer does, so if you don't understand why something has been changed in your draft, find out by asking him.

TIP 12 Keep a Proposal File—

Maintain a file of your personal proposal efforts, including both your original draft and the published version. Clip proposal articles and engineering writing articles from trade magazines. Save good samples from other proposals. Whether you enjoy it or not, you, as an engineer, will probably be spending a sizable portion of your professional life writing proposals. Any job worth doing . . . □

Charles C. Anderson is manager of proposal services for Reflectone, Inc., Stamford, Conn. He holds a B.S. from the University of Bridgeport, an ICS diploma in EE and is presently a Masters candidate in Corporate Communications at Fairfield University.



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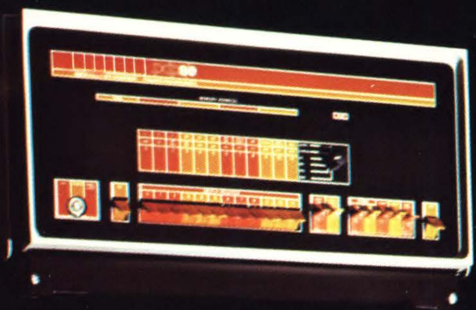
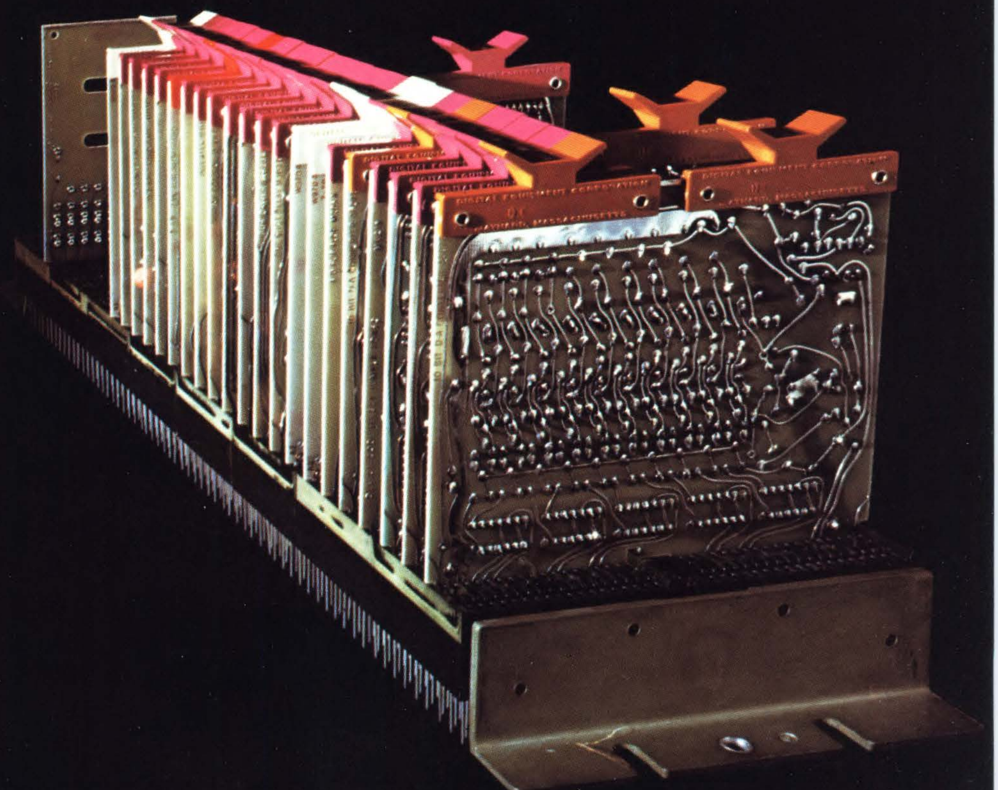


Exploring the Computer Interface



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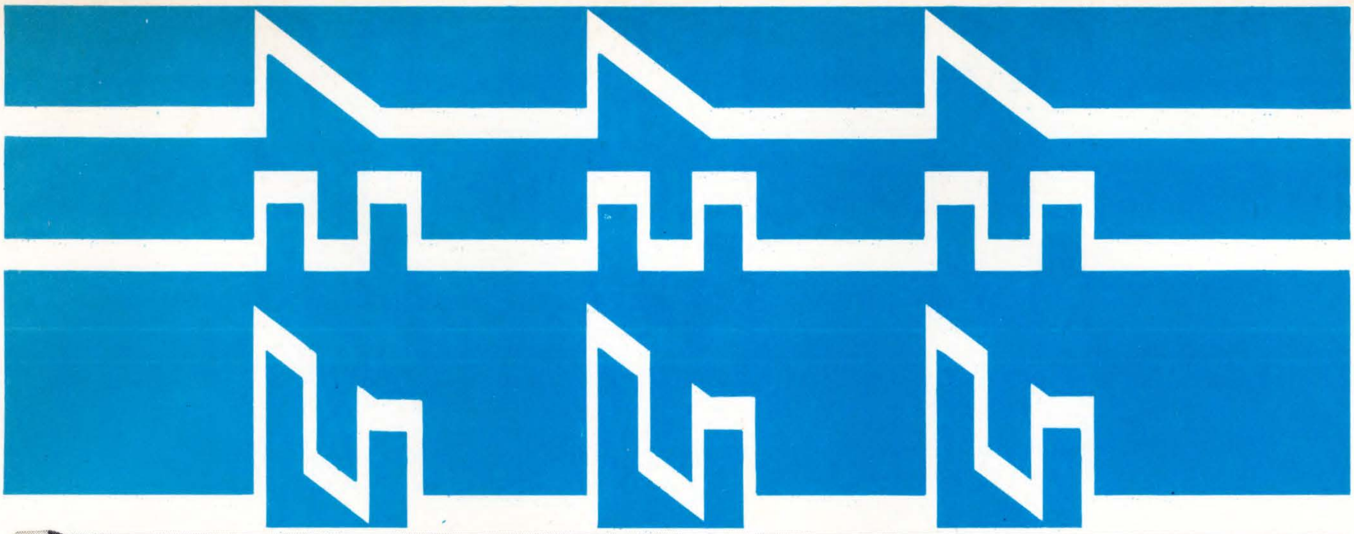

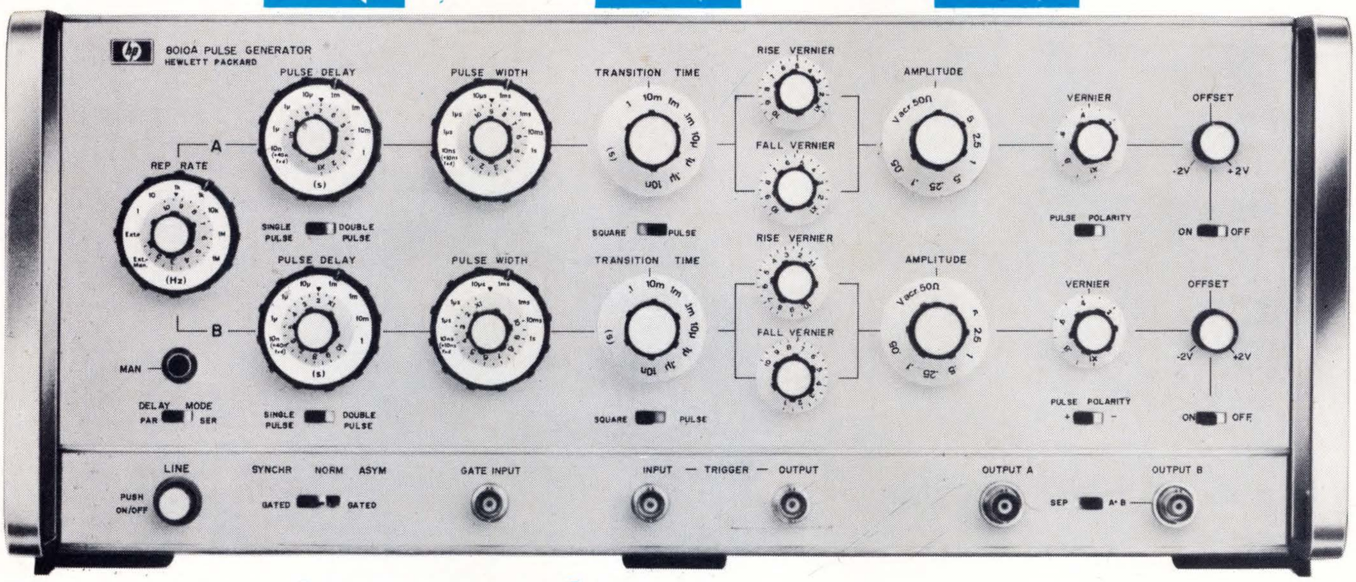

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computer hardware

EXCLUSIVELY FOR DESIGNERS OF COMPUTER MAINFRAMES, PERIPHERALS AND SYSTEMS

cover

Cover photo by Digital Equipment Corp. portrays the computer hardware that forms computer interface. For more on computer interface, see p. 010001.

directions

features

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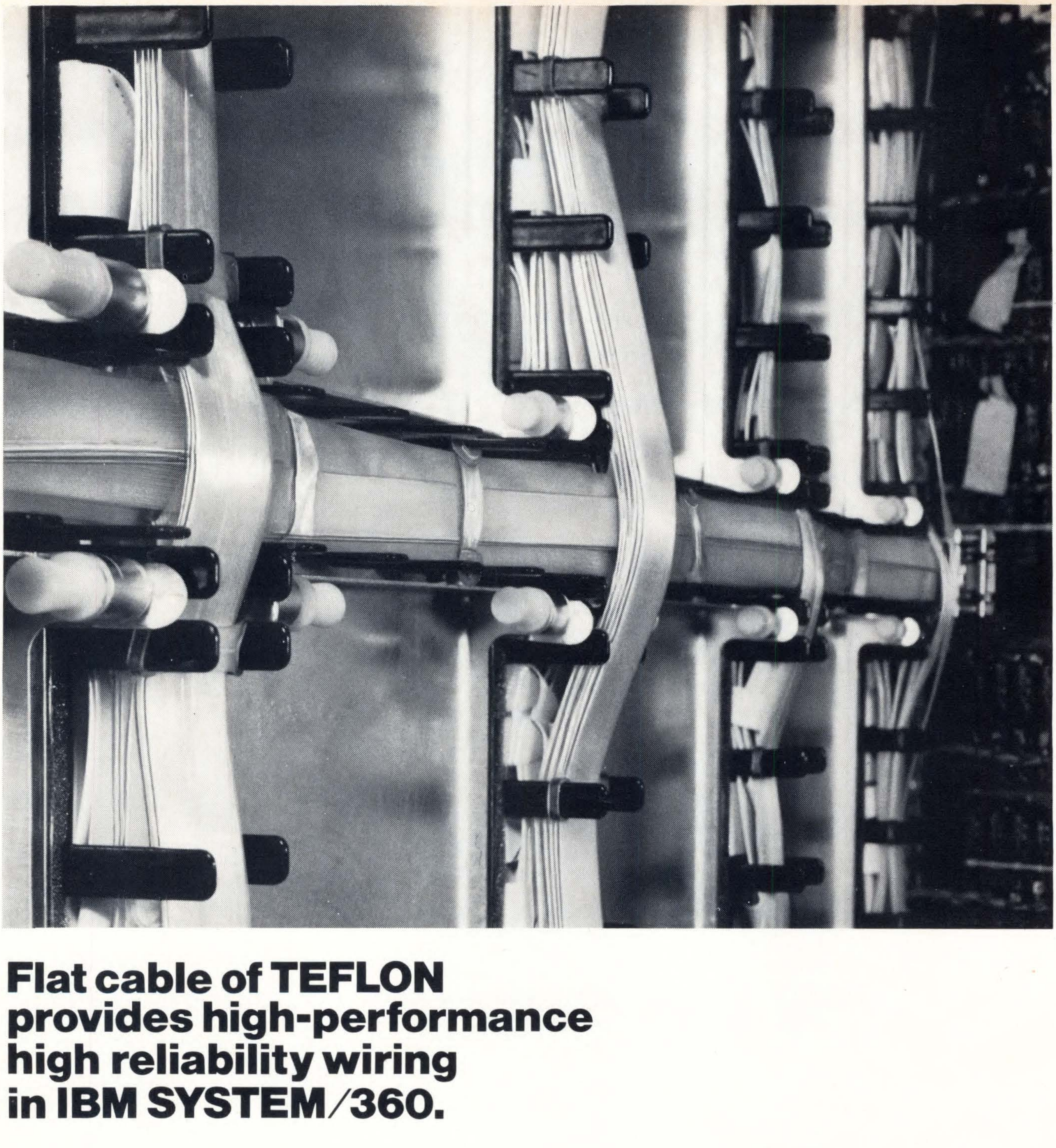

computer hardware a new EDN service

what is computer hardware?

It is a new section in EDN devoted exclusively to the unique technical information needs of EDP equipment and systems designers.

who receives computer hardware?

Only EDN subscribers who have indicated on their qualification forms that they are responsible for the *design* of computer mainframes, peripherals or systems will receive the Computer Hardware section in their EDN copies.

how often will computer hardware be published?

Once each month in the issue dated the 15th of the month. It will be located immediately before our regular "Design Products" section in these issues.

what kind of articles and departments can I expect to see in computer hardware?

Computer Hardware will consist of four clearly-defined sections—Directions, Features, Events and New Products. *Directions* will scan the forefront of computer-oriented hardware technology; *Features* will detail design techniques, methods and surveys relating to the hardware of computer equipment and systems; *Events* will discuss those portions of exhibits, symposia, courses and other meetings that relate to Computer Hardware readers; *New Products* will display hardware product innovations of direct and exclusive interest to computer equipment and systems designers.

why the emphasis on hardware?

Most computer-oriented magazines address themselves to *software* and the problems of *end users*. Our research convinced us that the hardware-related information needs of *designers* were not being met by existing publications. That's why we selected the name, Computer Hardware, and why content will concentrate on hardware design.

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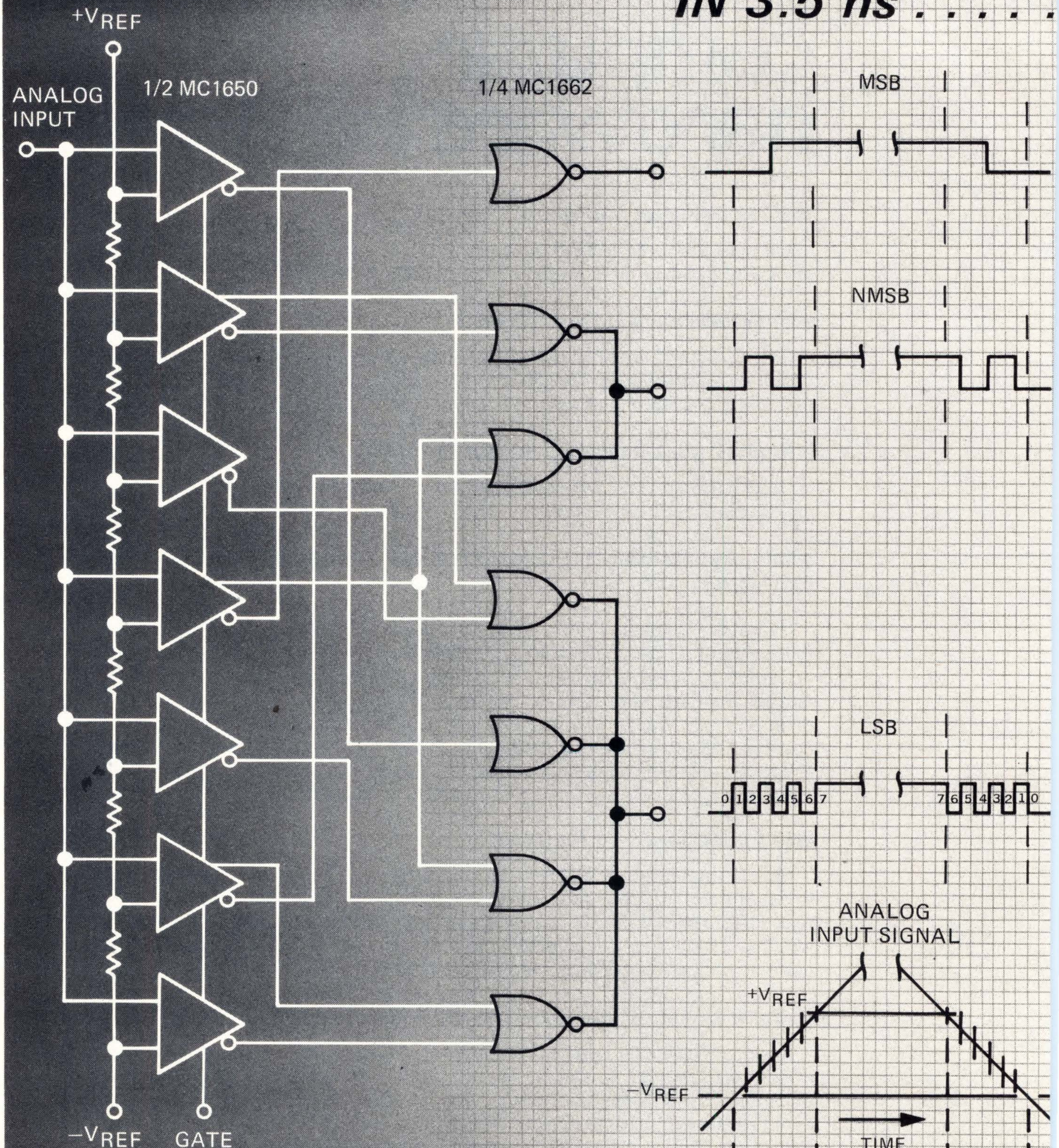
No. Use the regular card located inside the back cover for all items in both EDN and Computer Hardware. We are especially interested in your opinion of Computer Hardware as an entity, as well as the individual articles we publish. Feel free to use the portion of the card reserved for comment. Opinion expressed there is thoroughly reviewed (and acted upon) by the editorial staff, then passed along to pertinent outside authors and information sources.

FROM ANALOG-TO-DIGITAL IN 3.5 ns . . . . .



3-BIT A/D CONVERTER

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The comparator will accept analog signals with slew rates up to 340 V/μs and provides digital information at rates up to 200 megabits per second, at the least significant bit (LSB). And the MC1650 features a built-in memory whereby the gate input, when taken to a logic "0" level, will cause all bits of digital information to remain in the present state, regardless of a change at the analog input. The MC1650 incorporates two comparators in one package and operates at MECL III logic levels. Other features include a typical delay of 3.5 ns and complementary outputs which increase flexibility of design.

In the 3-bit A/D converter illustrated, the analog signal is represented as a straight line, but may assume any form as long as the maximum slew rate is not exceeded. The incremental steps are determined by the bias values supplied by resistors between $+V_{REF}$ and $-V_{REF}$. Equal values for all resistors (assumed here) will break the analog sensitivity of the system into equal increments, while different values result in unequal increments.

Apply the MC1650 to instrumentation applications such as frequency measurement, high-frequency sample and hold, and peak voltage detection. In navigation and aviation use the comparator for application in altimeters, peak detectors, and electromechanical system-control interfacing. And consider the high-speed applications for computer terminals and memory translation and amplification.

For complete MC1650 specifications write to Motorola Semiconductor Products Inc., P.O. Box 20912, Phoenix, Arizona 85036. Your local Motorola distributor has evaluation devices available now. Evaluation will introduce you to the latest concept of high-speed A/D data conversion where MECL III makes things happen.

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LSI critic voices cautious skepticism

Paul Niquette

El Segundo, Calif.—While many feel that LSI will soon form the cornerstone of computer architecture, there's at least one critic who doesn't think so. *Paul Niquette, Director of Advanced Development for Xerox Data Systems,* sees better alternatives. EDN interviewed him to learn why.

EDN: When did your company begin using complex ICs?

Niquette: Back in 1965, we adopted a technology that's now called MSI. Our first complex IC comprised 104 transistors and served as an 8-bit scratchpad. Designated the "304", that particular device turned out to be pretty famous.

EDN: How would you define LSI?

Niquette: It's a matter of degree; however, 100 gates seems to be generally accepted as the start of large scale integration. I sometimes wonder, though, what we'll call 1000 gates—or 10,000 gates.

EDN: Do you plan to adopt LSI technology for your computers?

Niquette: Though we're actively evaluating LSI, we have no plans to adopt that technology. I look upon the prevailing LSI technology with constructive skepticism.

EDN: What's the basis for your skepticism?

Niquette: Never before has any business experienced anything like LSI. My skepticism stems from LSI's uniqueness—which is characterized by the contemporaneous occurrence of two events. These are "low intrinsic value" and "high throw-away cost".

EDN: What do you mean by "low intrinsic value"?

Niquette: Every product has an intrinsic value that is measured by the cost of materials and labor required to build it. Now LSI has a very low material and labor cost—hence "low intrinsic value". Although the intrinsic value of an LSI device is worth only a dollar or two—that same device is likely to cost you $100 in the marketplace. This cost disparity arises because of poor yields. In other words, we pay for 97 LSI devices that fall in the wastebasket just to get three good ones to use.

EDN: Despite its low intrinsic value and high market price, doesn't LSI add "extrinsic" value to your equipment in terms of better performance and higher reliability?

Niquette: Not really. First of all, there are other alternatives, such as PC logic boards, that are doing their jobs extremely well. And secondly, I think it's logical to assume that everything made by man will fail—so where does that leave me with a failed LSI device?

EDN: You must now be referring to the "high throwaway cost".

Niquette: That's right. A failed PC board that houses ICs with small to medium scales of integration can be easily and economically repaired. But a failed LSI device performing the same function is destined for the wastebasket.

EDN: But wouldn't you expect greater reliability with the LSI device?

Niquette: If an LSI device is going to cost me ten times as much as its MSI/PC-board counterpart—then I would expect ten times the reliability. That's just not happening. LSI is still a very young technology and its reliability has yet to be proven. Anyone who doubts that ought to read the patent dealing with "electron wind".

EDN: And what is "electron wind"?

Niquette: The better known terminology is "mass migration". It turns out that whenever you pass a high current density through a conductor with a small cross-sectional area—the conductor actually wears away.

EDN: In other words, the electron flow is causing a metallic erosion in LSI devices?

Niquette: Erosion is a good word for it. Readily seen through a scanning electron microscope, this serious failure mechanism has yet to be well characterized.

EDN: Isn't MSI also susceptible to the ravages of electron wind?

Niquette: Yes—but to a far lesser degree because MSI has a higher microredundancy.

EDN: What do you mean by "microredundancy"?

Niquette: That's my way of describing redundancy on a microscopic level. To understand what I mean, consider the metal interconnect on a PC board. If a piece of this interconnect were chipped away, it would still function as a conductor—hence the PC board's metal interconnect has "microredundancy". Because the LSI metal interconnect is far smaller than its PC board counterpart—and I might add smaller than its MSI counterpart—LSI has a lower microredundancy. Although LSI's claim to fame is miniaturization—let's not overlook the tradeoffs that miniaturization carries with it.

EDN: From your continuing evaluation program, have you found any promising developments in LSI technology?

Niquette: The most promising thing that I've seen is silicon-gate MOS and some of the bipolar technologies to which it interfaces. Silicon-gate MOS has a lot going for it—self-alignment, low capacitances and small geometries. Given higher yields and better means to dynamically test dice to assure packaged operation—we would seriously consider using an LSI memory made with silicon-gate MOS devices.

EDN: What kind of yields would you expect?

Niquette: In the range of 30%.

EDN: Do you think semiconductor vendors will come across?

Niquette: Though I believe they're doing well at the MSI level, I just don't think they're going to make LSI fly—unless, of course, they come up with some major process breakthroughs. I can't forget that back in 1965 we qualified three vendors for our MSI scratch pad. At any given moment today, we're lucky to have one vendor that can still produce it.

EDN: And why is that?

Niquette: Horror stories! They call up and say, "We've lost second diffusion."

EDN: Is there any final thought you'd like to leave with our readers?

Niquette: Despite my skepticism over prevailing LSI technology, we're still a pretty adventurous company. Our Sigma computer line is selling very well. One of the reasons it turned out to be such a good product is due to the MSI scratchpad memory that we developed for it. The use of MSI was cost-effective —it was a right decision and we're proud of it. But if you knew the stories behind the scenes—some of the problems encountered—I think you'd agree that there's still a lot of black magic in semiconductor houses.

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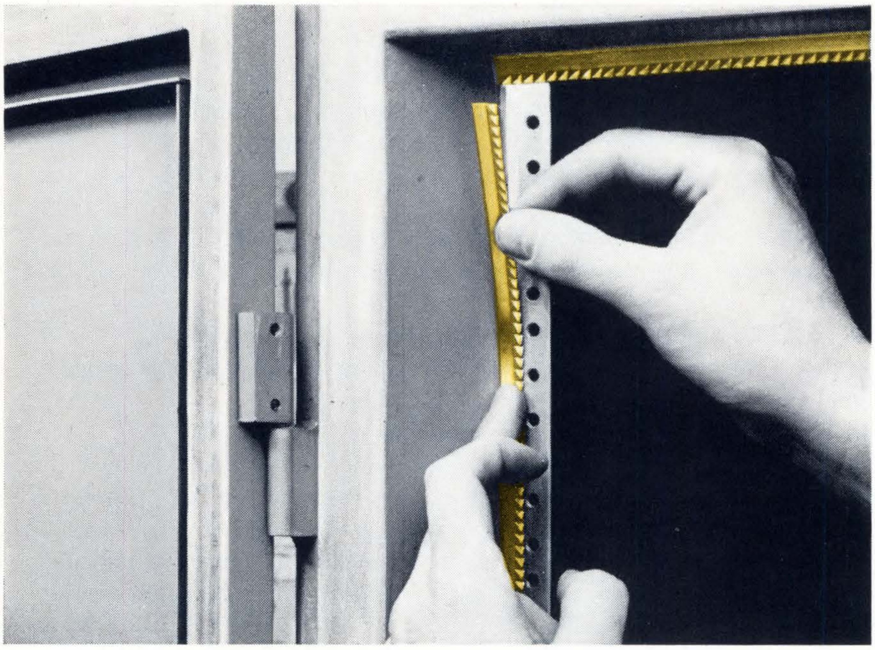

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CIRCLE NO. 405

"mini", "maxi" computers will change education—

Dr. Roger Levien

Minicomputers with programs fed to them by cassette and maxicomputers serving as central storage facilities available by telephone connection may sharply affect instructional techniques on the nation's campuses. But these recent technological advances will be effective only if they are accompanied by solutions to the production and distribution of instructional materials.

These views were expressed by Dr. Roger Levien at a three-day conference on "Computers in Instruction—Their Future for Higher Education" in October. Dr. Levien was head of a study by Rand, a non-profit research center in Santa Monica, on a $100,000 grant from the Carnegie Commission on Higher Education and a $45,000 grant from National Science Foundation, which will be entitled "The Emerging Technology: Instructional Uses of the Computer in Higher Education".

Significant advances in the technology make it imperative that decision makers in education consider now "things that are feasible which before this have only been speculated upon," Dr. Levien said.

He cited some of these advances:

Economy—"In 1955, the cost of performing one million additions on a computer was about $10. By 1975, a million elementary operations will cost less than one cent."

Speed—"In the vacuum-tube days, computers could execute from 10,000 to 100,000 computations per second. Now, with integrated circuitry, a million computations per second are common and some can do twice that."

Abundance—"There were about a dozen computers operating in this country in 1950. Today there are almost 80,000 and some authorities already are predicting that number will be doubled by 1975—then doubled again by 1980."

Sophistication—"We shall understand (in the coming era) how to program a computer to do the work of an engineer when he is applying well-developed design processes to a standard product; the work of a linguist when he is parsing a sentence in any one of several major languages; the work of an industrial manager when he makes a standardized decision (such as) when to reorder his inventory; the work of a teacher when he explains the essentials of a well-understood subject to beginning students."

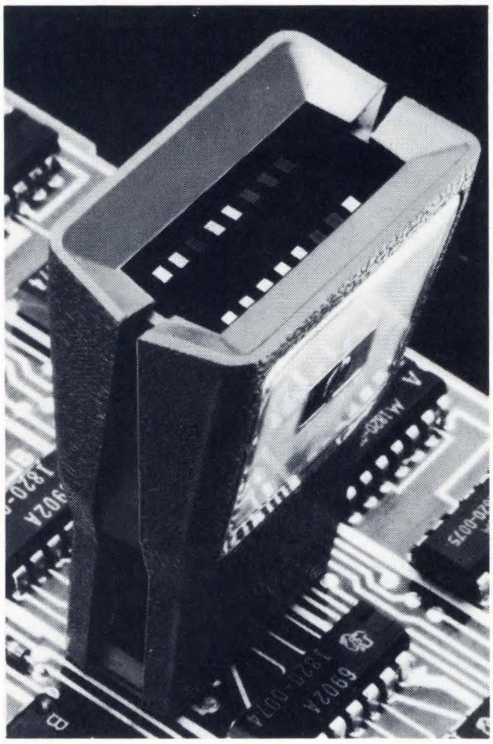
The computer, said Dr. Levien, will soon be able to ". . . operate with words and sentences as well as with letters and numerals; read, form and transform points, lines, arcs and the pictures formed from them; execute the logical operations that underlie inference, the way arithmetic operations underlie computation; and store and recall a single fact from files comprising millions."

Finally, in citing accessibility, Dr. Levien said: "The results of recent development will be computer service that is close at hand, like a typewriter or television-like console."

Computers will be easy to speak to in a language natural for the interests of the user and will be quick to respond at a conversational pace easy to understand.

"They will be ready for use at any hour. And through a single console, the user will have access to both a rapid reckoner and an encyclopedic memory."

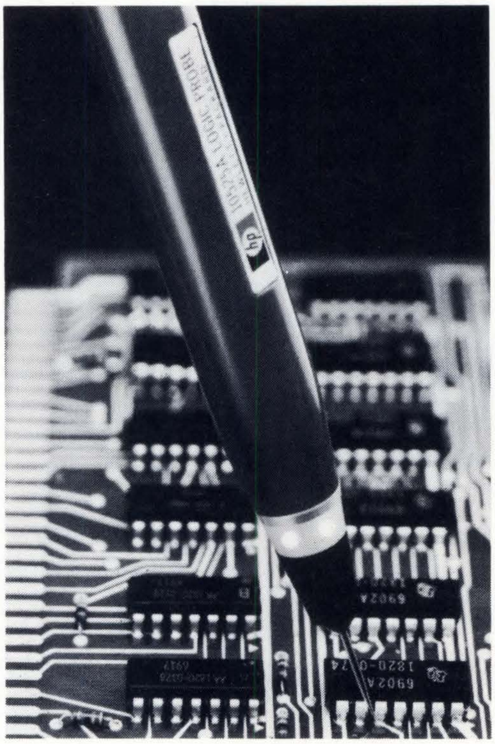
The IC troubleshooters.



For $125, it lets you see logic states at a glance.

Engineers testing the logic states of DTL or TTL IC packages no longer have to go the troublesome voltmeter route. The new HP 10528A Logic Clip shows you the state of all 16 (or 14) pins. This simple tool clips over the IC package, uses the circuit's power, is auto-seeking of Vcc and ground.

Bright LED's light up, indicating a high logic state. All this for just $125. Or less in quantity.



For $95, it lets you see pulse activity at a glance.

The HP 10525A Logic Probe makes tracing pulses through integrated circuits a painless task. Just touch the DTL or TTL circuit with the probe, and the tip flashes a signal for pulses as narrow as 25 nsec. A light in the tip indicates pulse, polarity, pulse trains, logic state.

It's almost like having an oscilloscope squeezed into a ball-point pen. And it only needs 5 volts and $95 to start troubleshooting your circuits.

Your local HP field engineer is your source for the clips and probes to speed up your IC testing. So give him a hurry-up phone order. Or you can write for full information from Hewlett-Packard, Palo Alto, California 94304; Europe: 1217 Meyrin-Geneva, Switzerland.

HEWLETT hp PACKARD

02008

CIRCLE NO. 406

directions

now—MOS/LSI kit for low-cost calculators—

Off-the-shelf set of standard MOS/LSI circuits provides American calculator manufacturers with a real boost in their continuing battle against low-cost imports. In addition, these sets should be of interest to data handling and instrumentation manufacturers who can use their capability in real-time data reduction. Such kits would save the manufacturer a year or more in design time normally required for logic and circuit development. An example is Electronic Array's set of six MOS/LSI circuits (See feature products).

designers generate their own patterns—

Because of the recent introductions of programmable solid-state ROMs, Spectrum Dynamics, Inc., Ft. Lauderdale, developed a portable "Memory Programmer" that permits programming of an off-the-shelf blank ROM. Manual or automatic programming and verification are performed quickly and reliably with this ten-pound unit, without auxiliary equipment.

Manual method involves a "program data card" that is fed into the unit one word at a time. A series of switches is selected to indicate the programming logic for each word. Then required voltages and currents are introduced to establish the pattern. Thus, any system requiring various ROM configurations may be quickly programmed.

Where duplicates of an established pattern are needed, the programmer quickly reads the pattern and produces a duplicate. Consequently, it becomes a production instrument in addition to its use in prototyping.

Access sockets are available for automated usage. Punched tape or card inputs can be devised to trigger the programming sequence. With patterning and verifying in under 150 ms/bit, a completed and checked ROM can be obtained in seconds. *For further information, see feature products.*

Straight answers to common questions about MOS/LSI

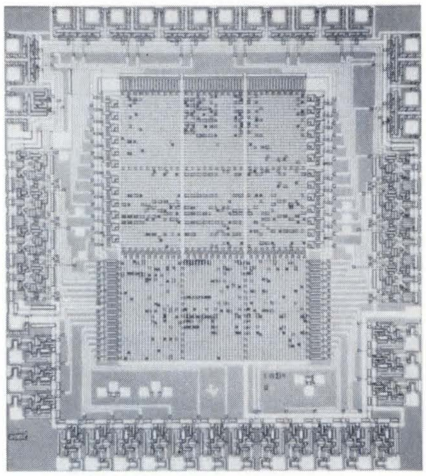
The pace of change in MOS technology is bewildering. New products, new processes, new companies are being announced with almost each new issue of industry trade journals. If you're considering MOS, these answers will give you a quick understanding of how TI can help you make the most of this dynamic, complex technology.

Q: First, where does TI stand in the MOS/LSI business?

A: To meet the industry's burgeoning demand for MOS, we have committed heavily in resources, facilities and talent to develop a broad-spectrum MOS capability. TI can offer you the most complete *custom* capability in the industry plus a broad range of *standard* catalog products from which to choose. A large portion of our newest facility is fully dedicated to MOS, and expansion capability is virtually unlimited. So, we are ready to meet your *volume production* requirements now and are committed to the kind of growth you can depend on for your future needs. We are confident this kind of capability is the key to clear-cut leadership in this growth industry. That is our publicly stated goal.

Q: But why should I consider TI rather than a "specialty" MOS supplier?

A: The answer lies in your range of options. Today, there are a number of advanced MOS processes offering many advantages and trade-offs which should be tailored



5040-Bit Programmable Logic Array

carefully to your specific requirements for speed, power consumption, circuit density, function, volume, economy and the like. Competence in circuit design is no longer enough; the industry has passed through the era when most MOS improvements were achieved by means of circuit design modification. The major advantages to you today are being brought about by innovations in process technologies and manufacturing capability. This requires resources, engineering talent, volume manufacturing know-how, computer-aided-design strength, and technological depth – in short, *real* commitment.

By coming to TI, you gain the flexibility that allows you to best adapt the optimum MOS approach to your requirements rather than vice versa. You can engage at any level and any stage; you can choose from several high-yield MOS production processes; you can draw on an extensive custom capability and a large selection of standard catalog products to best meet your cost/performance requirements – and you can get the circuits you need in whatever volume you need.

Q: From exactly what processes can I choose at TI?

A: Virtually any MOS/LSI process available in the industry. Depending on your requirements, we can employ ⟨111⟩ high threshold and ⟨100⟩ low threshold, or ⟨111⟩ nitride low threshold and ⟨self-aligned gate⟩. In addition, we are actively pursuing ion implantation and CMOS, though we feel these are not yet fully mature. We are also evaluating a variety of newer technologies and production techniques that hold considerable promise. To ensure the earliest advantage from these new technologies, TI will stay at the forefront of the MOS state-of-the-art.

Q: What about my custom requirements?

A: You can engage at any stage you desire for almost any circuit you require. As an example, we have produced volume-quantity circuits which can add, subtract, multiply and divide up to 12 digits for an electronic calculator which uses only three MOS/LSI chips. And we have designed and produced custom circuits for many different calculators and a variety of other types of systems.

Q: In going custom, what kind of help can I expect from TI?

A: TI will work with you at any phase of design and production. If you have a logic function in mind, but desire help with the logic implementation, we'll supply that help. We'll advise you in choosing the best MOS technology. We'll aid in the preparation of your logic and artwork, or work directly from the artwork you've prepared. We'll partition the system, produce the prototype and supply a computer-generated performance simulation for your check and verification. We have the capacity to produce and deliver whatever quantities you need, and if you like, we will second-source present MOS/LSI designs from existing photomasks.

Q: What standard catalog MOS circuits can I get from TI?

A: Today, we offer you 22 off-the-shelf circuits, and there are a number of others in development for announcement later this year.

TI's CATALOG MOS CIRCUITS

Shift Registers	
TMS 3000	Dual 25-Bit Static
TMS 3001	Dual 32-Bit Static
TMS 3002	Dual 50-Bit Static
TMS 3003	Dual 100-Bit Static
TMS 3012	Dual 128-Bit Static Accumulator
TMS 3016	Dual 16-Bit Static
TMS 3021	21-Bit Static
TMS 3028	Dual 128-Bit Static
TMS 3304	3 x 66-Bit Dynamic
TMS 3305	3 x 64-Bit Dynamic
TMS 3406	Dual 100-Bit Dynamic
Character Generators	
TMS 2403	USACII (5 x 7) Row Output
TMS 2404	EBCDIC (5 x 7) Row Output
TMS 4103	USACII (5 x 7) Column Output
TMS 4177 / TMS 4178	Combined, USACII (10 x 7) Row Output
TMS 4179	EBCDIC (5 x 7) Column Output
TMS 4886	USACII Parallel Output
Random Access Memories	
TMS 4003	256-Bit
TMS 4006	13 word x 6-Bit Digital Storage Buffer
Analog Switches	
TMS 6005	6-Channel
TMS 6009	6-Channel, Common Drain

Read Only Memories

Each of the read only memories in our programmable circuits line (see list at right) is available off-the-shelf as a pre-programmed sample to assist you in evaluating the electrical characteristics of these memories.

Q: What advantages are offered by programmable circuits?

A: While these are essentially standard circuits, they can be programmed to your specifications by simply changing one mask in the production cycle – providing an economical, quick turn-around approach to custom requirements.

Your choices here include three static read only memories of 1024, 2048, and 4096 bits with full decode. Also, there are three fast (200 ns) partial decode ROMs of 2048 bits for 4, 8 and 16 output bits. A full line of programmable character generators is available for all types of alpha/numeric displays.

Further, there are two programmable logic arrays of up to 6000 devices which perform sequential and combinational logic. These are combinations of master-slave J-K flip-flops and static read only memories on a single chip that permit easy implementation of random logic with the same turn-around time and low cost as a read only memory. They feature bipolar buffers on the same chip.

TI's PROGRAMMABLE MOS/LSI CIRCUITS

Static Read Only Memories	
TMS 2800 Series	1024-Bit
TMS 2600 Series	2048-Bit
TMS 4300 Series	4096-Bit
TMS 4500 Series	2048-Bit (128 x 16) High Speed
TMS 4600 Series	2048-Bit (256 x 8) High Speed
TMS 4700 Series	2048-Bit (512 x 4) High Speed
Character Generators	
TMS 2400 Series	5 x 7 Row Output
TMS 4100 Series	5 x 7 Column Output
TMS 4880 Series	5 x 7 Parallel Output
Programmable Logic Arrays	
TMS 2000	5040-Bit, 60 product terms
TMS 2200	5472-Bit, 72 product terms

Q: How are TI's programmable devices programmed to fit my requirements?

A: We provide a software package which you use to prepare the coding information on punched cards. Your punched-card instructions then tell our computers how to program your circuit. This results in fast turn-around time and eliminates human coding errors. Computer print-out of the circuit patterns can be returned to you for verification of coding accuracy before prototype production.

Q: Is the cost of programming expensive?

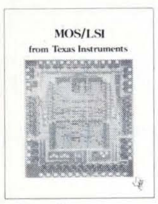
A: It's *free* on orders of 1000 or more pieces. For smaller quantities, there is a nominal charge depending on the type of devices and quantity you desire.

Q: How about price and delivery?

A: On catalog products, we can offer you immediate delivery at very competitive prices. The programmable circuit costs are comparable with standard catalog circuit prices. For example, the TMS 4300, a 4096-bit ROM, is priced at $25.00 each in quantities over 1000 units. It is available as a pre-programmed catalog device, or the same device can be custom programmed to your needs with no additional coding charge in these quantities.

Now about delivery: working from your photomasks, we can usually deliver dedicated-design custom products in two months or less. If you have MOS logic, but no photomasks, turn-around time is usually three to six months. If you prefer, we will work from your system specifications and deliver within four to eight months.

Q: How can I get more answers?



A: A good place to start is with our brand new technical brochure on MOS/LSI, Bulletin CB-126. For your copy, circle 401 on the Reader Service Card or write Texas Instruments Incorporated, P.O. Box 5012, M.S. 308, Dallas, Texas 75222. If you need more immediate help, call your local TI sales office or authorized distributor.

TEXAS INSTRUMENTS

INCORPORATED

With $250,000 a race riding on his system, this OEM places his bets on an HP tape drive.

CIRCLE NO. 408

American Totalisator has just computerized its world-famous Tote Board. So odds and payoffs can be posted instantly. And with indisputable accuracy.

Unless the computer "crashes."

In which case, you've got a mob of outraged race fans to contend with. So the computer is backed up with HP's 7970 Digital Magnetic Tape Recorder. If there is a "crash," the 7970 can be relied on to get the numbers back on the board in minimum elapsed time.

Reliability makes the 7970 a money winner for American Totalisator. Its exclusive HP features assure trouble-free operation from 10 to 37.5 ips.

And to make sure the 7970 stays in the winner's circle, there are 141 Hewlett-Packard sales and service offices around the world to serve you and your customers. If a 7970 should need work, simple plug-in service cards permit repairs on-site with minimum down time.

American Totalisator chose the HP 7970 Digital Magnetic Tape Recorder for reliability. If you want a sure thing, just call your local HP field engineer. Or write to Hewlett-Packard, Palo Alto, California 94304; Europe: 1217 Meyrin-Geneva, Switzerland.

42003

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MAGNETIC RECORDERS

BRADSTREET VACHON, Digital Equipment Corp.

exploring the computer interface

Every day the on-line services of computers accomplish nearly impossible feats. However, none of this can be effectively realized without a good marriage between the computer and the rest of the equipment—always an essential fact for a system designer to keep in mind.

Whether processes or instruments should be connected to computers is no longer a question. Speed, repeatability and tirelessness of computers make possible greater reliability and more efficient use of equipment and operational procedures. In many instances computers permit instrumentation to perform functions that otherwise would be difficult or impossible if attempted manually. However, with this growing awareness of the desirability for computerizing equipment, often one of the more important factors to any engineer involved in designing the final system is not faced squarely—developing the proper communication medium between the process or equipment and the computer.

Take the scientific field, for example. It is one thing to connect a computer to one or more laboratory instru-

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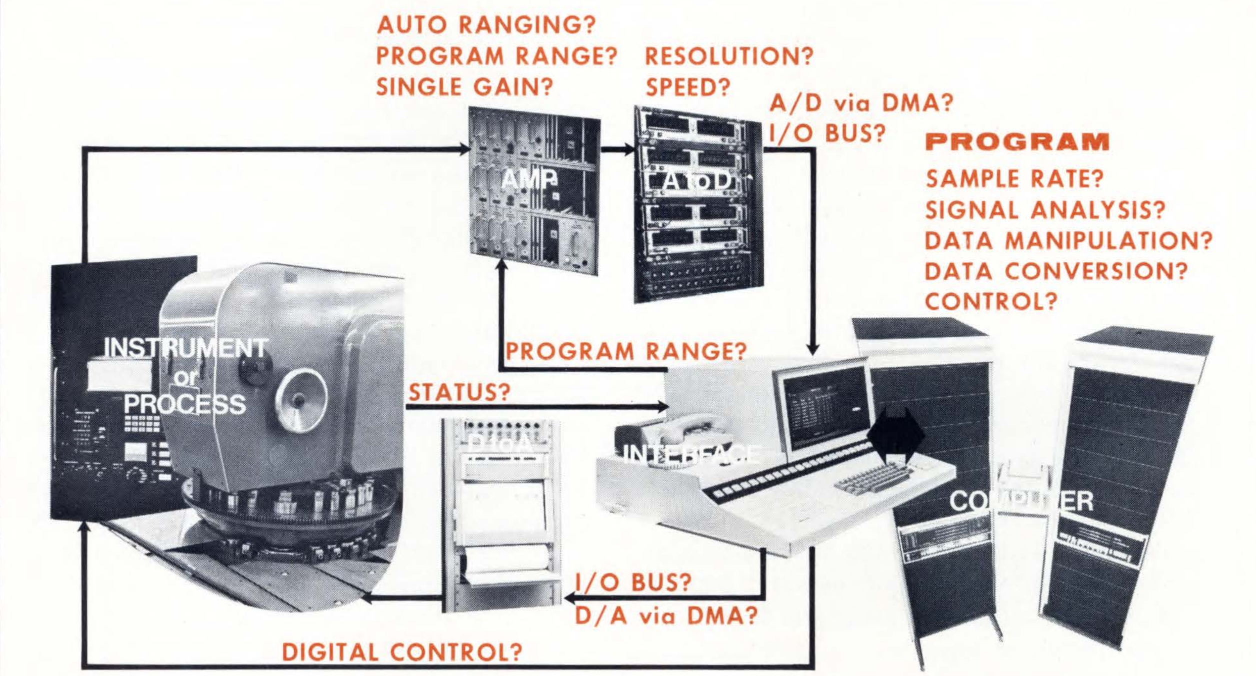


To achieve optimum design in a customized system, many questions, such as those shown, must be answered.

(Continued)

Computer Interface *(Cont'd)*

ments, but it is quite another to develop a system that includes a reliable interface. Obviously, the laboratory instrument output can be analog and the computer's input digital, so an analog-to-digital converter is required. But there are other considerations that are not so obvious.

—Does the system have only data-gathering functions, or does it also have control functions?

—Is there only one instrument, or are there many?

—Is there compensation for the wide dynamic range inherent in the output signals from many laboratory instruments?

These and many more questions must be resolved before it is possible to use a computer for control or monitoring of laboratory instruments. Of course, these same questions apply to other computerized systems and specialized computer peripheral equipment. Each presents a special and unique problem that requires the consideration of all parameters necessary for an efficient and effective system.

Defining the System

For efficient computerization of any process or experiment, the most important item to be considered is a concise definition of the interface. This means determining what parameters—both hardware and software—must be included in the interface to achieve the desired results efficiently.

Defining the interface requires an understanding of both the computer and the instrument or process to be computerized. Although this may be the assigned job of a project manager, it is seldom that one person has the expertise to cover both areas. As a consequence, a mutual understanding must be established between at least two people to define an adequate interface.

As an example, the end-user, such as a chemist, knows the "language" of his problem but seldom knows the "language" or interface parameters of a computer.

NUMBERS GAME

Be Sure of What You're Getting

An end user who elects to purchase peripherals and interface them himself should be aware of what he is buying. For example, a line printer manufacturer may offer a "low cost OEM version" for what seems an unbelievably low price. Does this sound like a good deal? Perhaps it may sound *too* good to be true. The rule here is: "Do not buy on the basis of reputation and price alone. Look into the specifications." Chances are that this line printer is only mechanical—without solenoid drivers, power supplies and a full-line buffer. What anybody who contemplates making such a purchase must realize is that volume users can build the equipment to produce a fully electrically-buffered printer. An end user just cannot build the electronics into the printer, build the interface to the computer, document it, test it and support it for less than he could buy a complete (more expensive) unit.

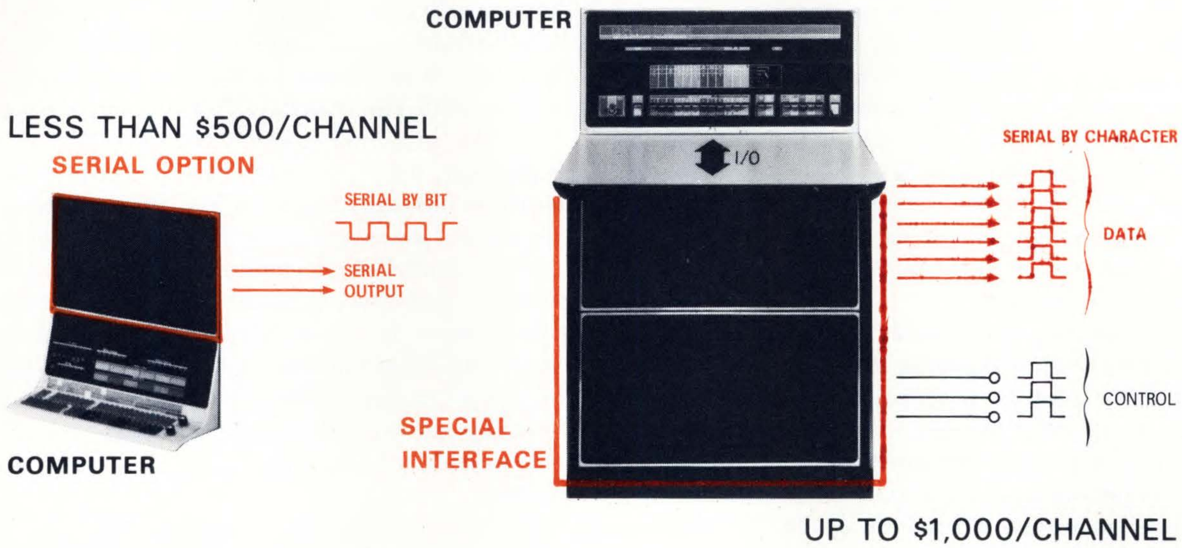
Same applies to tape drives and other peripheral devices offered in "OEM version". You may not be buying a complete peripheral device—just a large portion of one. A hint on OEM versions is to check model numbers and be sure you know what they mean before you buy. One digit difference in the model number could reduce the purchase price by $1000 but increase true cost by $10,000.

An OEM Speaks Out

A specific brand of synchronous MODEM has been used previously with computer systems. Let's say that the AJ-1 Series MODEM is tried and true with your system. In fact, the computer manufacturer has standardized interfaces available off the shelf. Your next customer says that he also has the same brand of synchronous model, thus it is unimportant to check the model number since it is probably just another AJ-1 Series.

Maybe you will be lucky, but if it is the less-used AJ-2 or BJ-1, you are in for a shock. Connectors alone cost nearly $80 more for an AJ-2 than an AJ-1. And that is just the beginning. Consider the other hardware and computer software changes required—plus changing all that documentation.

This word of caution does not apply just to MODEMS. A one-digit difference in model numbers can mean twice the speed, half the density, hundreds more lines per minute, larger tape reels, twice the rack space, or just a whole new input/output connection scheme.



JUST A SIMPLE SERIAL LINK

What Do You Mean by Serial Data?

Peripheral manufacturer told end user (who wished to interface four peripheral controllers) that required interface data path was "a simple serial interface". End user bought his computer with four-channel serial option commonly used for Teletype connection.

Peripheral controllers and computer system arrived at end user's plant at about the same time. To the end user's dismay, his definition and peripheral manufacturer's definition of "serial data" differed. Computer options were designed to generate data in a serial bit format and peripheral was designed to accept serial data 6-bits/char.).

End user had to design and build a four-channel special interface. Delays associated with design, parts, building and testing delayed project 3 months. Also, it cost several thousands of dollars. Clearly, this was a case of an apparently simple job becoming complex and costly because of conflicting and ambiguous terminology.

Even if he did, it is highly improbable that he would know it expertly, and this could be unfortunate—especially if he attempts to design the complete system himself.

On the other side of the fence, the computer manufacturer or consultant has an intimate understanding of how the computer works. He knows the computer language and how his system can be made to operate efficiently. However, he is not an expert with regard to the instrument or process to be computerized.

Therefore, an optimum design requires a working partnership between the end user and the manufacturer. This team effort becomes a form of mutual education, permitting an accurate and complete definition of all parameters for the best interface as well as the most efficient computerized system.

Importance of Teamwork

Because both hardware and software are developed simultaneously, it is important to have teamwork. To illustrate, consider interfacing a scientific instrument with a computer. This instrument may have an analog output with a dynamic range of 10^6 or greater. There are many factors that determine how this wide range can be handled. One typical factor is the frequency components of interest in the output signal. This factor determines the sampling speed; defines the operational range of the amplifiers; establishes the analog-to-

(Continued)

***Computer Interface** (Cont'd)*

digital conversion speed and suggests the characterization of the converter-to-computer interface.

Obviously, to be utilized efficiently, very fast converters must interface direct-to-memory as opposed to the slower program-transfer techniques. If programmed gain is used, as might be expected in slow instrumentation, the interface must also contain the control circuitry for the computer program to address the amplifiers' gain-changing elements. If this is the case, part of the software (operating program) requirement is defined.

The computer must be able to monitor and control the instrument intelligently. If control settings on the instrument affect the output signal, these effects must be made known to the computer. This status information is critical, and the interface must provide this data to the computer under program control—another software requirement has been defined, as well as a possible need for instrument modifications.

After further study of other factors, such as the number of instruments to be monitored and controlled and the amount of data manipulation and conversion to be done on each sample, one begins to get some understanding of the optimum interface parameters and the operating program design parameters. If either is developed first, without regard for the other, a burden is put on the remaining system elements, resulting in an inefficient hardware and/or software design.

A final consideration is the practicality of the design. Suppose the final design must fit into a volume no more than 10% larger than the original instrument. It may be physically impossible to perform the design at all, but even if possible, it certainly could not be done at all without close coordination between experts in both the computer and instrumentation fields. This is where a project manager must manage—in the engineering sense of the word.

Who Builds the Interface?

After a system has been specified, it must be built. A corollary to the statement that the development of a computer interface requires adequate definition is that the actual construction of an interface is almost as important and that the choice of a builder is not to be taken lightly.

There are three approaches to producing the computer interface: the user builds it; the computer manufacturer builds it; or a "third party" that specializes in designing computer systems builds it.

USER—Often, though not always, the user knows his process best. If the user completely understands his process and transducers, and if he has well-defined specifications on the computer he wishes to interface with, then it is possible for the user to define, design and assemble the interface. This sort of construction approach can be most efficient and powerful.

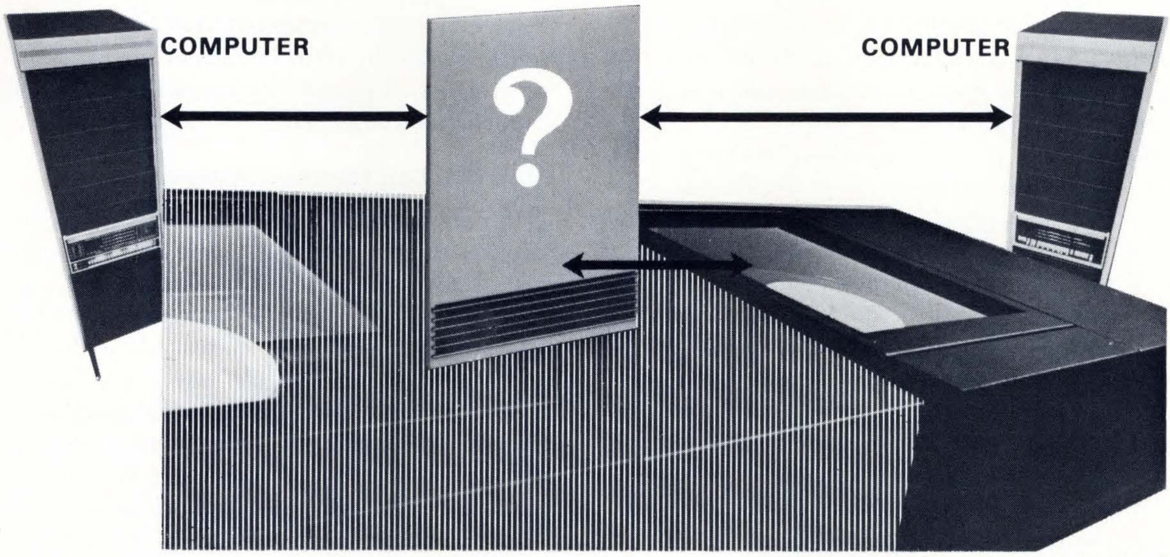
However, there are disadvantages. Frequently, the user does not really know the relationship between his process and the computer, so he creates a system that if it works at all does not employ the full potential available. An analytical instrument, for example, that is computerized by an end user might merely act as a simple data-reduction device—translating analog form to digital printout. With expert programming, however, this system could act as a controller or could provide second- and third-order derivations of the results on-line.

Another consideration is that the end user is responsible for making the system functional. If anything goes wrong, he has nobody but himself to blame—or turn to. Although the individual instruments or mechanisms within the system may be under warranty, the manufacturers are only obligated to service their instruments as "instruments" without regard for how they fit into the system.

MANUFACTURER—Just as the user knows his system or process best, the manufacturer knows the characteristics of his computer. If the manufacturer obtains well-defined parameters from the user, it is possible for him to design and assemble a reliable interface. Quite frequently, the computer manufacturer has already had experience in designing similar systems.

This approach has many advantages. The manufacturer knows his products better than anybody else. With proper definition, he can develop an interface that can operate with his computer with maximum efficiency. If the manufacturer designs the system, then the operation of the computer-based system as a system is his responsibility. Because the manufacturer has developed other systems, it is often easier for him to design the interface, even if he has never had experience with a similar system.

Also, manufacturers know from experience that most computerized systems tend to expand; accordingly, they usually include expansion capability. A system house for example, is under no obligation to provide for expansion unless this requirement is specifically contracted—and frequently the system houses deliver complete systems that are difficult or impossible to expand.



LET'S SAVE MONEY

Have You Considered the Software?

An end user wishes to save cost of buying two large mass storage devices for a dual computer by purchasing two computers and one mass storage unit that was to be connected to the computers by a special electronic switch. System arrived and was installed. In a few hours, the system was operational and all diagnostic routines ran as specified.

However, the computer manufacturer provided the mass-storage device with a sophisticated operating system program, which the end user was expected to use. But the program required a complete redesign to include use of special electronic switch. When investigating the cost, it was estimated that one man-year of programming effort was needed to do the trick. End user elected to discard the electronic switch and buy another mass-storage unit. He gambled to save a little money and lost both time and money because all facts were not considered.

Servicing a computer-based system is easier for manufacturers because they usually have a multitude of service centers and regional depots. Besides offering rapid response to service calls, this also implies a large depot of spare parts are available. If a user or systems house maintains the system, an inventory of spare parts is needed or they must be prepared for the system to be inoperative until the delivery of spare parts.

Naturally, there are disadvantages such as the manufacturer's desire to develop the interface for his products only, thus limiting the choice of available computers. Also, it is vital that the interface be defined exceedingly well so the manufacturer will produce the correct configuration. This in turn puts a different sort of burden on the designer—he must communicate clearly to the manufacturer what he is trying to do with his instruments or process.

THIRD PARTY—A third party might be a consulting firm or a "system house" comprised of professionals who do nothing but design computer systems. This type of organization tackles the whole job, from conception to on-line operation, and actually creates a customized system to do what the user wants.

The third party has its advantages. For instance, customized computer systems are their only business. Consequently, they probably have teams of instru-

(Continued)

Computer Interface (Cont'd)

mentation, process and computer specialists—all of whom have worked on computer systems and have an understanding of the interfacing problems. With this sort of organization there is less time wasted in developing the necessary interfacing.

However, there are corresponding disadvantages to this approach. The responsibility of the third party is to deliver precisely what the customer asked for—and no more. Therefore, the system usually meets today's requirement with no consideration for future development. This rigidly "locks in" the end user to the third party for modifications and improvements that invariably loom up a few weeks or months after the system is on-line. In addition, a third party meets the requirement of delivering a working system, but not of maintaining it. Responsibility for the upkeep after the warranty period (if any) usually rests upon the user unless previous contractual arrangements are made.

Furthermore, while system houses theoretically are not "locked in" to any particular computer or computer manufacturer, they may be more familiar with one specific computer. Naturally, they will tend to use the product that they know. In terms of choosing a computer under these circumstances, a third party offers no advantages over dealing directly with the manufacturer.

Finally, there is a possibility that a systems house may in fact have had little experience in a specific field. Even though they can tie a computer to an instrument or process, the responsibility for defining the system and interface reverts mainly to the user.

What Is the Best Approach?

Often the best way depends in part on the final configuration and what the user expects of it. Maybe the user wants a "turn-key" system—a complete package that performs a specialized function quickly and efficiently. Such a system however, is usually inflexible, and thus it may be difficult to incorporate improvements into or to expand for future jobs. For the user to whom this makes no difference, or for the user with little or no knowledge (or desire to learn) about computers, this may be the answer.

On the other hand, if the user visualizes future expansion of his system's capabilities or functions, a turn-key system is not a good solution. Rather, such a user needs a system that he can alter (or have altered) without redesign of existing hardware and software.

All of these considerations reflect aspects of a problem basic to every project design of a potential computerized system—cost. How do you measure cost in organizing a computer system? Indeed, this is the area that separates the project manager from the engineering designer. A project manager has to take long and detailed views of all aspects of cost.

How Do You Measure Cost?

On snap judgement, someone might say, "The least expensive system that will do the job." This, however, might not be a correct—or even a meaningful—answer.

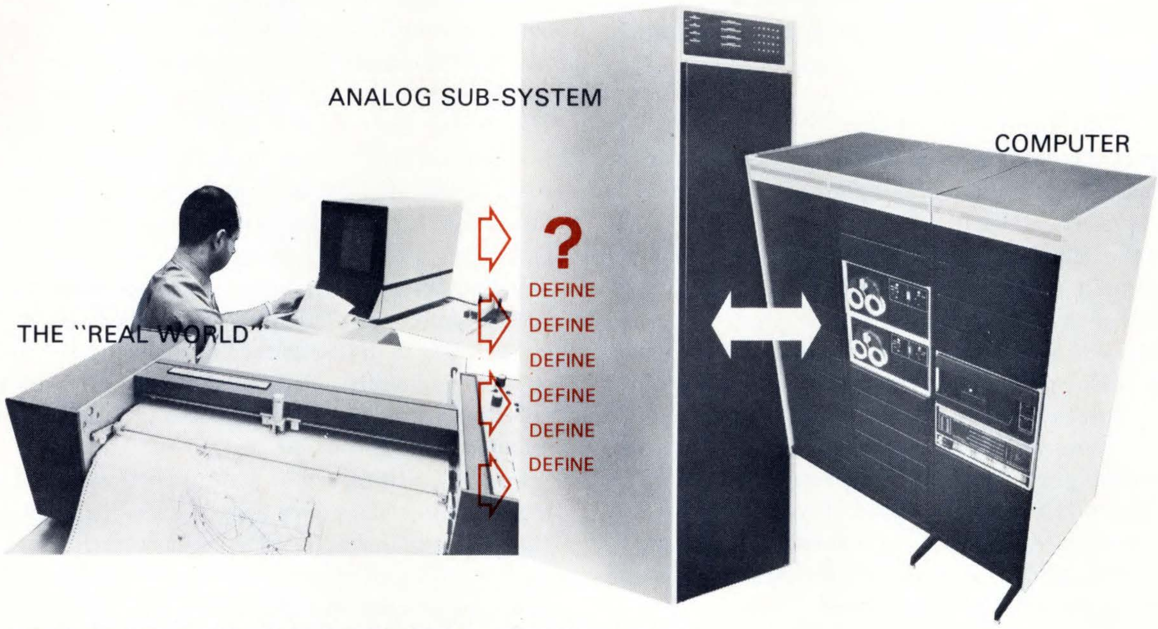
First of all, the "cheapest" system may be the least expensive for the original job but not be adaptable to an expanded or extended role. Secondly, it may be that the system originally described was inadequate to perform the user's task. This can happen when an end user requests a turn-key system and provides the system house or manufacturer with an incomplete or inadequate description. In either case, the system's capabilities are limited (in the latter case, for corrections), and the price of altering the system usually exceeds by a wide margin the price of a system with inherent expansion and alteration features.

The end user should consider here the very high cost of paying too little. If you economize to the point where you end up with a marginal or unsatisfactory solution to your immediate and near-future requirements, you have lost the ball game. On the other hand, for a small additional cost, you may attain flexibility, reliability, useability and expandability. Chances are that this will pay off handsomely in the long run when the ease of maintenance and expandability yields a realization of future requirements.

When we talk of a "least expensive" system, what are we really talking about? Is it hardware cost, engineering cost, servicing cost? Many times the "least expensive" system turns out to be anything but the lowest-cost, depending upon the criteria used to measure expense. An understanding of which criteria are right is one of the most important factors of good project management.

Development Cost

To demonstrate what has been discussed, assume a hypothetical system that uses a computer to control the output of an electrical power plant. First the system is defined and designed. The computer will monitor the voltage, frequency and load. Also, it will have sufficient decision-making capabilities to enable it to determine when to disconnect the power station from the power network to keep the system from a ruinous load. In



BUILD ME AN ANALOG SUBSYSTEM FOR MY COMPUTER

Specifications? Definitions? You Bet!

System house builds a compact A/D subsystem for an end user. It mates with end user's computer, and test signals demonstrate suitable accuracy and resolution. Yet, every time end user connects it to his equipment, multiplexer switches burn out immediately—sometimes dramatically.

Soon, the problem becomes apparent. There is a different low-signal reference point for each analog signal connected to each subsystem channel. In some cases, common-mode voltage becomes as large as several hundred volts. Analog subsystems must be specifically designed for this type of application.

Who is to blame is of little consequence. Someone has to pay for the delay and expense of redesigning with the analog subsystem—from scratch—based on new specifications acquired the hard way.

addition, the computer will have sufficiently fast reaction time and explicit control functions to permit the necessary disconnection in time, yet avoid being so hasty as to contribute to failure elsewhere by upsetting the overall network.

The power station personnel probably can design such a system. Based on an inexpensive computer such as the PDP-8/L, hardware cost could conceivably be kept below $20,000. However, this does not include the development and debugging of software, which involves time, money and usually "outside" help—unless the power station has a programmer. And, of course, there is the intangible expense of a nonoperating system during the development stages. With a system designed in-house, $20,000 probably represents less than a third of the final cost.

If a consultant (third party) or a computer manufacturer proposes the same system, the initial cost could be approximately $35,000. However, this system will be operating within a matter of days after installation. The question that must then be answered is: "What is the cost per day for nonoperation?"

Installation

When the end user designs and builds the system, he assumes the responsibility for making the components

(Continued)

Computer Interface (Cont'd)

of the system work as a system. Yet each component within the system may be serviced by its respective manufacturer. But specialized items and designs are not covered by any warranty and this applies equally to any nonstandard modification by the end user. In fact, just the problem of continuously training service personnel might make this approach undesirable to the end user.

On the other hand, the manufacturer's seemingly higher price allows him to guarantee satisfaction regardless of the circumstances. If problems develop during installation because of misunderstanding or inadequate initial definitions, the computer manufacturer is in a position to have engineers work with the end user to guarantee ultimate satisfaction. By contrast, the lowest price, shave-it-to-the-bone attitude of an independent third party seldom leaves room for any contingencies. As a result, the end user faces a take-it-or-leave-it attitude (or worse) when dealing with a consultant under these circumstances.

Service

There is the matter of service and maintenance. Who will service the power station control system once it has been built? Who has the spare parts for it? How long can the station afford to be without the services of the system?

Indeed, no matter what sort of computerized system you are talking about, the service problem is critical during and after installation, but it must be considered in the beginning. And to a certain extent, this reflects upon the question: "Who builds the system?"

For fast repairs, the end user requires a reasonably large inventory of parts. Without them, an intolerable delay could develop at a crucial time. Depending upon the application, this criterion alone might be a key factor in deciding against building an in-house system.

With a system house, the end user may be in virtually the same situation, because the system responsibility after acceptance then reverts to the end user. Although the end user did not put the machine together, he still has to keep it running. Even with a service contract the system house is faced with the basic problem of replacing parts. Since system houses usually develop one-of-a-kind systems, they would need a larger inventory of parts to maintain all of these custom-designed systems. In addition, if they did keep all these parts, the costs involved in maintaining such an inventory will ultimately be reflected in the price of the end user's contracts.

By contrast, the computer manufacturer is in a better position with regard to service. First, there are the logistic considerations. A manufacturer usually has a widespread organization of servicing depots. This means not only fast service, but low transportation cost—which reflects in the service contract costs. Also, if the manufacturer generates the system configuration, he assumes system responsibility and repairs the system as a system. Another point is that the manufacturer usually uses standard parts even in special equipment. This reduces the spare parts stocking problem to those supplied by one vendor—the computer manufacturer. Because the spare parts are available, service calls will be quick and efficient—again reducing service contract cost.

Finally, with regard to malfunctioning systems, the manufacturer has a deep knowledge of his product and has well established trouble-shooting techniques that permit rapid and efficient repair of an ailing computer, thus further reducing the effective costs of repair.

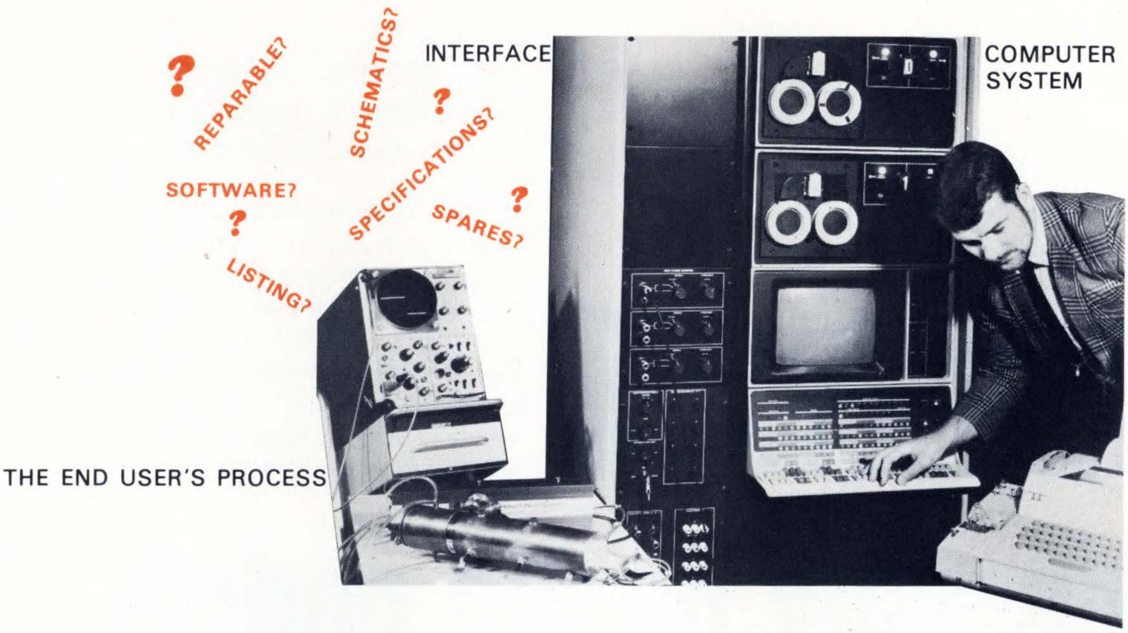
A rather subtle point is continual service longevity. Too often independent "low cost" third parties suffer from the "here today, gone tomorrow" syndrome. Under certain conditions, this can spell disaster for the end user. The end-user project manager must have the foresight to think through these sometimes-overlooked aspects.

Costly Alternatives

Eventually, the majority of systems are expanded or extended after a period of operation. This happens because, after an end user has worked with his system for a while, he discovers other areas of application. Therefore, the major question is whether to incorporate expansion capabilities in the initial design or to face the problem of expansion only when and as it occurs —sometimes a costly alternative.

There is no absolute answer to this question, any more than there is an absolute answer to the question of who should design the interface itself. Because a large number of systems do get extended—and considering that leaving provisions for expansion within the initial design usually does not cost much more than a nonexpandable system—it is considered a good investment to provide for future growth. Adding expansion capabilities later generally proves to be a very intricate and costly undertaking.

Like the problem of the original design, who is responsible for modifying the system depends upon many variables. Here, however, it is a little more clear-cut



I'LL MAINTAIN MY COMPUTER-BASED SYSTEM

Are You Sure You Know How?

An end-user project manager agrees to maintain his computer system containing special interface designed and built by his engineer. Inevitably, the interface develops problems—6 months after installation. However, the engineer determines the problem in less than 2 hours. While still filled with pride for saving the cost of a service contract, the engineer is transferred. Then the manager turns to the computer manufacturer for a service policy on the entire system.

It is then that he learns that his engineer has the complete design in his head—no documentation. Also, the "mother board" is a custom package. He did recall his engineer saying something about cost savings in his packaging approach.

Who does the user turn to for service? Computer manufacturer will service his standard equipment, but what about interface? Only one man, the designer, knows for sure what it is—better get him at any cost.

because the expansion will almost invariably involve the computer. The end user's resources, and usually even those of the system houses, are not as comprehensive as those of the computer manufacturer in any expansion program.

Final Analysis

In order to build that optimum system, many design factors must be considered—some not too obvious. Since the most important consideration in the area of design is definition of the interface parameters, these parameters should be nailed down precisely as a prelude to and guide to choosing a system design. ▭

Bradstreet Vachon is manager of the Computer Special Systems Group at Digital Equipment Corp., Maynard, Mass. Bradstreet is a graduate of Wentworth Institute and has been granted two patents. He is a member of ISA. Mr. Vachon feels that "far too much emphasis has been placed on looking at C.P.U. costs—which actually can be as little as 1/6 the total costs of system implementation".

JEFFREY C. KALB, National Semiconductor Corp.

exclusive-OR unravels cyclic codes

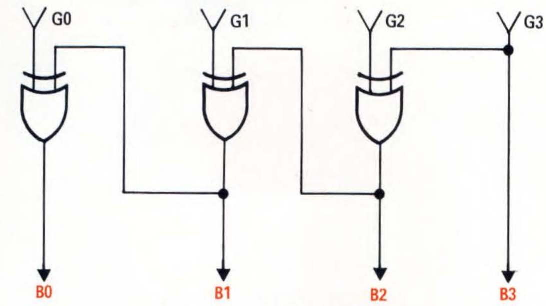
Four exclusive-OR gates in a single package permit a fresh look at the design of cyclic-code converters.

Popular techniques for designing cyclic-code converters have been expensive in terms of the actual hardware needed to build the circuits. Usually this is because they are serial converters built with conventional gates. Today, multicircuit chips allow code conversions such as Gray-to-binary or binary-to-Hamming to be performed in parallel—but with a substantial reduction in hardware. Designers now can attack the conversion speed and cost problems broadside.

Gray-to-binary conversion is extremely easy to design. For example, the actual gate complexity using conventional gates is 15 for the 4-bit converter shown in **Fig. 1**. However, with quad exclusive-OR gates such as the DM 7086/DM 8086, all that is required is one package and three connections.

Converting binary to a Hamming code is more complex, because the Hamming code is three-dimensional. This type of code detects and corrects errors using parity check bits distributed throughout the message word. With the help of a truth table, the exclusive-OR gates easily unscramble the necessary logic. In **Fig. 2**, six gates (1-1/2 packages) convert a 4-bit binary word into a 7-bit Hamming-code word. With the circuit in **Fig. 3**, three check bits permit single error detection.

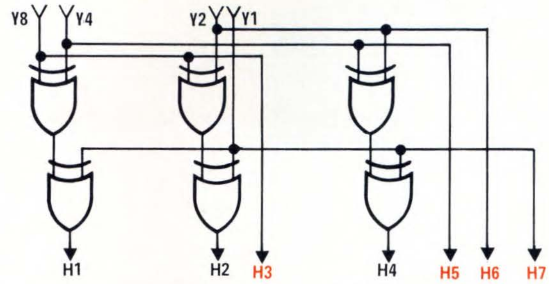
Exclusive-OR gates certainly are not a new logic concept. The novelty of these devices is that they provide a minimum-package solution to functions best performed with exclusive-OR logic. Each package is functionally equivalent to four AND/OR/INVERT gates and eight inverters—equivalent to 20 gates/package. Obviously, these devices are more economical to use. A "minimum gate" solution in reality requires more packages and costs more by the time the system is built. ▭



GRAY/BINARY TRUTH TABLE

No.	INPUTS G3	G2	G1	G0	OUTPUTS B3	B2	B1	B0
0	0	0	0	0	0	0	0	0
1	0	0	0	1	0	0	0	1
2	0	0	1	1	0	0	1	0
3	0	0	1	0	0	0	1	1
4	0	1	1	0	0	1	0	0
5	0	1	1	1	0	1	0	1
6	0	1	0	1	0	1	1	0
7	0	1	0	0	0	1	1	1
8	1	1	0	0	1	0	0	0
9	1	1	0	1	1	0	0	1
10	1	1	1	1	1	0	1	0
11	1	1	1	0	1	0	1	1
12	1	0	1	0	1	1	0	0
13	1	0	1	1	1	1	0	1
14	1	0	0	1	1	1	1	0
15	1	0	0	0	1	1	1	1

Fig. 1 – **Gray-code conversion to binary code** is ideal for exclusive-OR elements. As indicated in truth table, binary bit B2 is "1" whenever Gray code bits G3 and G2 are different; B1 is "1" whenever bit combination of G1, G2 and G3 is odd, and so on. To increase the word length, extend the daisy chain to the left.



BINARY/HAMMING TRUTH TABLE

No.	INPUTS Y8	Y4	Y2	Y1	OUTPUTS H7	H6	H5	H4	H3	H2	H1
0	0	0	0	0	0	0	0	0	0	0	0
1	0	0	0	1	1	0	0	1	0	1	1
2	0	0	1	0	0	1	0	1	0	1	0
3	0	0	1	1	1	1	0	0	0	0	1
4	0	1	0	0	0	0	1	1	0	0	1
5	0	1	0	1	1	0	1	0	0	1	0
6	0	1	1	0	0	1	1	0	0	1	1
7	0	1	1	1	1	1	1	1	0	0	0
8	1	0	0	0	0	0	0	0	1	1	1
9	1	0	0	1	1	0	0	1	1	0	0
10	1	0	1	0	0	1	0	1	1	0	1
11	1	0	1	1	1	1	0	0	1	1	0
12	1	1	0	0	0	0	1	1	1	1	0
13	1	1	0	1	1	0	1	0	1	0	1
14	1	1	1	0	0	1	1	0	1	0	0
15	1	1	1	1	1	1	1	1	1	1	1

Fig. 2 – **Hamming code** is an error-detecting and correcting code that employs check bits distributed throughout message word. Truth table illustrates how a 4-bit binary word converts into 7-bit Hamming code.

Information bits H3, H5, H6 and H7 are message bits and are the same as respective binary bits Y8, Y4, Y2 and Y1. Information bits Y8, Y4 and Y1 form check bit H1; Y8, Y2 and Y1 form H2; and Y4, Y2 and Y1 form H3. Check bits detect odd parity (they are "1" when number of information bits is odd).

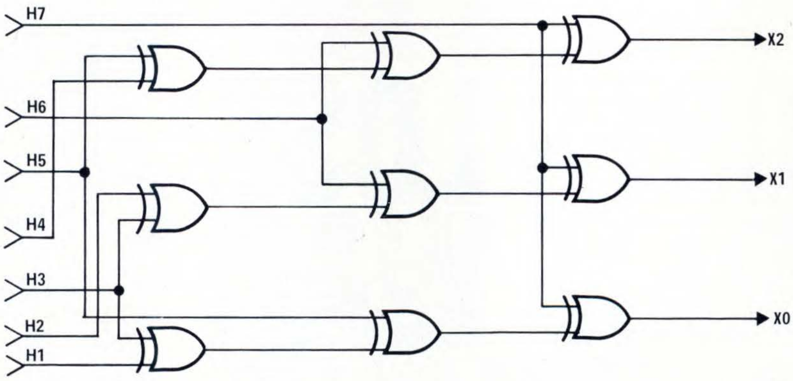
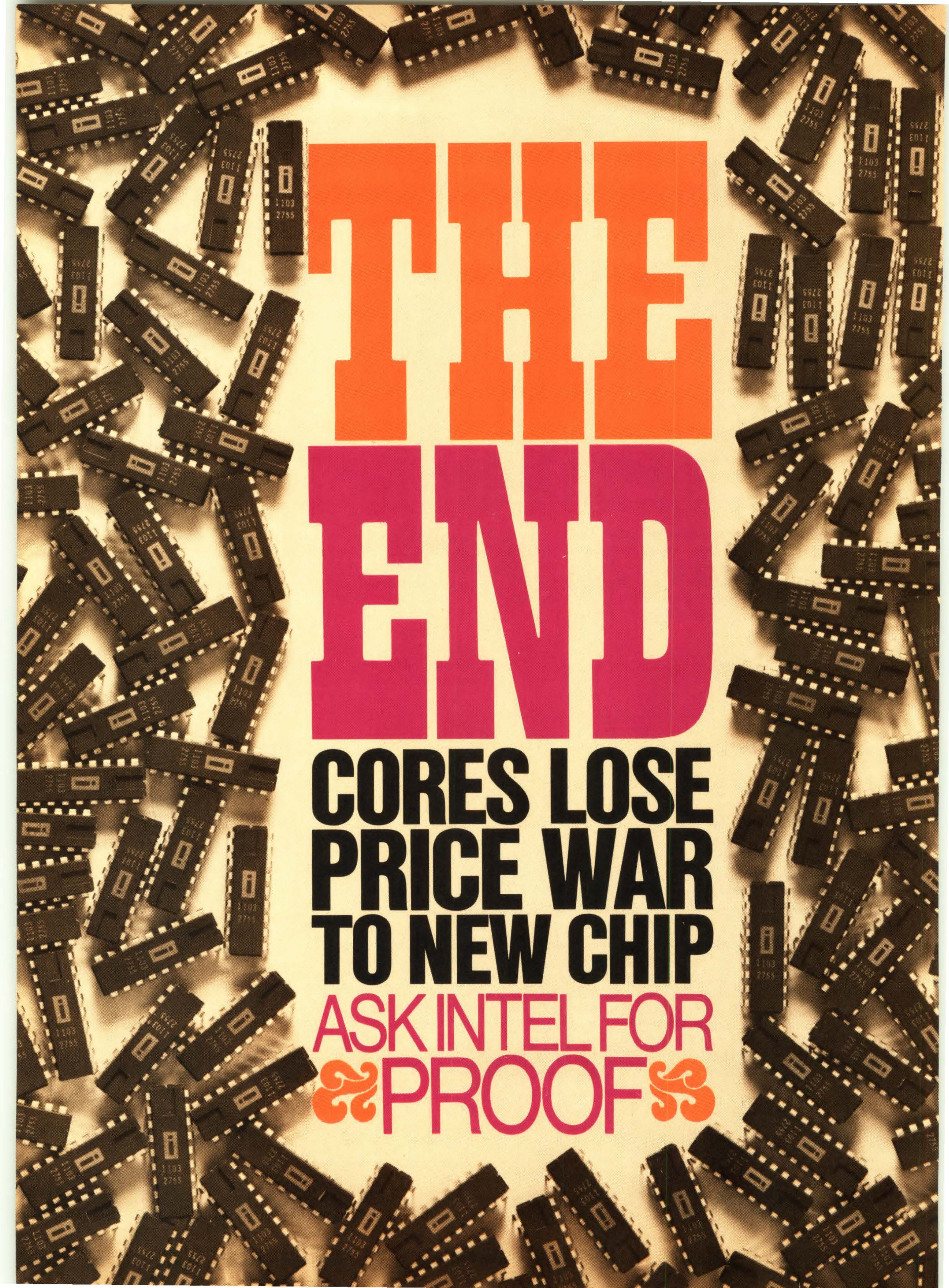


Fig. 3 – **When receiving transmitted Hamming code,** check bits provide error detection. Bit positions H1, H3, H5 and H7 generate error output X0; H2, H3, H6 and H7 generate X1; and H4, H5, H6 and H7 generate X2. Error outputs are "0" only when there is an even number of "1s" in each four-bit group. If there is an error in either information or check bit, appropriate error output goes to "1". Binary combination of these outputs identifies the erroneous bit. Following examples illustrate circuit operation.

	VALID MESSAGE							ERRONEOUS MESSAGE							BIT POSITION		
NO.	H7	H6	H5	H4	H3	H2	H1	H7	H6	H5	H4	H3	H2	H1	X0	X1	X2
3	1	1	0	0	0	0	1	0	1	0	0	0	0	1	1	1	1 (H7)
9	1	0	0	1	1	0	0	1	0	1	1	1	0	0	1	0	1 (H5)
12	0	0	1	1	1	1	0	0	0	1	1	1	0	0	0	1	0 (H2)

Jeff Kalb, director of digital IC operations at National Semiconductor Corp., Santa Clara, Calif., is responsible for design, development and production of all digital IC components. Jeff received his degree in electrical engineering from the University of Cincinnati. He has four patents pending and has authored several articles.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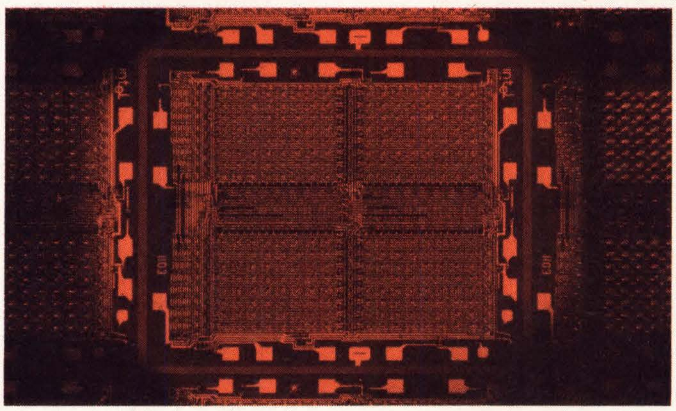

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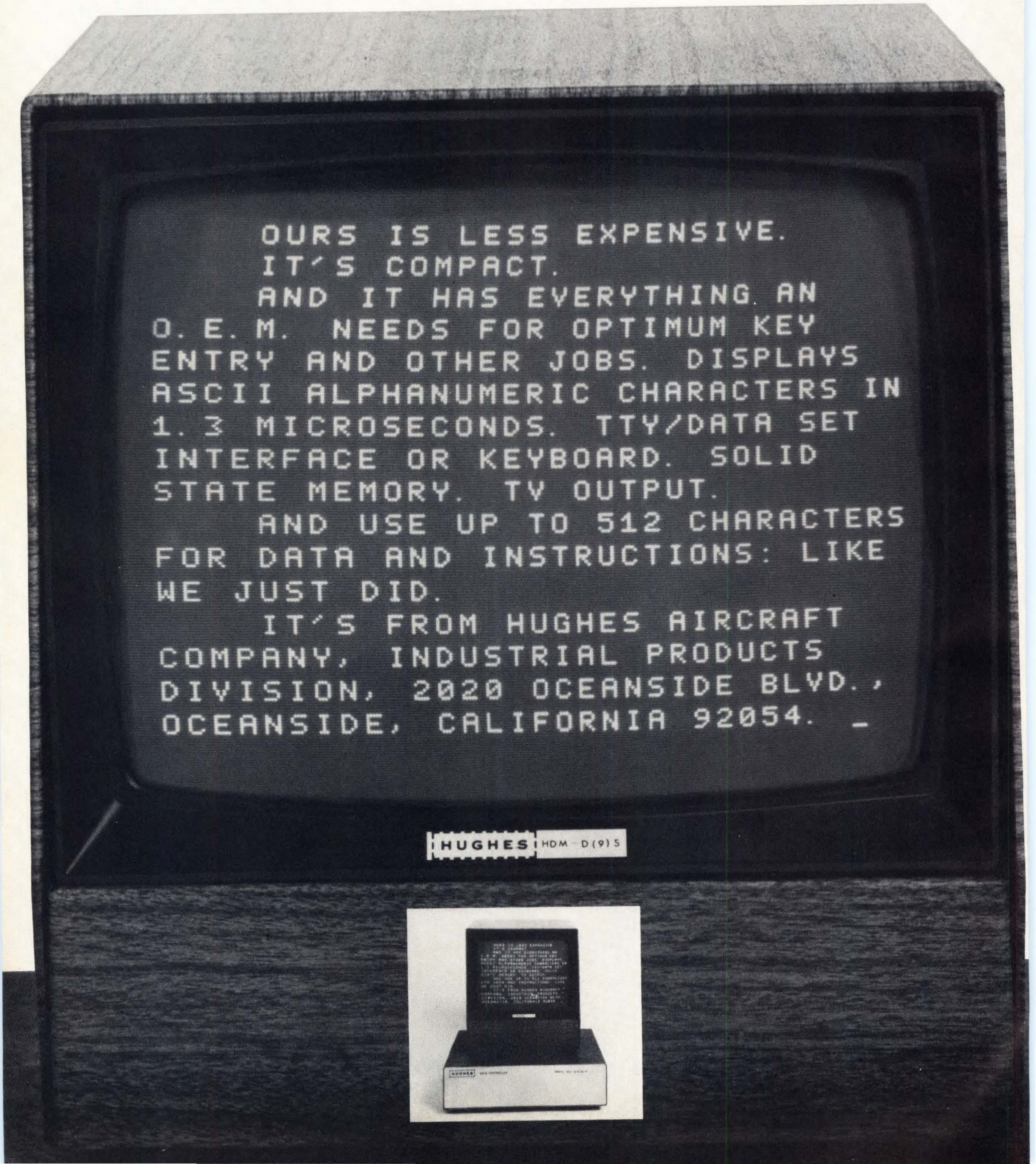


B. D. BROEKER, JR., Motorola Semiconductor Products, Inc.

digital circuits invade GHz range

An increasing number of digital circuits have invaded the once-private realm of RF circuitry. Monolithic emitter-coupled logic handling frequencies up to 400 MHz has become routine, with 1 GHz as the next plateau.

Often the highest-speed digital circuit in a system is the binary divider or toggling flip-flop. When the system speed approaches the state of the art, a binary divider is used to divide the operating frequency down to a more readily operable range. Thus, prescalers have evolved in counter and synthesis circuitry. With a few simple modifications to a basic ECL circuit, a binary divider can be developed that is capable of operation to 1 GHz.

Basic gate, shown in **Fig. 1**, consists of a current-mode switch and emitter follower outputs. Assuming that current-mode logic will be used, there are several changes that can be made to the basic ECL circuit to decrease propagation delays and other switching times.

The first change is to omit the emitter follower output and coupling stages that give the logic family its name. By coupling the collector of one current mode switch directly to the base of the next current switch, the propagation delay through the coupling transistors is eliminated. This, of course, necessitates a smaller logic swing if the current switch transistors are to be kept out of saturation. A 300-mV logic swing was chosen as being sufficient to drive the current switches, yet small enough to keep the switches in the active region.

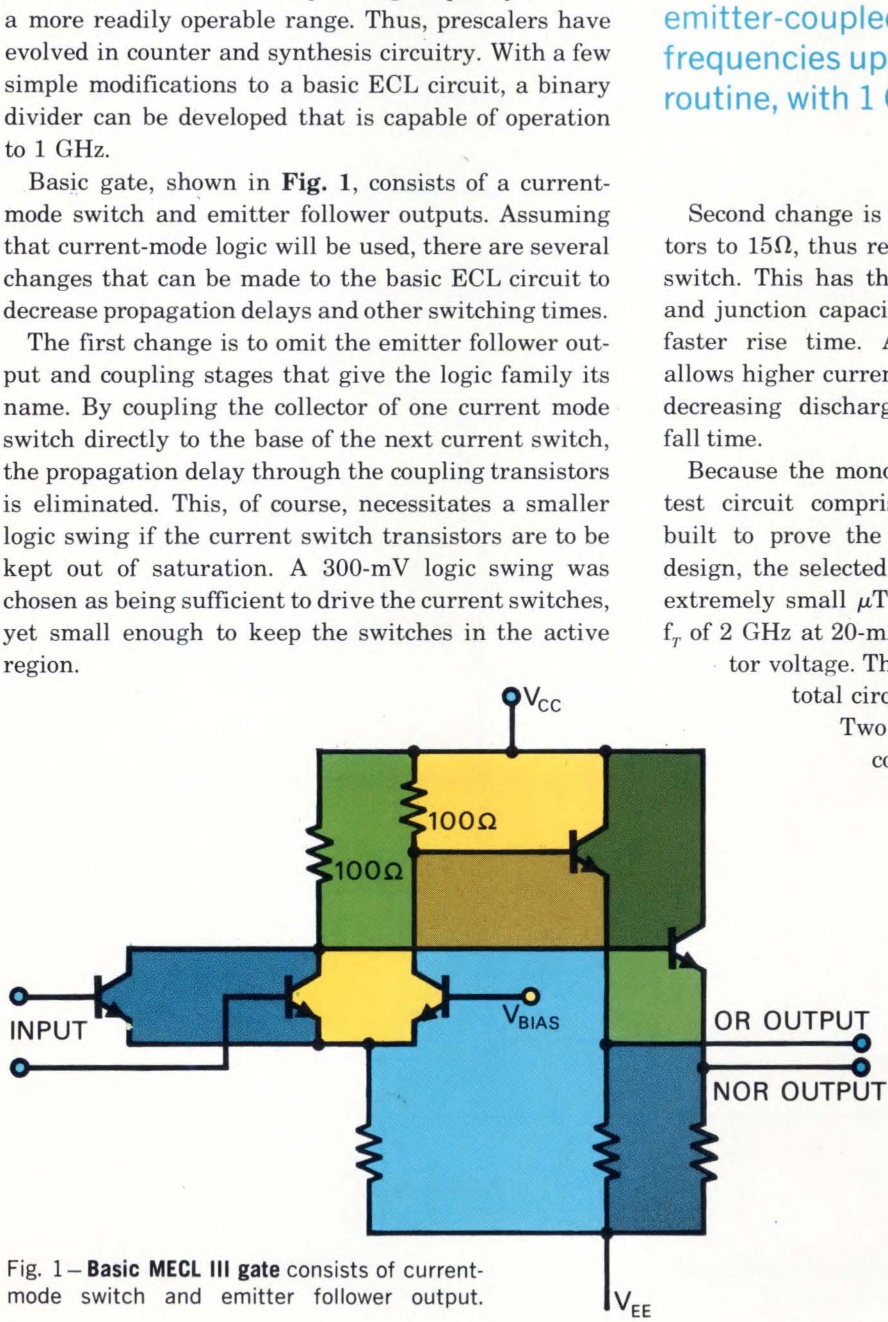


Fig. 1 – **Basic MECL III gate** consists of current-mode switch and emitter follower output.

Second change is to reduce the 100Ω collector resistors to 15Ω, thus reducing the impedance level of the switch. This has the effect of reducing the parasitic and junction capacitance time constant, resulting in faster rise time. Also, the 15Ω collector resistor allows higher currents within the 300-mV logic swing, decreasing discharge time and resulting in faster fall time.

Because the monolithic design was not complete, a test circuit comprised of discrete components was built to prove the design concepts. For the initial design, the selected transistor MMT3960B was in an extremely small μT epoxy package and had a typical f_T of 2 GHz at 20-mA collector current and low collector voltage. The small package allows very small total circuit size.

Two current-mode flip-flops cross-coupled in a master-slave configuration form the 1-GHz divider (**Fig. 2**). The second-level current switches control latching and updating of the individual flip-flops. These switches are driven in such a way that the logic state of the master is shifted into the slave on the positive transition of the input voltage, then inverted and transferred back to the master on the next negative transition – result, a ÷2 function. The secondary switches, as well as all others, are driven differentially to eliminate rise- and fall-time difference effects. Since the divider is intended for direct

(Continued)

interfacing with MECL III circuits, an output stage was added to provide an 800-mV logic swing. If this output stage is not to saturate, the master and slave outputs must be translated downward with a diode drop in the power supply section.

The final circuit is shown in **Fig. 3**. The only emitter-follower used in the circuit is in the output where additional delay is noncritical because it runs at one-half the frequency of the remaining circuits within the device.

To minimize interconnections, one transistor was soldered directly to another. The resulting three-dimensional array with outward radiating resistors (**Fig. 3**), while difficult for mass production, provides very short signal paths and produces maximum frequency response. During tests, the device could be "tweaked" to a maximum operating frequency of 1.04 GHz.

In an effort to increase reproducibility, several printed-circuit board designs were considered in an effort to keep overall size as small as possible. The selected board has components on both sides with several transistors stacked on top of others. Micro-miniature connectors were used because they have better high frequency transmission characteristics than the standard BNC types. Maximum operating frequency of the transistor MMT3960B is about 850 MHz mounted on this board—15 percent decrease in circuit response attributable to physical layout. A newly-released transistor MMT8015 with f_T of about 4 GHz was tried, and the maximum toggle frequency on the board increased to 1.15 GHz.

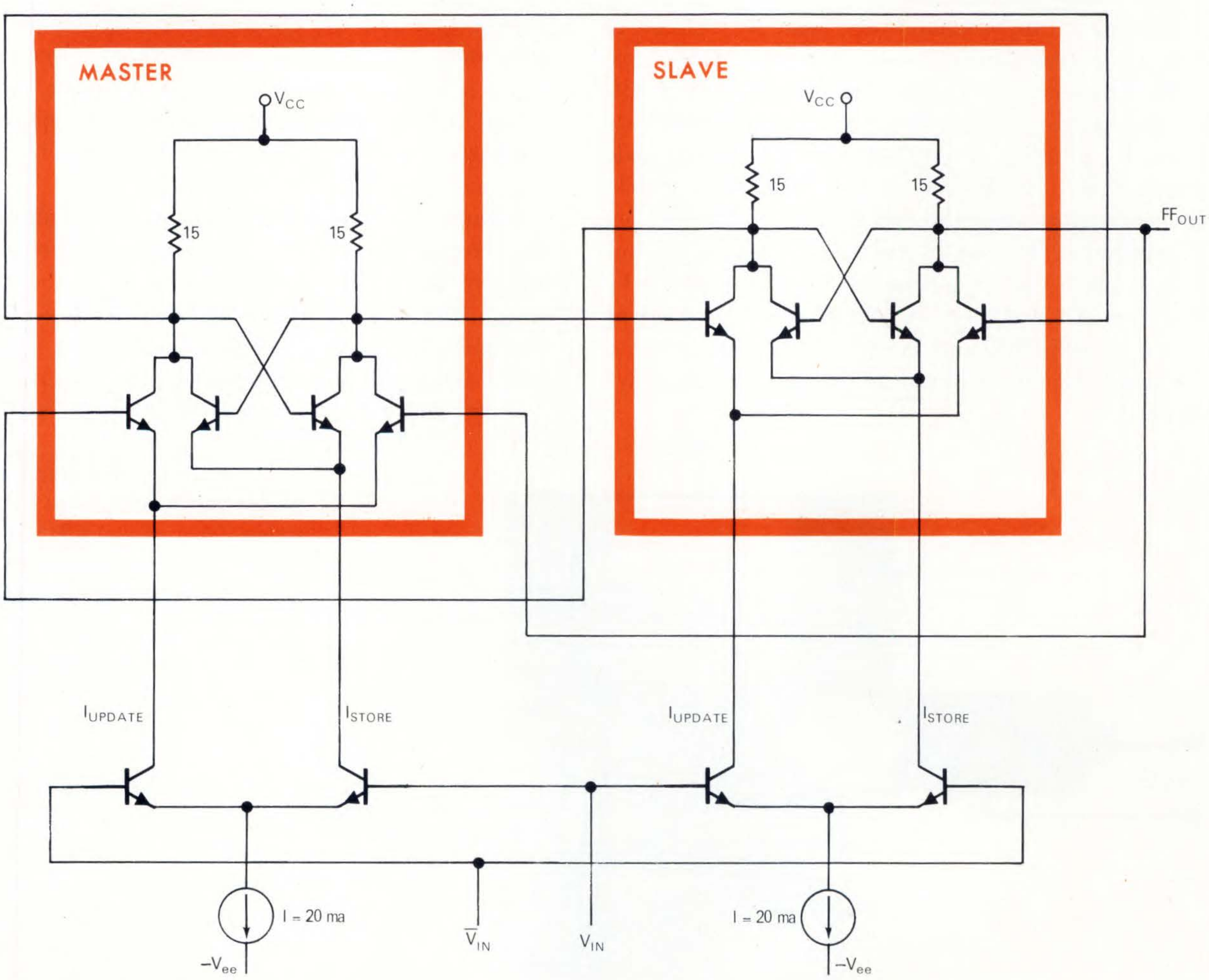


Fig. 2—**A 1-GHz divider** comprised of modified MECL III elements with second level current switches. These switches control latching and updating of individual flip-flops.

The divider has no current switch offset such as that designed into the MC1670S, thus it is sensitive to the input rise time. The input current switch must see switching times less than the propagation time of the master-slave sections, or the divider can oscillate during transitions. A current-mode Schmitt trigger was used to drive the divider at lower frequencies. If this input characteristic is satisfied, the device can be used from its maximum limit down to close to dc, depending on the size of the input-coupling capacitors.

This divider can be used in a multitude of counter, synthesizer or signal processing applications. However, the 250- to 750-mV input requirements place a strain on the state of the art in amplifier design. Therefore, it is probable that the initial use will come in synthesis circuits where signals of proper amplitude are available. As soon as suitable gain amplifiers are available, electronic counters using this divider will be able to count directly from dc to 1 GHz. ▭

Bud Broeker is a section manager in the Computer Applications Dept. at Motorola Semiconductor Products, Inc., Phoenix, Ariz. Bud's major duties include application engineering and responsibilities for memory and interface system designs. He received a B.S.E.E. from Lehigh University and M.S.E.E. from the University of Illinois.

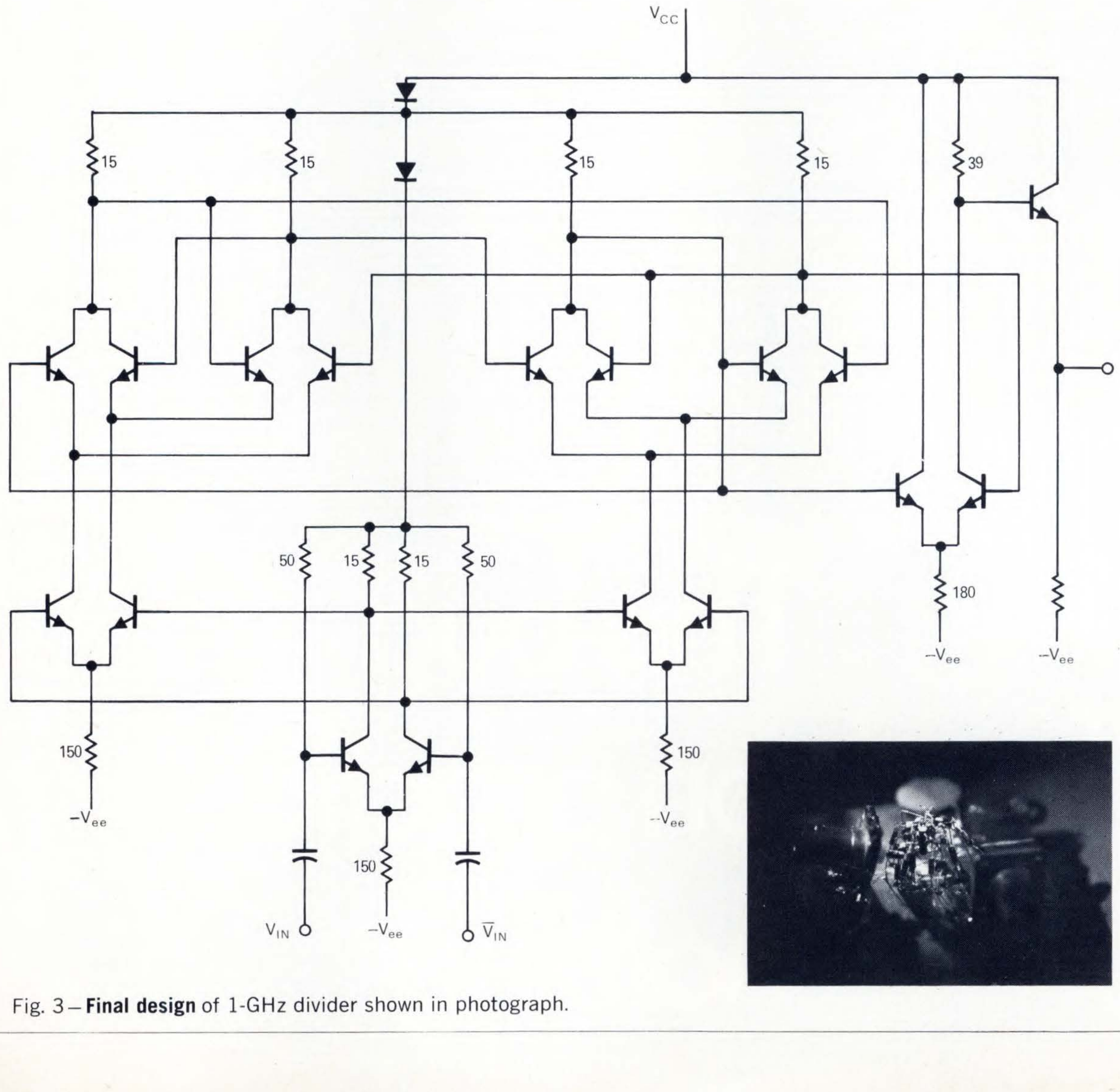
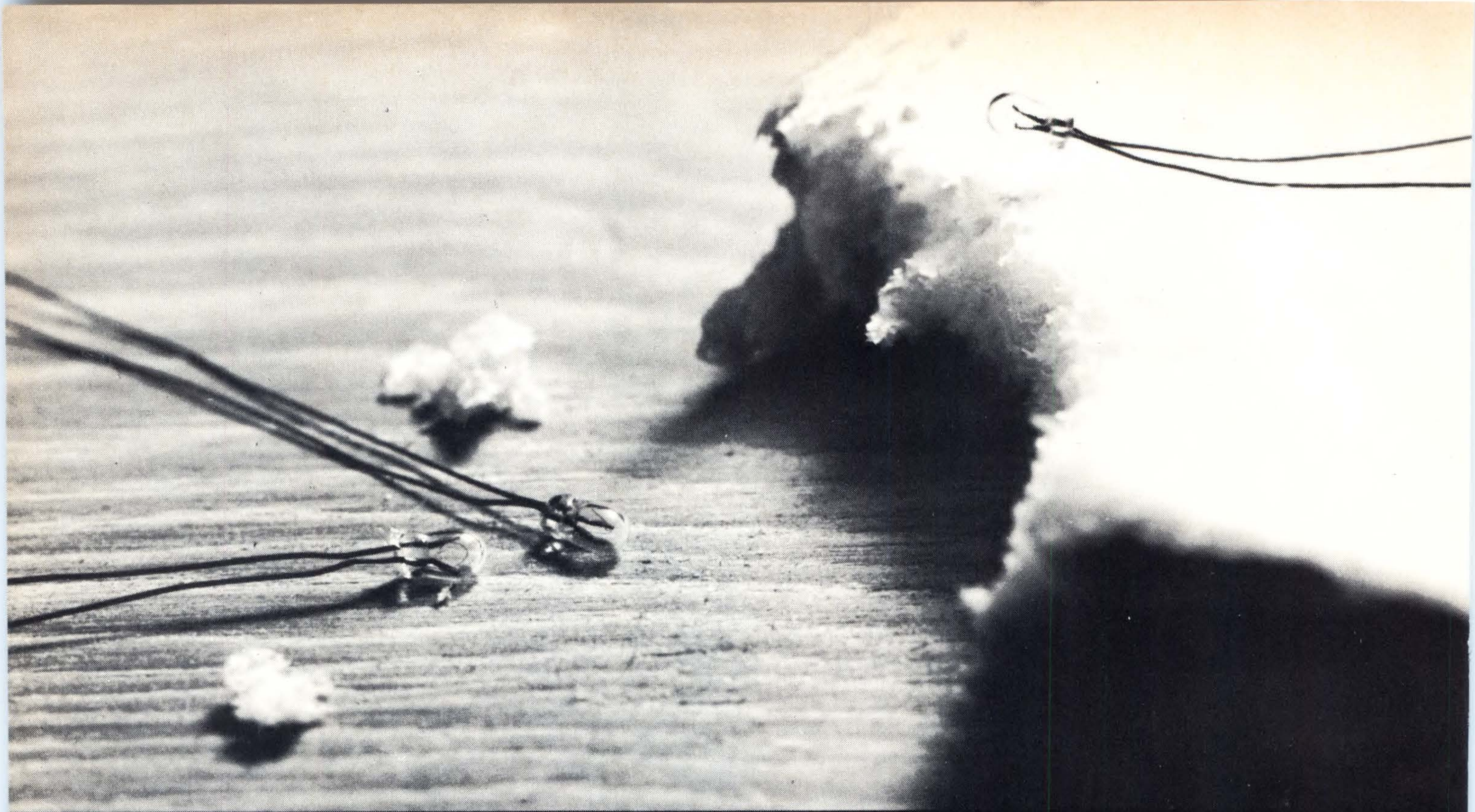


Fig. 3 – **Final design** of 1-GHz divider shown in photograph.



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1970 FJCC preview

Technical Program for the 1970 Fall Joint Computer Conference includes 26 sessions designed to provide a view of the latest developments and expected trends in computer hardware, software and applications. Seventy-four technical papers and nine panel discussions are planned on a number of major topics of importance to the computing field. The conference, sponsored by the American Federation of Information Processing Societies (AFIPS), held Nov. 17-19 in the Astrohall in Houston, also features exhibits of computer hardware, software and services.

In the hardware area, pertinent sessions will be held on computers and communications and on memory systems. As part of the presentation on Computers and Communications, a special panel session will attempt to lay bare some of the problems in this field and to formulate reasonable approaches for solving them. In the area of memories, the planned session should give the attendee a fairly good picture of what's currently being done in hierarchical memory systems development.

Hardware sessions are:

SESSION 2—MODERN MEMORY SYSTEMS (Tuesday 12:30-2:30) Session Chairman: L. Litman, Shell Development Co., Houston, Texas.

2/1—On Memory System Design, R. M. Meade, Cogar Corp.

2/2—Design of a Megabit Semiconductor Memory System, D. Lund, C. A. Allen, S. R. Anderson and G. K. Tu, Cogar Corp.

2/3—Design of a Very Large Storage System, S. J. Penny, R. L. Fink and M. Alston-Garnjost, Lawrence Radiation Labs.

SESSION 3—DESIGN FOR RELIABILITY (Tuesday 12:30-2:45) Session Chairman: W. G. Bouricius, IBM Corp., Yorktown Heights, New York.

3/1—Optimum Test Patterns for Parity Networks, D. C. Bossen, D. L. Ostapko and A. M. Patel, IBM, Systems Development Div.

3/2—A Method of Test Generation for Fault Location in Combinational Logic, Y. Koga and C. Chen, Univ. of Illinois and K. Naemura, Nippon Telegraph and Telephone Public Corp.

3/3—The Application of Parity Checks to an Arithmetic Control, C. P. Disparte, Xerox Data Systems.

SESSION 10—COMPUTERS AND COMMUNICATION—A BURGEONING INDUSTRY (Part I—Wed. 11:00-12:30) (Part II is Session 13—Wed. 2:00-4:30)

Session Chairman: R. A. Kaenel, Bell Telephone Labs., Murray Hill, N. J.

10/1—The Telecommunications Equipment Market: Public Policy and the 1970s, M. R. Irwin, Univ. of New Hampshire.

10/2—Digital Frequency Modulation as a Technique for Improving Telemetry Sampling Bandwidth Utilization, G. E. Heyliger, Martin Marietta Corp.

10/3—The Aloha System—Another Alternative for Computer Communications, N. Abramson, Univ. of Hawaii.

SESSION 13—COMPUTERS AND COMMUNICATION—A BURGEONING INDUSTRY (Part II—Wed. 2:00-4:30)

Session Chairman: R. A. Kaenel, Bell Telephone Labs., Murray Hill, N. J. Presentations: "Communication Based Data Processing in the 1970s", F. N. Trapnell, T. C. Hudson Assoc., London England; "Computer Networks and the Common Carrier", J. W. O'Byrne, MCA, Washington, D. C.; "Communications Control Systems", A. E. Lewis, Comcet, Rockville, Md.; "Communications Software Organization", W. A. Levy, Informatics, Riveredge, N. J.

SESSION 25—SELECTED COMPUTER SYSTEM ARCHITECTURES (Thurs. 2:00-4:00).

Session Chairman: R. W. Watson, Shell Development Co., Emeryville, Calif.

25/1—Associative Capabilities for Mass Storage Through Array Organization, A. M. Peskin, Brookhaven National Labs.

25/2—Interrupt Processing with Queued Content-Addressable Memories, J. D. Erwin, E. D. Jensen, Southern Methodist Univ.

25/3—A Language-Oriented Computer Design, C. McFarland, First Business Computing Corp.

A BROAD PERSPECTIVE (Wed., November 18, 8:30-10:00) Mr. Gerhard L. Hollander, Hollander Associates, will present "System Architecture in the LSI Era". (10:30-12:30), Dr. John W. Carr, III and Dr. David K. Hsiac will present "Multiprogramming Systems Design and Operation—Current and Future".

Fall Joint Computer Conference Proceedings may be ordered through the American Federation of Information Processing Societies, 210 Summit Ave., Montvale, N J 07645, at a cost of $26 with a 50% discount to members of AFIPS constituent societies provided the order is prepaid.

coming soon...

CONFERENCE ON DISPLAY DEVICES, Dec. 2-3, United Engineering Center, New York, N.Y. Designers should find the invited paper "Display Requirements for Future Man/Machine Systems" by Stephen W. Miller of Stanford Research Institute to offer a good deal of insight into the limitations of the presently used CRT and what is needed for future systems.

ADAPTIVE PROCESSES: DECISION AND CONTROL SYMPOSIUM, Dec. 7-9, Univ. of Texas, Austin, Texas. D. G. Lainiotis, Electronic Research Center, Univ. of Texas, Austin, Texas. 78712.

COMPUTER SYSTEMS ANALYSIS, Dec. 9-11, Washington, D. C. Three-day seminar designed to insure that computer systems analysis is carried out with reference to specific hardware, software, and logical criteria; to identify procedures for updating computer-based operations; and to appraise available options of the Systems Analyst. Brig. Gen. Fred Karch, The Institute for Advanced Technology, 5272 River Rd., Washington, D. C.

INTERNATIONAL SYMPOSIUM ON CIRCUIT THEORY, Dec. 14-16, Sheraton Biltmore Hotel, Atlanta, Ga. With a theme "The impact of new technologies and disciplines on circuit theory", sessions of interest are: ICs and Telecommunications for the 70s, Graphs and Structural Properties of Networks, Digital Filtering—Design Problems and Application, Computer Aided Network Design, Graphs and Networks in the Real World, Digital Filters, Active Circuits and Modeling, Systems and Computational Techniques for Networks. Ivan Frisch, Network Analysis Corp., Beechwood, Old Tappan Rd., Glen Cove, N.Y. 11542.

call for papers

NATIONAL TELEMETERING CONFERENCE AND EXPOSITION, April 12-15, 1971, Washington Hilton Hotel, Washington, D. C. Specific paper areas on Computer Communications covering: computer traffic statistics, multiplexing techniques and inquiry-response systems communications. Signal Processing covers: coding and data compression theory, programmed data processors and decision and information theory. Send 300-word abstract by Dec. 14, 1970 to Henry B. Riblet, NTC '71 Technical Program Chairman, The Johns Hopkins Univ., 8621 Georgia Ave., Silver Spring, MD 20910. Telephone: (301) 953-7100.

COMPUTERS AND AUTOMATA—TOWARDS A COMMON THEORY April 13-15, 1971, New York City. Tentative arrangement of sessions is: Basic Limitations on Speed and Power, Real-Time and Other Time-Bounded Computations, Computer Architectures and Synthesis of Automata and Logical Circuit Design. Send abstract of 500 words before Dec. 15, 1970 to: Polytechnic Institute of Brooklyn, MRI Symposium Committee, 333 Jay St., Brooklyn, NY 11201, Attn.: Jerome Fox. Telephone: (212) 643-2393.

1971 ELECTRICAL & ELECTRONIC MEASUREMENT & TEST INSTRUMENT CONFERENCE, June 1-3, 1971, Skyline Hotel, Ottawa, Ontario, Canada. Papers on: Automation of Measurements, Digital and Sampling Techniques and Pulse Measurements. Send four copies of 200-word abstract and 500-1000-word summary by Jan. 15, 1971 to Mr. F. L. Hermach, Electrical Instruments Section, National Bureau of Standards, Washington, D C 20304.

1971 IEEE/OSA CONFERENCE ON LASER ENGINEERING AND APPLICATIONS, June 2-4, 1971, Washington Hilton Hotel, Washington, D C. Papers on Optical Information Processing, Storage and Retrieval Systems and Techniques, including Holography. Send 2 copies of 35-word abstract and 500-word summary by Jan. 11, 1971 to Mr. Donald R. Herriott, Bell Telephone Labs., Murray Hill, N J 07974. Telephone: (201) 582-3908.

1971 SUMMER COMPUTER SIMULATION CONFERENCE, July 19-21, 1971, Sheraton-Boston Hotel, Boston, Mass. Understanding through simulation. Papers should stress the conceptual aspects of computer simulation, rather than language or computational details, and emphasis should be placed on the communication of ideas through examples. Send 500-word abstract by Nov. 30, 1970 to Program Co-Chairman, Edward E. L. Mitchell, Raytheon Co., Hartwell Rd., Bedford, Mass. 01730. Telephone: (617) 274-7100 Ext. 3212.

CIRCLE NO. 415

FASTEST MOS ROM IN THE WORLD.

(In fact, the guaranteed fastest MOS ROM in the business!)

We call ours IROM. It's the industry's fastest ion-implanted read-only-memory. The Hughes IROM 2560 has a guaranteed maximum access time of 500 nsec.

Specify the word patterns you need. 256 x 10-bit word organization. For fast character-generator requirements, use the Hughes IROM 2560.

Hughes IROMs are also ideal for look-up tables, microprogramming, control logic, and code conversion. Inputs and outputs are TTL compatible. Static operation. No MOS clocks required.

And, of course, Hughes can deliver. Hughes has moved IROM into volume production.

So, if you have a ROM problem, we have an IROM solution for you.

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Newport Beach, CA 92663.

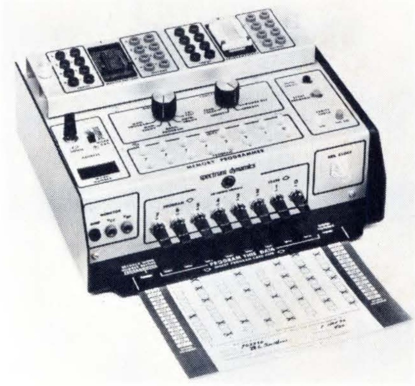
HUGHES

HUGHES AIRCRAFT COMPANY
MOS DIVISION

field program your own ROM

Spectrum Dynamics, Inc., Ft. Lauderdale, Fl., offers a memory programmer Model 402 that is portable and is designed specifically to establish patterns on programmable integrated-circuit read-only memories. Manual or automatic programming and verifying are performed quickly and reliably without auxiliary equipment. Manual programming of a 64 by 8 ROM, using a specially designed program data card, is achieved in minutes. This master pattern may then be used for programming duplicate ROMs automatically.

The address section, 512-word capability, includes an up/down counter, a 3-digit word number readout and a word capacity selector. Program switches permit selection of up to eight logical "1"s for each word. Electrical programming is accomplished internally by generated signals of exact amplitude and duration—prescribed by the ROM manufacturer.



One row of bit indicators displays the program logic set into the storage by the operator, and a second row displays the logic actually programmed. Numerous other features have been incorporated to insure fast and accurate programming.

Using interchangeable socket assemblies, the Model 402 accommodates many types of device packages such as 16- and 24-in dual in-lines and 24-pin flat packs. Optional features include programming from external sources like card of tape readers. A separate tester, designated Model 124, checks parameters of the ROM. The 12- by 10- by 5-in unit weighs 10 lb. Price is $945. Spectrum Dynamics, Inc., Ft. Lauderdale, FL 33307. **420**

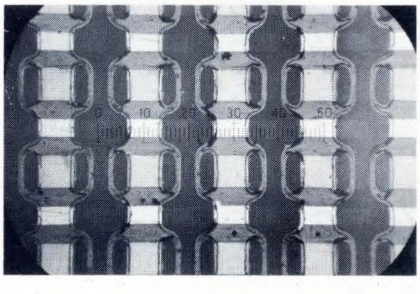
unique memory concept surpasses other technologies

Less than 100 ns cycle time, batch fabrication, low drive current requirements, no deterioration of performance due to aging, non-volatile and high package density all describe a unique approach labeled "flux ring". In a nutshell, this is what Signal Galaxies offers memory designers and users for less than one cent per bit.

Relaxed magnetic characteristics, provided by this concept, are part of the key to the memory's outstanding performance. Signal Galaxies is currently offering planar arrays of thick-film elements that provide 8 to 32k bits of storage with up to 16k elements in a 4 in^2. By late 1970, up to 64k-bit arrays in a single stack will be offered. These, in turn, can be easily expanded into million-bit memories.

Two adjacent memory elements per bit provide 100% redundancy. Although failure of one element will cause degraded output of that element, the remaining element will still function as a storage unit. This redundancy also permits degraded elements to be bypassed when necessary by stringing a few wires from adjacent bit elements.

Complementary bit structure and uniformity of the plane insures self-cancellation of common-mode noise—a problem in virtually every memory technique. A further advantage of the "flux ring" is "magnetic closure", a proprietary technique that provides nonvolatility of memory bits



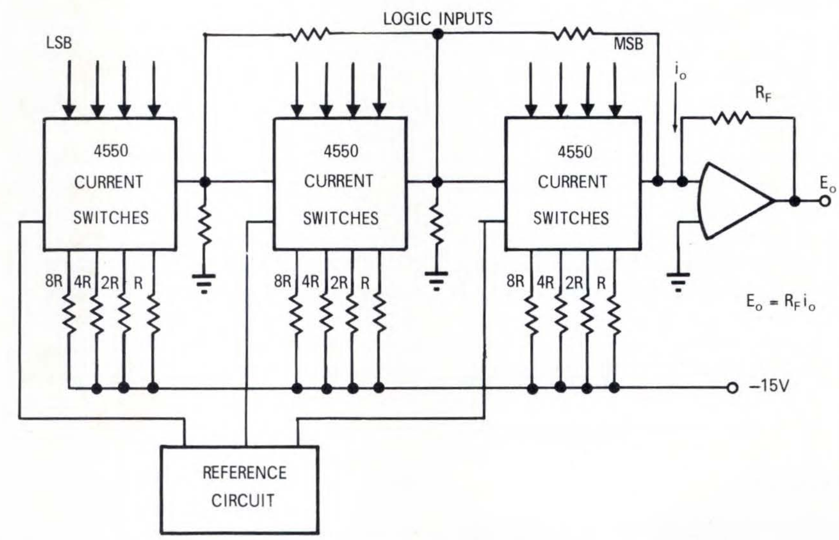
because the elements remain locked in their magnetized state in case of power failure.

Output voltage is independent of word current direction. Word drive currents are lower for "flux ring" than for plated wire. For example, flux-ring drive currents are approximately 450 mA as opposed to 900 to 1200 mA for plated wire, thereby permitting the use of smaller word-select transistors. Rise times for this memory are typically <10 ns. Aging in conventional planar film memories usually is indicated by increase of skew and dispersion. With the "flux ring", these are mechanically defined parameters, so there can be no change in them, and the output flux available is greatly increased.

Users can organize the "flux ring" memory either as 2D or 2-1/2D, depending upon how they set up their electronics. Cleanrooms meeting semiconductor standards and a series of several thousand comprehensive tests on each plane performed by Signal Galaxies assures uniform, high quality of all planes. Users can test them on the same equipment used to test plated-wire memories. With each plane is shipped a complete computer diagnosis of the upper and lower limits of the readout signals and location of the 12 lowest and highest signal bits. Signal Galaxies, Inc., 6955 Hayvenhurst St., Van Nuys, CA 91406. **421**

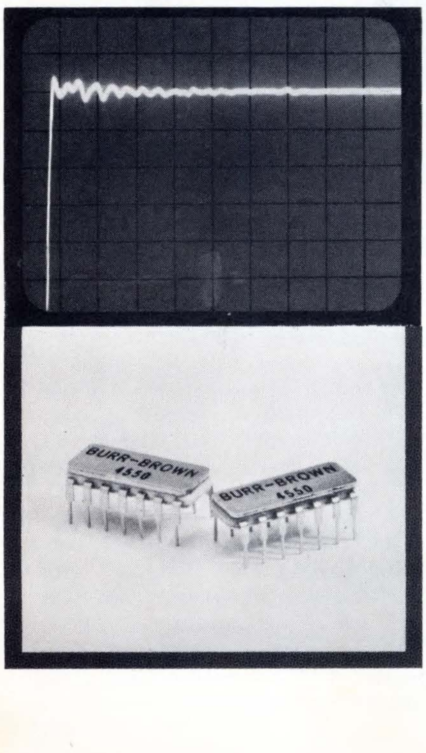
D/A Converter Touts 9/1 Settling Improvement

With a price tag that ranges from \$10 to \$36 (100 units), Burr-Brown introduces Model 4550 quad current switch that offers these specifications: 12-bit accuracy (±0.01%) using a −15V supply, switching time of 200 ns for settling to within ±0.01%, temperature coefficient of error only ±2 PPM/°C and a choice of two operating temperature ranges 0 to 70°C and −55 to 125°C.



12-bit D/A converter. Reference circuit contains zener diode, op amp and summing resistors that provide base drive to all quads which compensates for drift.

To achieve these characteristics, the monolithic IC design team at Burr-Brown attacked those areas that were the performance limiting parts of circuits presently available. With current switching instead of voltage switching, for example, time delays from the charge-storage effects in saturated transistors are eliminated. However, current switching poses the problem that it is difficult to get V_{BE} matching and good thermal tracking between current switches that have extreme differences in current. In a 12-bit converter the MSB switch current is 2048 times larger than that through the LSB switch. To overcome this limitation, Burr-Brown chose a current switching method where current densities are made equal. Logic partitioning is identical to Analog Devices μDAC concept (AD550).



Each Burr-Brown 4550 contains a 4-bit section that produces four weighted-current outputs. Nominal values are 1, 1/2, 1/4 and 1/8 mA but the 4550 can switch up to 5-mA currents. This higher current level allows use of lower impedances which improve switching speed.

To make 8-bit to 12-bit converters, 4-bit sections are cascaded and 16:1 current attenuators between circuits provide proper sealing.

In this design, monolithic construction makes having an initial V_{BE} match within 500 μV easy and both V_{BE} and beta track accurately. For temperature compensation of full-scale output, a reference transistor included in each quad substrate tracks the current switches. With an external op amp, a stabilizing loop is formed that holds all current densities constant with V_{BE} drift.

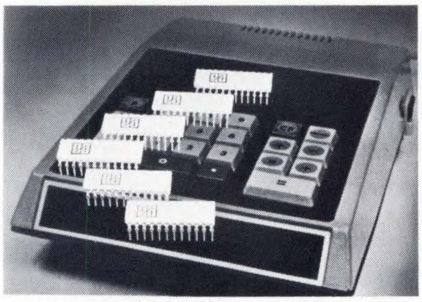
For switching, Burr-Brown uses all npn high-gain input switches to avoid use of slow monolithic pnp circuitry. The emitter-base reverse bias that turns off the current switches is controlled by an input gating circuit. This circuit is designed to minimize the time delay caused by emitter-base capacitance charge-storage effects. Result is a 9/1 improvement in switching speed and settling time to 200 ns for a 12-bit conversion. A bonus from this high speed design is that power supply range is improved. The 4550 operates from a positive supply of 5 to 18 Vdc and from a negative supply of −14 to −16Vdc. Burr-Brown Research Corp., International Airport Industrial Park, Tucson, AZ 85706.

MOS/LSI Calculator Circuits Now in Standard Kit

Six MOS/LSI circuits that provide the entire electronic logic required to build an eight-digit, four-function, desk-top calculator have been announced by Electronic Arrays, Inc.

Offered as the industry's first off-the-shelf calculator circuits, the set provides the functions of add, subtract, multiply and divide. Data entry by the user-supplied keyboard is to eight digits with internal arithmetic operations and storage to 16 digits. A fixed decimal point can be electronically set and constant multiplier/divisor can be entered and stored. Sign and overflow are indicated and non-significant zeroes are suppressed. The maximum solution time with a 200 kHz clock is 120 ns. There are separate clear and clear-entry functions. The user supplies his own display system to the BCD outputs.

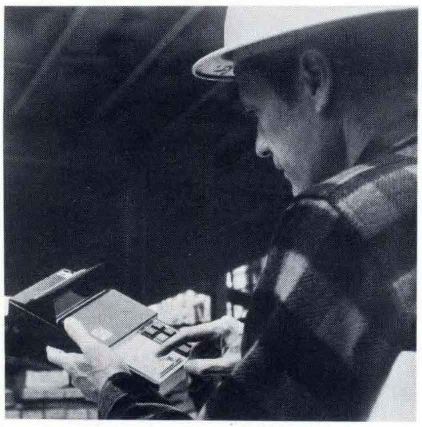
Each of the six MOS circuits is packaged in a 24-pin dual in-line hermetic package and all utilize p-channel enhancement mode technology. The set is composed of (1) an input chip, (2) a register chip, (3) an arithmetic chip, (4) a control ROM, (5) control logic and (6) an output chip. Price in lots of 1-10 is $158.46/set dropping to $119.04/set in 100-499 quantities. See



them at FJCC in Houston, Nov. 17-19, Booth 1427.

Electronic Arrays, Inc., 501 Ellis St., Mountain View, CA 94040. **224**

Systems



Portable calculator, Marchant One, weighs only 38 oz, yet has the capacity and features of larger machines. The 10- by 5- by 2-in unit has 8-numeral display and the price is $495, including battery recharger. SCM Corp., 299 Park Ave., New York, NY 10017. **236**

Digital computer laboratory makes logic design come alive for students and researchers. Complete lab, including workbook, circuitry and patch board, sells for $395. Quantum Electronics Corp., 1106 Wisterwood, Houston, TX 77043. **226**

Two computers, 2114C and 2116C, are 16-bit machines with memory cycle times of 2 and 1.6 μs respectively. Storage capacities are 8k (2116C) and 4k (2114C) with expanding capabilities. Hewlett-Packard, 1501 Page Mill Rd., Palo Alto, CA 94304. **227**

Digital communication system, DCC-90, can be used as a front-end processor and a remote programmable concentrator. System features synchronous and asynchronous communications with 2000 to 50,000 baud and 40 to 9600 baud respectively. Time-Zero Corp., 12701 S. Van Ness Ave., Hawthorne, CA 90250. **228**

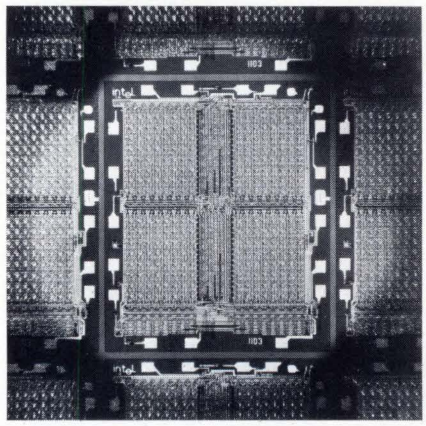
Optical page reader, DFR-100, operates at between 8 and 64 characters/s. The 32-lb unit handles document sizes up to 8.5 by 14 in. Power requirement is 117 Vac, 60 Hz, with 200W power dissipation. Datatype Corp., 1050 N.W. 163 Dr., Miami, FL 33169. **229**

Data acquisition system, "Milliverter", accepts up to 64 low-level together with 32 high-level analog inputs. Unit is available with either 12- or 14-bit A/D converter. Throughput rate is 40 kHz. Raytheon Computer, 2700 So. Fairview St., Santa Ana, CA 92704. **230**

A/D converter provides high resolution video with 64 separate shades of gray. Converter made up of ICs samples inputs every 10 ns with 6-bit resolution. Hughes Aircraft Co., Box 90515, Los Angeles, CA 90009. **231**

Computer system 1080 provides acquisition and analysis of spectral data using Fourier or CW NMR techniques. Features include 20-bit word and a memory that can be expanded from 8192 to 45,056 words. Fabri-Tek Instruments, Inc., 5225 Verona Rd., Madison, WI 53711. **232**

Memories



Monolithic memory, Type 1103, is a MOS RAM with 1024 by 1 organization and is fully decoded. Contained in a plastic 18-pin DIP, price is $0.01/bit in 100,000 or more quantities. Intel Corp., 365 Middlefield Rd., Mountain View, CA 94040. **233**

A 256 by 8 ROM features 350 ns cycle time and 175 ns access time. It requires 5V supply and is TTL compatible (74 Series). In 100 quantity, it sells for $289. Unicom, Inc., 1275 Bloomfield Ave., Fairfield, N J 07006. **234**

Medium capacity 2-1/2D core memory, NANOMEMORY 2500, stores up to 294,-912 bits. Using 18-mil cores, the cycle time is 500 ns and access time is 300 ns. All electronics and stacks are PC board mounted. Electronic Memories, 12621 Chadron Ave., Hawthorne, CA 90250. **235**

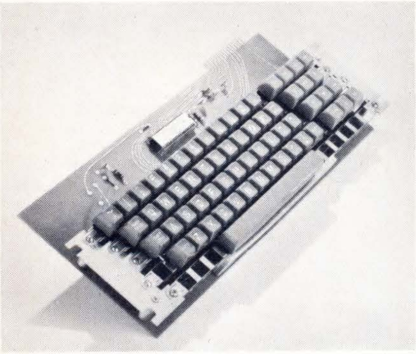
Plated wire memory, NM-1000 Series, features 200 ns read access, 300 ns read time and 500 ns write time. Maximum capacity is 163,840 bits. Stack is modular in design. Nemonic Data Systems, Inc., 1301 W. 3rd Ave., Denver, CO 80223. **237**

Plated-wire memory (4k by 72), 2D multiplexed array, may be organized as 8k by 36, 16k by 18 and 32k by 9 systems. Standard configuration prices are $0.035/bit for complete systems. MSI, Hawthorne, CA. **238**

Serial memory, MOSTOR 100, is a 1024 by 8- or 9-bit system with a sequential access time of 0.3 μs. Packaged on a PC board, the basic storage element is a 512-bit, dynamic MOS shift register (EA1206). Electronic Arrays, Inc., 501 Ellis St., Mountain View, CA 94040. **239**

Mass memory system Discotor 510 combines fast head-per-track access (8.7 ms) with interchangeable disc capability. Total capacity is 10 megabits with as high as 2.35 MHz transfer rate. Systematics/Magne-Head Division, General Instrument Corp., 13040 S. Cerise Ave., Hawthorne, CA 90250. **240**

Keyboards



Keyboard has all encoding—up to 9 bits and 4 levels—on one LSI/MOS chip. Specifications include 88 encoding keys plus direct functions, 200 mW power drain and double-shot-molded keytops. Clare-Pendar Co., Box 785, Post Falls, ID 83854. **241**

Keyboard array 53SW1-1 offers USASCII code assignment with four modes of operation. Both encoding and switch termination require only one PC board. Power requirement is 5Vdc, 0.8A. Micro Switch, 11 W. Spring St., Freeport, IL 61032. **242**

Magnetic Tape

Tape transport, PEC 6000 Series, attains high performance 75 ips operation without a vacuum column buffer. Transports use 10½-in reels and are designed for minicomputer application. Peripheral Equipment Corp., 9600 Irondale Ave., Chatsworth, CA 91311. **243**

Synchronous recorder, Model 205, uses 1/8-in tape width cassettes and stores 2 megabits. Packing densities of 500 or 800 bpi and operating speeds of 6 or 12 ips are available. Mobark Instrument, Inc., 1038 W. Evelyn Ave., Sunnyvale, CA 94086. **244**

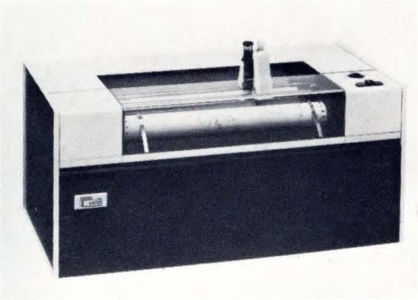
Four tape loop system, Model 4196 Cartri-File, has total storage capacity exceeding 12 megabits. Each loop can be independently controlled. Data transfer rate is 18,000 bps. Tri-Data, 800 Maude Ave., Mountain View, CA 94040. **245**

Cassette bulk memory, ST-2 Minicorder, provides 2 megabits of storage in a compact unit. Measurements are 8 7/16- by 9 1/2- by 3 3/16-in and weight is 6 1/4 lb. Genisco Technology Corp., 18435 Susana Rd., Compton, CA 90221. **246**

Cassette tape transport, Model 250, is a 4.5- by 6- by 2.4-in unit with recording and retrieval rate of 1000 8-bit characters/s. Unit required ±5V. Price is $250 in OEM quantities. Computer Access Systems, 3050 W. Clarendon Ave., Phoenix, AZ 85017. **247**

Cassette tape transport, Compudette 1100DC, is for portable applications where low power drain is critical. Write speed is variable to 450 steps/s and read speed is selectable from 3 to 12 ips. Compucord, Inc., 225 Crescent St., Waltham, MA 02154. **248**

Hard Copy



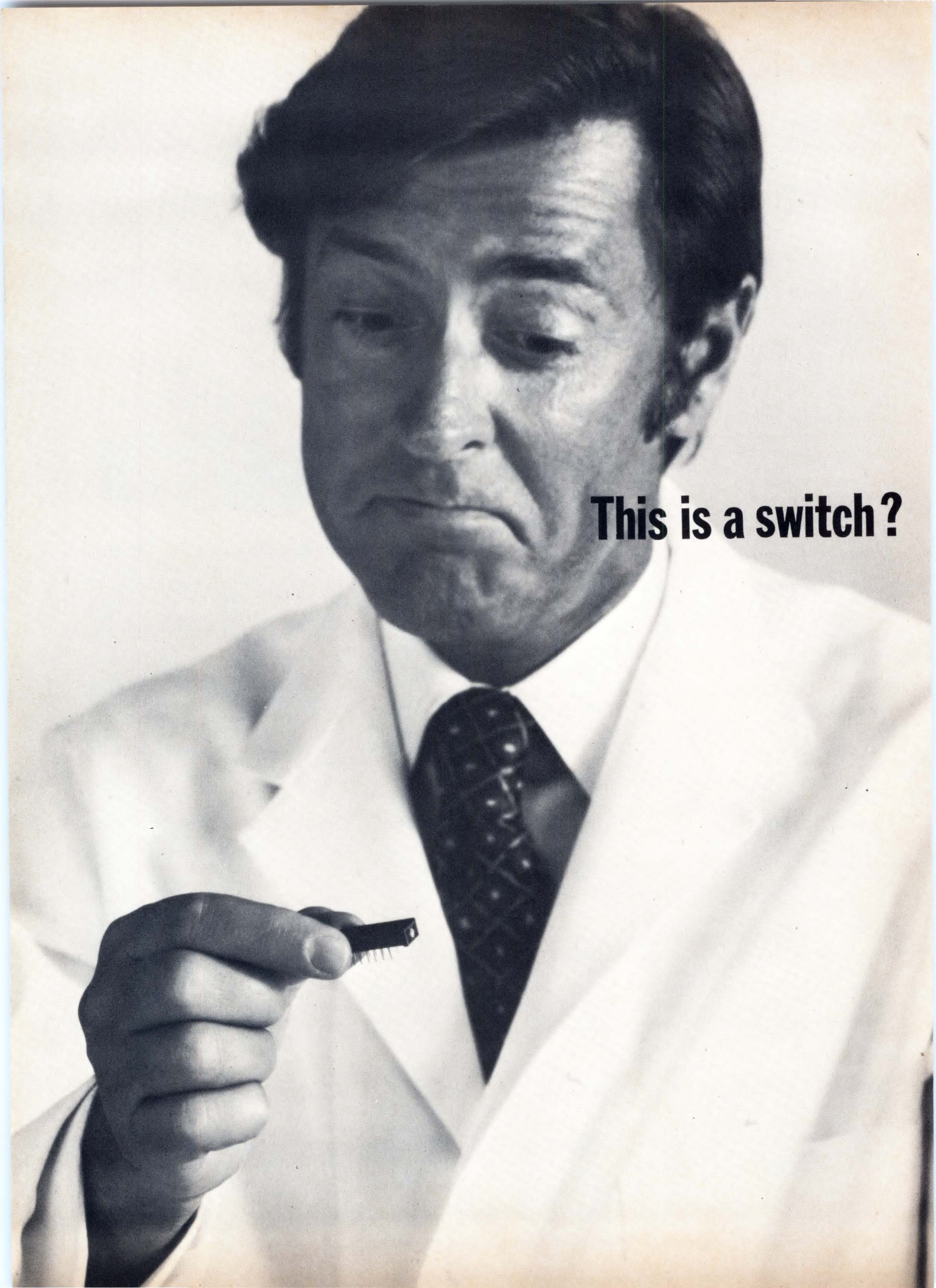
Incremental plotters, Series 1430, come with four factory selectable step sizes and operate at 300 steps/s (250 steps/s for 0.01-in unit). The 14-in plotter weighs 45 lb. University Computing Co., 1300 Frito-Lay Tower, Dallas, TX 75235. **249**

Card Reader Model 9630-02 is a table top unit for OEM use. This low cost 96-column reader has an operating speed of 1200 cards/min and costs $4500 with OEM quantity discounts available. Decision Data, 300 Jacksonville Rd., Warminster, PA 18974. **307**

Strip printer, CRS 4, prints 64 alphanumeric characters at 35 characters/s. It weighs 4 lb and measures 4 1/8 by 8 1/8 by 3 in. Price is $149.99 ea. (quantities of 1000). Computer Terminal Systems, Inc., 52 Newtown Plaza, Plainview, NY 11803. **308**

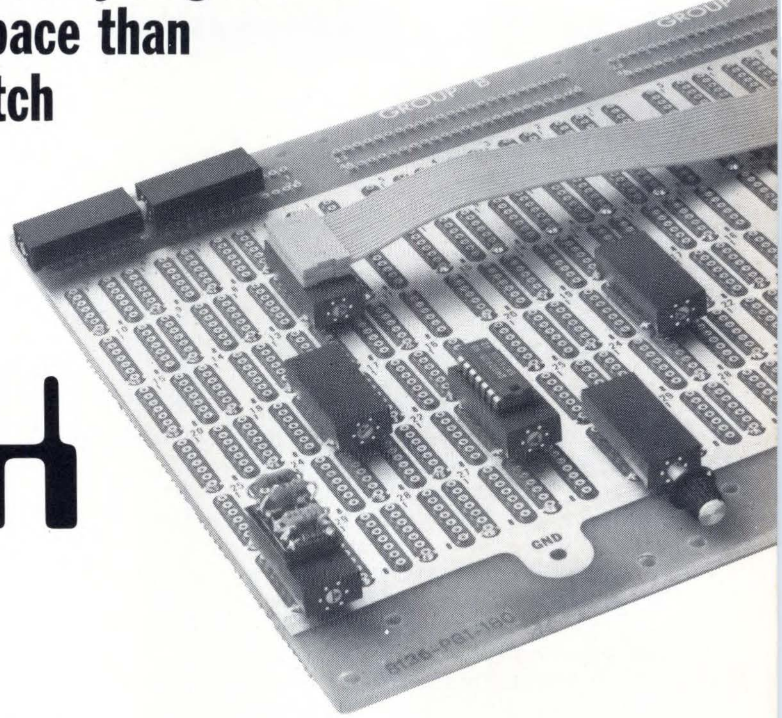
Card reader operates up to speed of 90 cards/min for full 80 column card. Cards are read photoelectrically. Reader is front loaded and unloaded. Hopper capacity is 1000 cards. Data Pathing, Inc., 370 San Aleso Ave., Sunnyvale, CA 94086. **309**

Printing mechanism, Mark X, is for applications requiring low cost output. Unit prints up to ten columns at one line/s on standard adding machine paper. Price is <$170 in OEM quantities. Data Specialties, Inc., 1548 Old Skokie Rd., Highland Park, IL 60035. **310**


This is a switch?

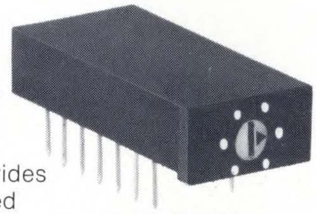
You've never seen anything like it before.

A 14 pin dual inline switch that gives you greater programming capability in less space than any rotary, toggle, or sliding switch used in dual inline packaging.



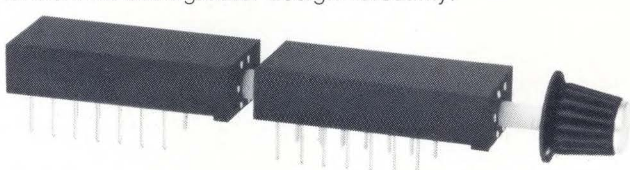
DAVEN'S NEW 100% IC COMPATIBLE

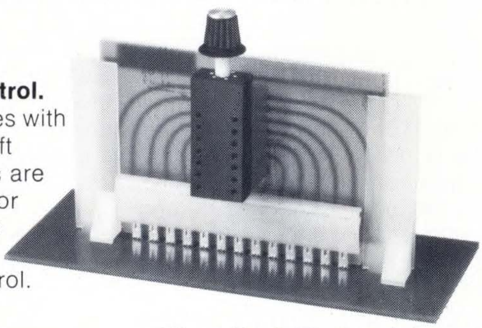
DIPSWITCH



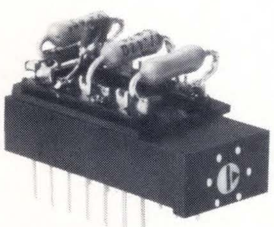
Low Profile (only .230″ high) allows PC cards to be stacked in ¼″ increments. Screw driver slot, readily accessible in the front, provides six, equally spaced, detented positions, each corresponding to a respective circuit configuration. Switch positions are clearly identified at the front, and a pointer located above the screw driver slot. Factory-adjusted stops can limit the number of desired switch positions to your specifications.

Tandem Capability. A special coupling and rear shaft extension enables Dipswitches to be joined in tandem for even greater design versatility.



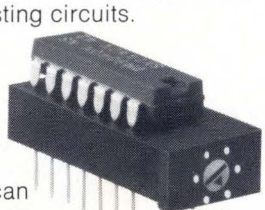


Knob Control. Dipswitches with flatted shaft extensions are available for operations requiring knob control.



Dipswitch with Resistors

Piggy Back Feature lets you plug any 14-pin dual inline package onto the top of the switch. For example, up to six different voltages can be selected for field adjustment or testing circuits.



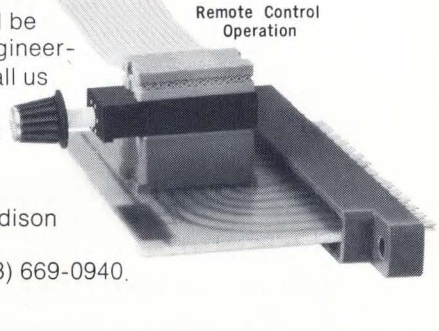
Dipswitch with IC Component

Other electronic circuits, packaged into IC components, such as delay lines, voltage dividing networks, and relays can be used in important new ways at considerable savings in cost and space. A puncture seal type is available for immersion in cleaning fluids.

Like any other IC component, the Dipswitch can be wave-soldered into a printed circuit card. The plastic housing of Celanese X917 is impervious to tetrachlorethylene cleaning solutions, Freon and alcohol. The Dipswitch is also available in a completely sealed waterproof housing.

Without special tooling and assembly costs, the Dipswitch can give you unmatched programming capability with utmost economy. We'll be glad to assist you in any engineering application. Write or call us for the complete story on this great new development in dual inline switching.

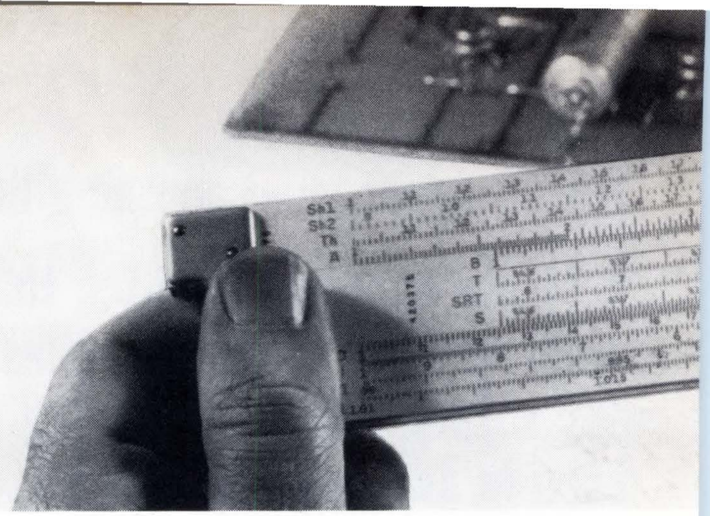
Remote Control Operation



Daven Division, McGraw-Edison Company, Manchester, New Hampshire 03101. (603) 669-0940. TWX 710-220-1747.

DAVEN McGRAW EDISON

RCA Solid-State Data for Designers



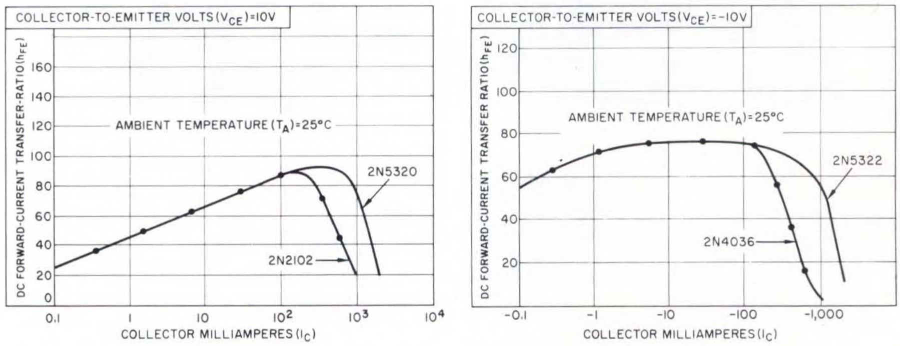
Profit makers: RCA's power transistor families

Here are two established families of RCA low-power transistors—the 2N5320 and its companion type, the 2N5322—that can help you increase profit margins from your equipment sales.

These extremely reliable devices are suitable for a myriad of general-purpose industrial applications. To name just a few: industrial controls, test instrumentation and control equipment, and power amplifier drivers.

The n-p-n 2N5320 and its p-n-p complement, the 2N5322, are double-diffused epitaxial planar transistors in hermetic TO-5 cases that feature 1 A current capability. They are big brothers to RCA's 2N2102 (n-p-n) and 2N4036 (p-n-p) transistors that have 0.5 A current capability. Examine their performance curves. You'll find they have the characteristics you need for your circuit application.

Circle Reader Service No. 40



TYPICAL STATIC BETA CHARACTERISTICS FOR TYPES 2N5320, 2N2102, 2N5322, AND 2N4036.

Application	MOD. or CW	Room Temperature Devices: Emitter	Laser Diode	Laser Diode Stack	Laser Array
Paper Tape Reader	CW	40736R			
Card Reader	CW	40736R			
Shaft Encoder	CW	40736R			
Keyboard	CW or CODED	40736R			
Circuit Isolator Coupler- "DC Transformer"	MOD	40736R			
Data Transmission	MOD	40736R TA7762R			
Line Finder/ Edge Sensor	CW or PULSE	40736R	TA7606, 7, 8, 9, 10, TA7699, TA7925		
Intrusion Alarm	MOD or PULSE	40736R TA7762R	TA7606, 7, 8, 9, 10, TA7699, TA7925, TA7763, TA7864	TA7764 TA7765	
Remote Control Signalling	MOD	40736R TA7762R	TA7606, 7, 8, 9, 10, TA7699, TA7925, TA7763, TA7864	TA7764 TA7765	
Voice Communications	PULSE		TA7606, 7, 8, 9, 10, TA7699, TA7925, TA7763, TA7864		
Ranging	PULSE		TA7699, TA7925, TA7763, TA7864, TA7705, TA7787	TA7764 TA7765	TA7687-92 incl.
Night Vision Applications	PULSE		All types above plus TA7867*		TA7924†

*GaAlAs—wavelengths from 800 to 880 nm

†77°K

Looking for GaAs lasers and IR emitters? RCA has the devices to meet your requirements

Gallium-arsenide lasers and/or IR emitters are now being designed into a wide range of signaling and illumination equipment. For such applications, RCA offers a broad line of lasers and emitters—well-suited to meet these requirements.

RCA injection lasers feature high peak powers, low drive currents and proven reliability. Because of their simplicity, ease of drive, and covert wavelength, they are naturals for intrusion alarms, ranging, data-link communications and secure illumination. RCA IR emitters feature small size and high efficiency. Their pre-focused, high brightness beam pattern allows optimum performance in card readers, shaft encoders, short range intrusion alarms and data-link communications. Finally, RCA lasers and emitters are compatible with most photodetector systems.

Try RCA's superior GaAs lasers and IR emitters in *your* system. You'll beam!

Circle Reader Service No. 41

RCA Thyristors expands its triac line to 600 volts

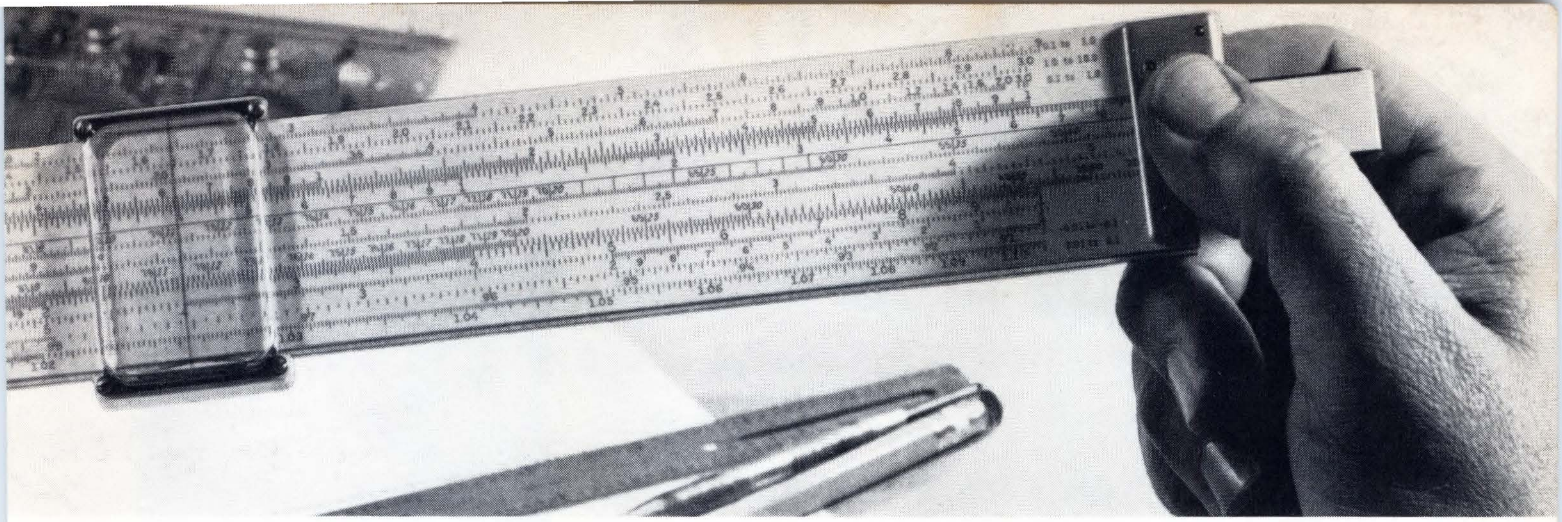
RCA announces a new line of 600 V triacs available now for industrial control manufacturers. These new triacs have a 600-V peak repetitive rating at a maximum rated junction temperature of 100°C.

In difficult industrial applications where ac power sources demand added safety margin, this group of RCA triacs can be used to assure reliable equipment operation.

600 VOLT TRIACS				
Package	10 A	15 A	30 A	40 A
Press-Fit	40795	40797	40671	2N5443
Stud	40796	40798	40672	2N5446
Isolated Stud	40801	40804	40807	40690

These new triacs (as the chart illustrates) range from 10 amperes, with availability in press-fit, stud and isolated stud packages.

Circle Reader Service No. 42



TA7625A: a new high power op amp

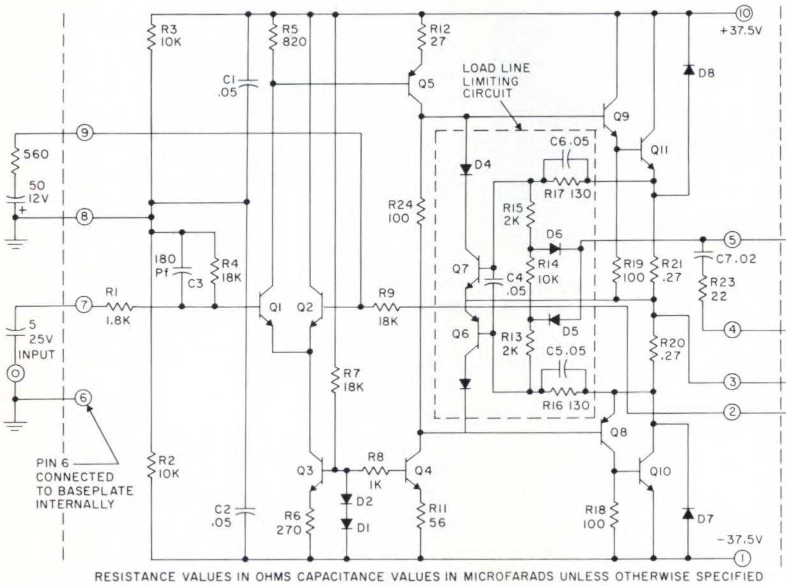
RCA's new TA7625A plastic power hybrid amplifier is capable of handling 7 amperes peak current. It is a modification of RCA's well known TA7625 linear amplifier, and thereby provides added versatility. With minor circuit changes, the TA7625A can replace the TA7625.

The TA7625A has both short-circuit protection and reactive load-fault protection. Its inverting terminals are external. Thus the feedback resistor (22 ohms across terminal 3 and 4) can be varied to minimize distortion at low frequencies.

What does this mean to the designer? It means that he is better able to use the hybrid as a current source. It also means that the TA7625A has greater capability and versatility in servo-amplifier applications, in voltage-regulator circuits, inverters, and in deflection-amplifier circuits ($V_S = \pm 37.5$ V max.).

Contact your local RCA Representative for planned price reductions.

Circle Reader Service No. 44



RESISTANCE VALUES IN OHMS CAPACITANCE VALUES IN MICROFARADS UNLESS OTHERWISE SPECIFIED

SCHEMATIC OF TA7625A HYBRID POWER MODULE.

Custom design your own 30 MHz broadband amplifier with IC's transistor array

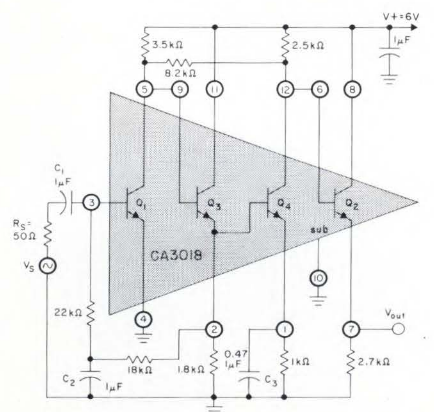
RCA's CA3018—monolithic, four-transistor array—offers the circuit designer a best-of-both-worlds approach. Here you have the economy, compactness, and device matching and temperature tracking you expect of IC's, combined with accessibility and design freedom that normally require discrete transistors. In the CA3018, two independent transistors and two Darlington-connected transistors are housed in a 12-lead TO-5 style package.

The wideband video amplifier shown here (in the schematic at right) utilizes the CA3018 to provide a 30-MHz bandwidth and a gain of 49 dB—with two feedback loops for excellent stability across the full frequency range. Gain of the amplifier is constant within 1 dB over the full −55°C to +125°C temperature range. With slide rule and breadboard you can custom-tailor this circuit to your own specifications.

RCA's CA3018 and its companion type, the CA3018A, are well suited to a variety of applications in low power systems in the dc through VHF range. The CA3018 provides a V_{BE} match of ± 5 mV. In the CA3018A, V_{BE} is matched within 2 mV and performance characteristics are controlled from 10 μA to 10 mA. You can purchase the CA3018 for just 98¢, the CA3018A for $1.35 (at 1000-unit levels).

The circuit shown here may also be built with the five-transistor CA3045 in a DIC package or the CA3046 in a DIP package.

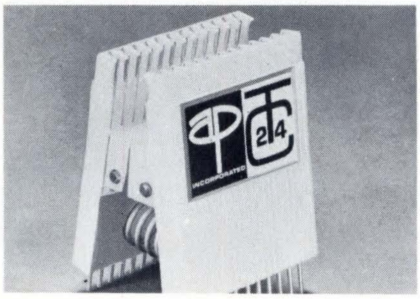
For Application Note ST-3895, "Design Ideas for RCA Linear Arrays," circle Reader Service No. 43.



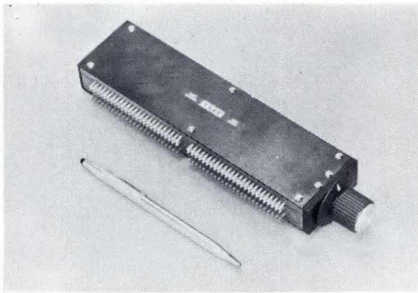
SCHEMATIC OF WIDEBAND VIDEO AMPLIFIER USING THE CA3018.

For price and availability information on all solid-state devices, see your local RCA Representative or your RCA Distributor. For specific technical data, write RCA, Commercial Engineering, Section 50K-15 UM6, Harrison, N. J. 07029. International: RCA, 2-4 rue du Lièvre, 1227 Geneva, Switzerland, or P.O. Box 112, Hong Kong.

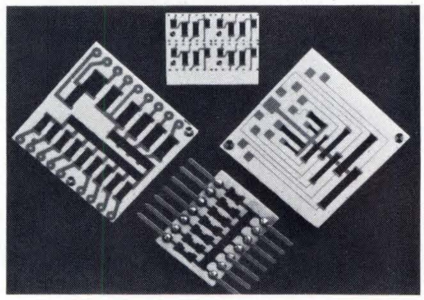
RCA Solid State Division



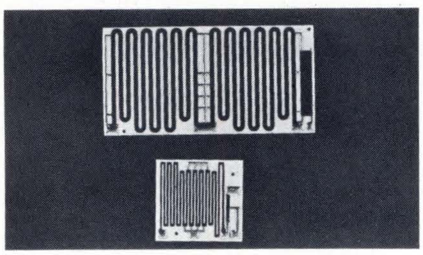
IC test clips accommodate 24- to 40-pin packages. Four units available, all accommodate DIPs with 0.5 and 0.6 in pin spacing. Firm spring-controlled grip assures positive contact. These clips also serve as excellent extractors for damage-free removal of DIPs. Price is $21 in quantities of one to nine. A P Inc., 72 Corwin Dr., Painesville, OH 44077. **250**



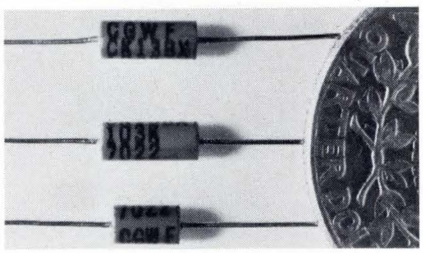
Centipole transfer switch contains 100 poles with double throw action and has behind-panel depth of 10 in. Switch is available with either solderable terminals or plug-in connectors for standard PC board connections. Solenoid types are available on special order. Daven, Div. of Thomas A. Edison Industries, Grenier Field, Manchester, N H 03103. **253**



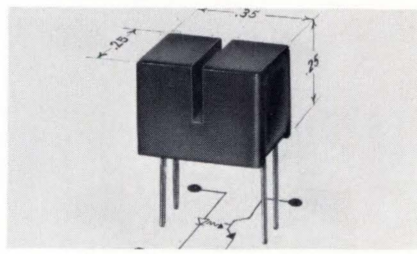
Thick-film resistor networks exhibit a 1% tolerance. Temperature compensation is matched up to 10 PPM. Resistance change over 1000 hour life at 85°C is less than 1%. Units are available in dual in-line packages, conformal coating or epoxy molded packages. Availability depends upon complexity. Cal-R Inc., 1601 Olympic Blvd., Santa Monica, CA 90404. **256**



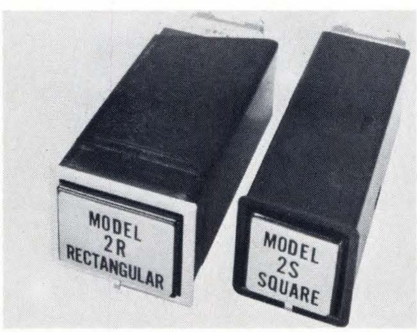
Thick-film voltage dividers, HD Series, are designed specifically for miniaturized applications requiring up to 10 kV. Resistance ratio tracks to <25 PPM/°C for temperature change and 10 PPM/V for voltage change. Resistance values range from 300 kΩ to 250 MΩ. Individual resistor tolerance is ±10%; ratios between tapped sections can be supplied to ±2%. Components, Inc., Biddeford, ME 04005. **251**



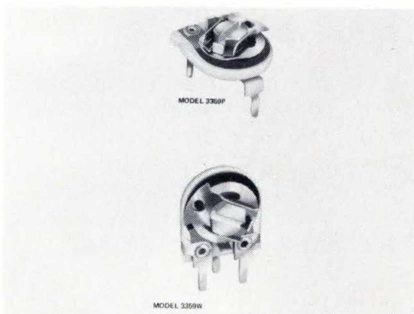
Three Glass-K BX/BR capacitors provide semi-precision performance over −55 to 125°C. Identified as CYK12, CYK13 and CYK14, capacitance values range from 10 to 100,000 pF with 10 or 20% tolerance. They qualify to both MIL-C-11015/20 and MIL-C-39014/5. Their axial leads are both solderable and weldable. Corning Glass Works, Corning, NY 14830. **254**



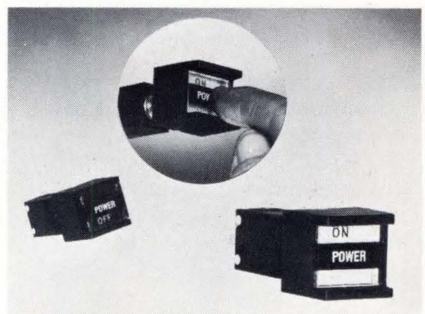
Optical switch Model OS 100, comprised of LEDs and phototransistors, switches by passing a mechanical device through a 0.06-in air gap to break a light beam and open the circuit. The unit is a 4-pin package measuring 0.25 by 0.25 by 0.35 in. This unit also doubles as an optically-coupled isolator. Price in 100-lot quantity is $8.05 ea. HEI, Inc., Jonathan Industrial Center, Chaska, MN 55318. **257**



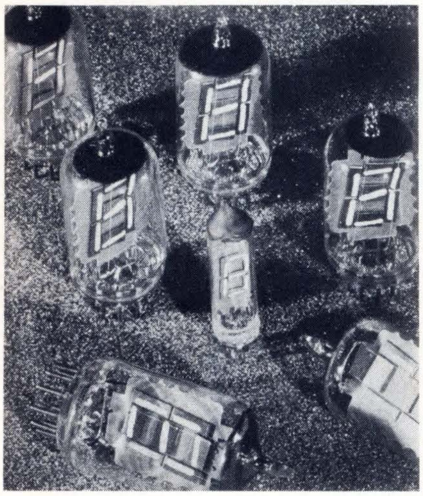
Display switches, Model 2R and 2S, offer two separate message areas, illuminated in a choice of six colors. Exclusive "Lever Latch" permits removal of front-panel display module for relamping and message changes without tools. Units are available in 28 Vdc and 115 Vac ratings, with switching capabilities from 10 μA to 5A. Price is $6.95 each in 100 lot quantities. Stacoswitch, 1139 Baker St., Costa Mesa, CA 92626. **252**



Cermet potentiometer Model 3359 is a 3/8-in single-turn unit that is designed for PC board application and sells for $0.50 each in 1000 quantity. Temperature coefficient is 0 to 300 PPM/°C for values up to 1kΩ, 0 to 200 PPM/°C for 1kΩ and up. Power rating is 0.5W at 70°C. Two versions are offered: top-adjust Model 3359P and side-adjust Model 3359W. Bourns, Inc., 1200 Columbia Ave., Riverside, CA 92507. **255**

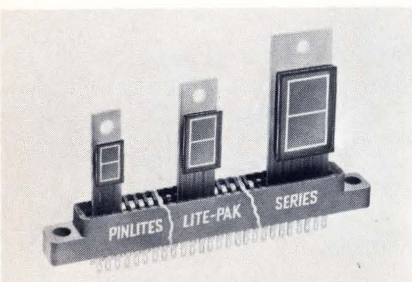


Pushbutton switch physically changes color. As the switch is pushed, a reflecting prism at the sides of the switch cap causes color bands to change color, thus eliminating ON/OFF errors. The cap is mounted in a barrier adapter that accepts a switch-based with one or two sets of double-break contacts rated at 10A, 30 Vdc or 125/250 Vac. Complete assembly price is between $4 and $6. Marco-Oak, Box 4011, Anaheim, CA 92803. **258**

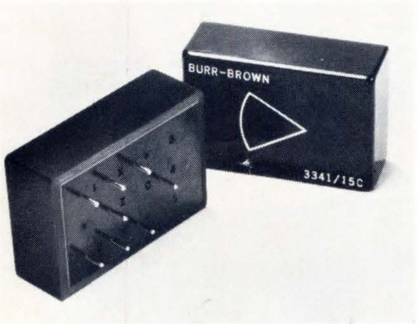


Low-voltage indicators are 7-bar segment, vacuum fluorescent tubes that provide alphanumeric readout. Family consists of the Y-4075 (10-pin tube in a T-3 envelope) and the Y-1938 and Y-1939 (9-pin tubes in T-6½ envelopes). Character sizes range from 0.23 by 0.43 in (Y-4075) to 0.36 by 0.57 in (Y-1938 and Y-1939). General Electric Co., 316 E. 9th St., Owensboro, KY 42301. **259**

R/C combinations in chip configuration are ideal for use in filters or general peripheral circuitry. Referred to as the "The R/C Bug", they contain up to 16 monolithic ceramic-chip resistors, 12 ceramic-chip capacitors or any combination of both. Contained in a normal 14-lead dual in-line package, the unit can be handled by automatic machinery. Crownover Electronics Corp., 7705 Fay Ave., La Jolla, CA 92037. **260**



Digital readout, called "Lite-Pak", plugs directly into a standard 0.05-in center edge connector and presents a 7-segment, directly-viewed incandescent display. Features include patented cross-over filament that eliminates dark spots in the corner; 120° wide-angle viewing; a wide color selection; and required voltage source of 3 to 5V dc. Pinlites, Inc., 1275 Bloomfield Ave., Fairfield, N J 07007. **261**



Line driving op amps slew at 1000V/μs and settle to 1% in 200 ns. Both Model 3341/15C and 3342/15C have output capability of ±5V up to 20 MHz when driving a 50Ω line. Voltage drift is ±25 μV/°C and ±50 μV/°C respectively. Both models have FET inputs and operate single-ended (inverting). Prices are $69 and $59 respectively. Burr-Brown Research Corp., International Airport Industrial Park, Tucson, AZ 85706. **262**

Voltage controlled crystal oscillator operates from 0 to 75°C without oven. Model VCXO-541 units are available from 150 kHz to 4 MHz. Size is 1 by 1.55 by 0.56 inches and weight is 40g. Solid State Electronics Corp., 15321 Rayen St., Sepulveda, CA 91343. **263**

D/A converters provide ± 1/2-bit accuracy over the temperature range of −30 to +100°C and are available in 8- and 10-bit versions. All are complete with TTL and DTL compatible input switches, resistor network, internal precision reference and output amplifier. Prices range from $29 to $99 in single lots. Micropac Industries, Inc., 905 E. Walnut St., Garland, TX 75040. **264**

Programmable-gain data amplifier, only 3 by 2 by 0.4 inch in size, is priced at $245. Model 3600K has voltage drift of ±1 μV/°C and noise of 2 μV rms. Operation is on standard ±15V dc and +5V dc system power supplies. Burr-Brown Research Corp., International Airport Industrial Park, Tucson, AZ 85706. **265**

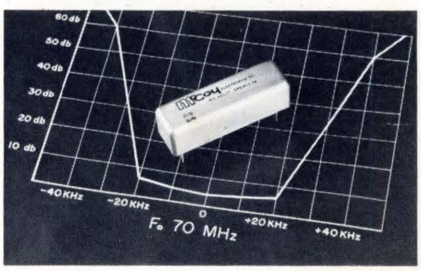
Fork oscillator, Model FS-11-1, contains driving circuit, drive and pickup coils, and temperature compensated fork. Its hermetically sealed case is 1-1/2 inch^2 by 3/8 inch high. Operating temperature range is −55 to +85°C. American Time Products, Bulova Watch Co., 61-20 Woodside Ave., Woodside, NY 11377. **266**

Frequency synthesizer comprised of four multi-chip ICs is intended for telecommunications systems up to 200 MHz. Component microsystems include Model SH-8095 emitter-coupled logic prescaler, Model SH8096 programmable divider, Model SH8097 VHF voltage-controlled tuner and oscillator and Model SH8098 programmable reference divider and reference oscillator. Units are available in hermetic 30-lead flatpacks with prices as low as $228 for all four units (industrial grade). Fairchild Semiconductor, 313 Fairchild Dr., Mountain View, CA 94040. **267**

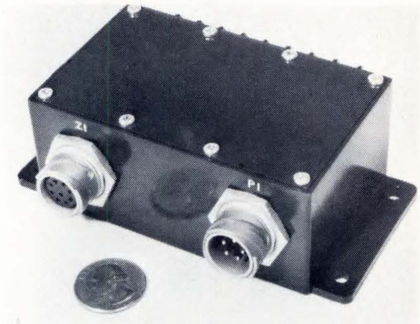
Dual FET analog gate has low ON resistance (50Ω maximum). Model CAG13C is a SPST break-before-make switch. It is supplied in a 14-lead TO-87 flat pack and sells for $40 in 100 quantities. Teledyne Crystalonics, 147 Sherman St., Cambridge, MA 02139. **268**

Power supply module, Model PM532, delivers 5V at 1A from a package measuring 3.5 by 2.5 by 1.25 inch. Operation is from 115 ±10V ac, 50 to 400 Hz. Operating temperature range is −25 to +71°C. Price is $63.95. Computer Products, Box 23849, Ft. Lauderdale, FL 33307. **269**

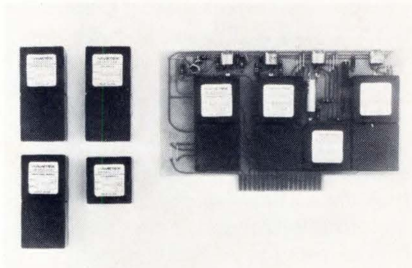
Standard microcircuit modules including a dual, a quad, a power relay driver and a MOS clock driver are introduced by Centralab. These thin-film chip hybrids require area of 0.69 by 0.75 inch on a PC board and are priced between $10.20 and $16.40 in single quantity. Centralab Electronic Div., Globe-Union Inc., 5757 North Green Bay Ave., Milwaukee, WI 53201. **270**



Monolithic filter with center frequency of 70 MHz has 6 dB bandwidth of ±20 kHz minimum and 60 dB bandwidth of ±40 kHz maximum. Insertion loss is 5 dB, input and output impedances are 50Ω. Package size is 1-61/64 by 19/32 inch. McCoy Electronics Co., Mount Holly Springs, PA 17065. **271**



DC power switches handle load currents of 0 to 100A (surge to 1000A) at load voltages to 100V dc. Switching rate is up to approximately 700 Hz, and essentially square pulses of current as short as 50 μs can be delivered continuously over the operating range of −55 to +100°C. Package size is 3 by 4 by 5 inches. United Technology Center, Div. of United Aircraft Corp., Sunnyvale, CA 94088. **272**

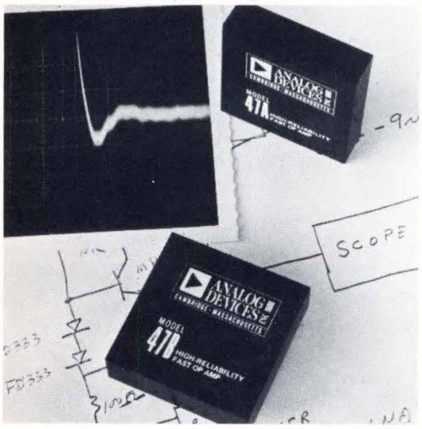


Modular signal generator—comprised of generator, sine converter, trigger, and regulator modules—generates sine, square, triangle, pulse and ramp waveforms from dc to 100 kHz. Power required is + and −15V dc regulated. Wavetek, Box 651, San Diego, CA 92112. **273**

Combination crowbar and circuit breaker package is available with firing voltages of 6.5 or 16.5V and current ratings of 2, 5 or 10A. The crowbar operates in 500 ns, the circuit breaker in 10 ms, avoiding crowbar destruction. Sample cost is $20. Heinemann Electric Co., 235 Magnetic Dr., Trenton, N J 08602. **274**

Oscillator with ±0.001% stability from 0 to 60°C and current drain of 1 mA is offered at frequencies from 1 Hz to 1 MHz. Size of the Series 162 units is 1-1/2 by 1-1/2 by 0.5 inch and price ranges from $40 to $98. Accutronics/Div. of Gibbs Mfg. and Research Corp., 628 North St., Geneva, IL 60134. **275**

Op amp with differential input uses monolithic IC for moderate input drifts and high dc voltage gain. The Model P/N-6.830 has 6 dB/octave roll off and features 10^7 dc gain, 5 MHz full signal bandwidth, $300V/\mu s$ slewing rate and 50 mA output current. MTBF is in excess of 10 years at 25°C. Size of the plug-in modules is 1.7 by 2.3 by 0.45 inch. Electronics Assoc., Inc., West Long Branch, N J 07764. **276**



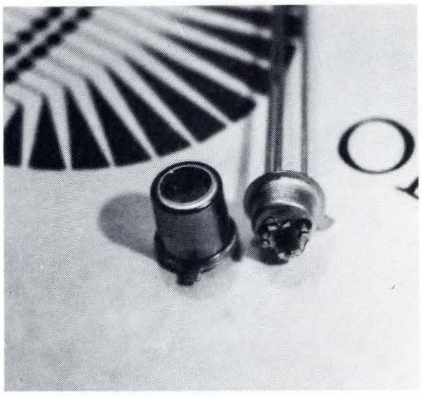
Op amp, Model 47, settles to 0.01% in 1 μs in both inverting and noninverting modes. Featured are FET input, all metal-can transistors and operating temperature range from −55 to +125°C. Prices range from \$69 to \$95. Analog Devices, Inc., 221 Fifth St., Cambridge, MA 02142. **277**

Miniature synchro bridge accepts S1, S2, S3 synchro outputs and converts them to a 2-wire voltage representing synchro position. The Model SB-M-11 has accuracy of 20s of arc. Size is 0.44 by 0.5 by 1.75 inch, and price is \$100. Theta Instrument Corp., Fairfield, N J 07006. **278**

Solid-state relay can switch a bipolar dc signal of up to ±100V at current levels of ±50 mA. Featured is 50 μs switching and long life. Operating temperature is −55 to +100°C. Package size of Model 2850-10050 is 1.31 by 1.31 by 1.75 inches. Solid State Electronics Corp., 15321 Rayen St., Sepulveda, CA 91343. **279**

Wideband amplifier, Model 610, covers from 1 to 100 MHz at 20 dB gain with less than 15 μV equivalent input noise. It can drive 1V pk-pk into a 50Ω load with less than 1 dB gain compression. Size is 1.75 by 1 by 0.6 inches, and price is \$150. Arvee Engineering Co., Inc., Box 3759 Torrance, CA 90510. **305**

Silicon power transistors in the 2N5928 Series feature a V_{CE} (sat) of <1V at 100A and a guaranteed h_{FE} at 150A. Devices have V_{CE} (sus) to 120V and are rated 200W at 100°C. Packaged in the JEDEC TO-114 container, price range is from $109.50 to $219 each. PowerTech, Inc., 9 Baker Ct., Clifton, N J 07011. **280**



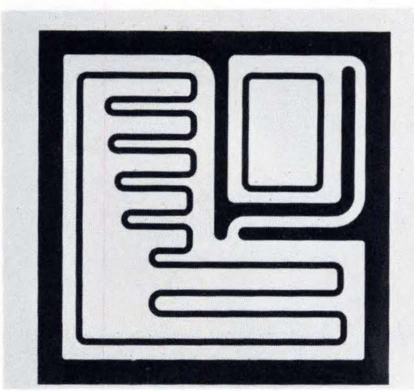
Broadband photon detectors in the KN-15 Series provide high sensitivity from 2000Å to 3μm with a time constant of approximately 500 μs. Peak detectivity is typically 1×10^{11}cm(Hz)$^{1/2}$W^{-1} with responsivity of 4 to 7×10^5 V/W. Optoelectronics, Inc., 1309 Dynamic St., Petaluma, CA 94952. **283**

Microwave tuning varactors in the E700 Series have an f_{co} in excess of 100 GHz and a working voltage of 60V. These tuning units are made from 1 to 22 pF and provide full octave tuning capability. Prices range from $7.80 to $25 each in lots of 100. Eastron Corp., 25 Locust St., Haverhill, MA 01830. **286**

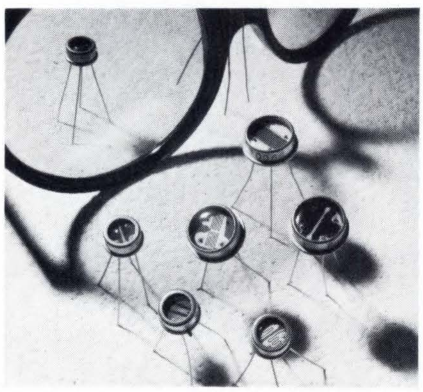
Semiconductors in the ECG line, part of a repair kit, replace 95% of the most popular solid-state components found in home entertainment products. The ECG303 repair kit consists of 24 commonly used semiconductor devices which are replacements for over 20,000 equivalent types. The kit is priced at $37.92. Sylvania Electric Products, Inc., 730 Third Ave., New York, NY 10017. **281**

Dual 32-bit static shift register V001 is a low voltage p-channel MOS unit that requires only a single phase TTL compatible clock. It features dc to 2 MHz operation from −55 to 125°C, power dissipation typically 1 mW/bit at 2 MHz and a price of $3.25 each in lots of 100 items. Varadyne, Inc., MOS Operation, Semiconductor Div., 10432 N. Tantau Ave., Cupertino, CA 95014. **284**

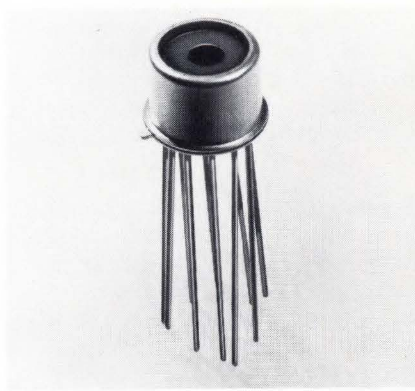
Hex 32-bit MOS/LSI shift register TMS-3112JC is organized as six registers by 32 bits. The unit is produced by low-threshold MOS technology and requires +5 and −12V supplies. Available in a standard 24-pin ceramic dual in-line container, price in lots of 250 to 999 is $11.20 each. Texas Instruments, Inc., Inquiry Answering Service, Box 5012, M/S 308, Dallas, TX 75222. **287**



Complementary power Darlington transistors, the first available in the industry, include five new series that provide gain up to 2500 typical, current from 4 to 16A, collector-emitter breakdown voltage ratings of 60 and 80V and 100-up quantity prices that range from $3.20 to $8.50 per complementary pair. Technical Information Center, Motorola Semiconductor Products, Inc., Box 20924, Phoenix, AZ 85036. **282**

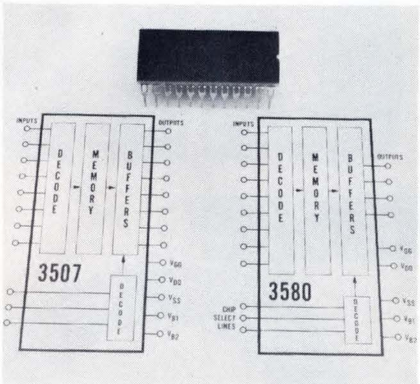


Dual element photocells contain two completely independent and isolated photosensitive elements on a common ceramic substrate. The family of 10 new devices offers a dynamic resistance range > one million to one, and peak spectrum response can be specified in the range of 5150 to 7100Å. Unit price in production quantities is $0.90 each. Raytheon Co. Industrial Components Operation, 465 Centre St., Quincy, MA 02169. **285**



Photodiode/operational amplifier HAD-1000 incorporates in a TO-5 package the SGD-100A silicon photodiode chip and a dual FET, differential input operational amplifier. The unit operates from 0.35 to 1.15 μm, offers a slew rate of 6V/μs, 2 MHz gain bandwidth product, input impedance of $10^{12}\Omega$ and output impedance $<100\Omega$. EG&G, Inc., Electronic Products Div., 170 Brookline Ave., Boston, MA 02215. **288**

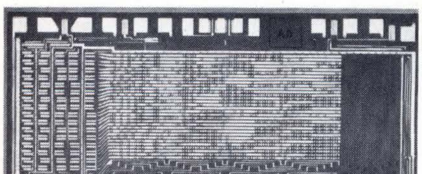
Static read-only memories 3507 and 3580 are MOS units organized as 256 words by eight bits and 512 words by four bits respectively. Outputs have wired-OR capability which permits direct stacking of up to eight packages. Access time is <1.3 μs over the operating temperature range from 0 to 70°C, and price in lots of 100 to 999 units is $20 each. Fairchild Semiconductor, 313 Fairchild Dr., Mountain View, CA 94040. **289**



Zener diode BZX86 is a 300W unit that provides surge suppression up to 3 kW for 50 ms. Mullard, Inc., 100 Finn Ct., Farmingdale, L.I., NY 11735. **292**

Germanium pnp alloy high-power transistors feature current capabilities to 25A. Designated JAN 2N456B-457B-458B Series and JAN 2N1021A-1022A Series, these units are available packaged in the JEDEC TO-3 case. Other characteristics include a V_{CE} (sat) of 0.5V, V_{CBO} to 120V and V_{CEX} to 120V. Solitron Devices, Inc., 1177 Blue Heron Blvd., Riviera Beach, FL 33404. **293**

Teardrop disc thermistors are epoxy coated and provide insulation up to 5000V dc. Units are available with resistance values from 100 to 20 kΩ, tolerances from 0.5% to 20% and diameters of 1/8 in or less. Prices range from a few cents to a few dollars, depending upon tolerance and quantity. Cal-R, Inc./Thermonetics Div., 1601 Olympic Blvd., Santa Monica, CA 90404. **290**



Static MOS read-only memories in the 7600 Series are the fastest static ROM family in the industry, with a typical access time of 350 ns. Chip organization in the series includes units with 256-word by four, 128-word by eight, 256-word by eight, 512-word by four, 512-word by five, and 256-word by 10. In lots of 100 to 999, prices range from $14.70 to $29.10 (−25 to 70°C), and from $22.10 to $41 each (−55 to 125°C). Intersil, Inc., 10900 N. Tantau Ave., Cupertino, CA 95014. **291**

EDN CARAVAN ROUTING

November 2 - November 30, 1970

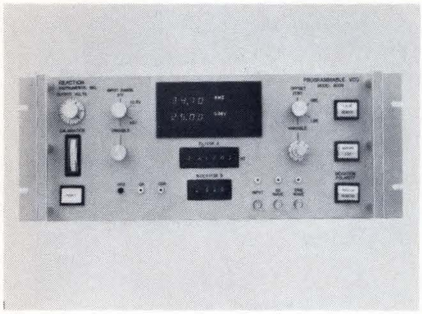
DATE / DAY / TIME	AREA	SITE
Monday, November 2		
9:00 - 12:00 noon	Orlando, Florida	Dynatronics, Inc.
1:30 - 4:30 p.m.	Melbourne, Florida	Radiation, Inc.
Tuesday, November 3		
9:00 - 12:00 noon	Palm Beach Gardens, Fla.	RCA (EDP Div.)
2:00 - 4:30 p.m.	Ft. Lauderdale, Fla.	Bendix Corp. (Avionics Div.)
Wednesday, November 4		
9:00 - 12:00 noon	Miami, Florida	Milgo Electronics Corp.
Thursday, November 5		
9:00 - 12:00 noon	Sarasota, Florida	Electro-Mechanical Research
1:30 - 4:30 p.m.	St. Petersburg, Fla.	General Electric (Nuclear Energy Div.)
Friday, November 6		
9:00 - 12:00 noon	St. Petersburg, Fla.	Electronic Communications, Inc.
1:30 - 4:30 p.m.	St. Petersburg, Fla.	Honeywell Inc. (Aerospace)
Monday, November 9		
10:00 - 12:00 noon	Houston, Texas	Texas Instruments Incorporated
1:30 - 4:30 p.m.	Stafford, Texas	Texas Instruments Incorporated
Tuesday, November 10		
9:00 - 12:00 noon	Austin, Texas	IBM Corp.
1:30 - 4:30 p.m.	Austin, Texas	Texas Instruments Incorporated
Wednesday, November 11		
9:00 - 12:00 noon	Austin, Texas	Tracor Inc.
Thursday, November 12		
9:00 - 12:00 noon	Dallas, Texas	Texas Instruments Incorporated
1:30 - 4:30 p.m.	Dallas, Texas	Recognition Equipment Inc.
Friday, November 13		
9:00 - 12:00 noon	Garland, Texas	LTV Electrosystems
2:00 - 3:00 p.m.	Ft. Worth, Texas	Westronics, Inc.
Monday, November 16		
9:00 - 12:00 noon	Albuquerque, N. M.	Sandia Corp.
Tuesday, November 17		
1:30 - 3:30 p.m.	Scottsdale, Arizona	Motorola Inc.
Wednesday, November 18		
9:00 - 12:00 noon	Phoenix, Arizona	Honeywell Information Systems Inc. (Computer Operations—Phoenix)
1:30 - 4:00 p.m.	Phoenix, Arizona	Sperry Flight Syst. Div.
Friday, November 20		
9:00 - 12:00 noon	La Jolla, Calif.	Control Data Corp. (Analog-Digital Systems)
1:30 - 4:30 p.m.	San Diego, Calif.	NCR (Data Processing Div.)
Monday, November 23		
9:00 - 12:00 noon	Fullerton, Calif.	Hughes Aircraft Corp.
1:30 - 4:30 p.m.	Fullerton, Calif.	Beckman Instruments Inc.
Tuesday, November 24		
9:00 - 12:00 noon	El Segundo, Calif.	Hughes Aircraft Corp./Space Sys.
1:30 - 4:30 p.m.	El Segundo, Calif.	Xerox Data Systems
Wednesday, November 25		
9:00 - 12:00 noon	Hawthorne, Calif.	NCR (Data Processing Inc.)
1:30 - 4:30 p.m.	Canogo Park, Calif.	Hughes Aircraft Corp.
Monday, November 30		
9:00 - 12:00 noon	Sunnyvale, Calif.	Memorex Corp.
1:30 - 3:30 p.m.	Santa Clara, Calif.	Hewlett Packard Co.

Sweep and marker generator covers from 30 kHz to 110 MHz in a single sweep range and features twin variable pulse markers and crystal-comb calibrators. The sweep itself offers continuously variable sweep widths and center frequency over the full 110 MHz range. The variable markers have digital frequency dials, and the crystal combs mark at 1 and 10 MHz intervals. Price is $1345. Kay Elemetrics Corp., 12 Maple Ave., Pine Brook, N J 07058. **294**

Variable bandwidth amplifiers, the ITV-1 series, provide 35 dB of gain at center frequency of 30, 60 or 70 MHz. Bandwidth is variable between 0.2 and 12 MHz for the 30 MHz unit, and noise figure is 8 dB max. Varian, Solid State Div., 611 Hansen Way, Palo Alto, CA 94303. **295**

Digital multimeter measures ac and dc volts, ohms and frequency. The 4-1/2-digit Model 8420 offers resolution of 0.01%, along with basic accuracy of 0.01% for dc volts. Price is $695. California Instruments Corp., 3511 Midway Dr., San Diego, CA 92110. **296**

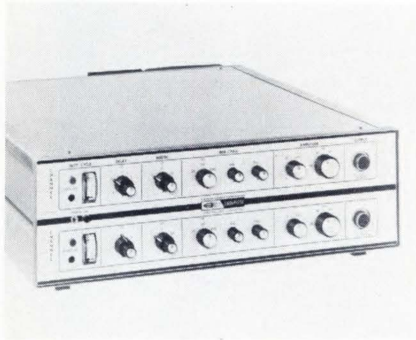
Pulse generator for time domain testing features continuously variable manual control of pulse rate, delay, width and amplitude. Performance includes double pulse to 40 MHz, 3 ns rise and fall time, 20 ns to 100 ms pulse width, and triggering from dc to 25 MHz. Positive and negative outputs are independently variable between 0.5 and 10V. Price of Model 3103 is $395. Lear Siegler, Inc., Cimron Div., 1152 Morena Blvd., San Diego, CA 92110. **297**



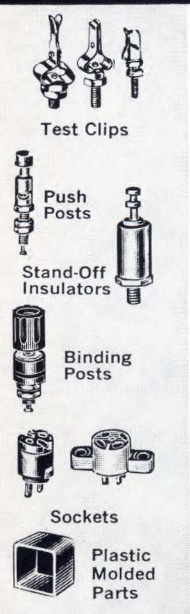
Programmable FM signal generator, Model 6009, offers full computer or front panel control of percent deviation and of center frequency from 100 Hz to 10 MHz, together with voltage control of frequency deviation up to ±39.9% of center frequency. Features include a deviation calibrator, LED numeric display, FM linearity better than 0.1% and center frequency accuracy of 1%. Price is $5950. Reaction Instruments, Inc., 215 Mill St., N.E., Vienna, VA 22180. **298**

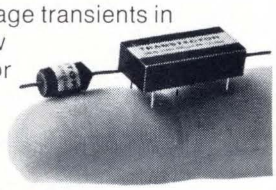
Dual-channel oscilloscope with 35 MHz bandwidth and sensitivity of 5 mV/cm is particularly suitable for field computer applications. Viewing area of the Cossor model CDU 150 is 8 by 10 cm, yet weight is only 27 lb and size is only 10 by 10 by 16 inches. Price is $1695. Raytheon Service Co., Boston Service Center, 177 Pine St., Natick, MA 01760. **299**

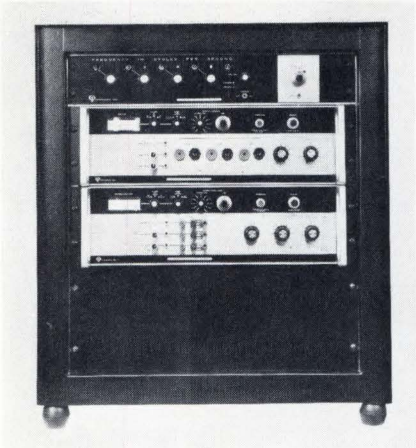
RF power amplifier with 10W output and 100 MHz bandwidth is flat within ±1 dB from 0.05 to 80 MHz. Operation is Class A. Price of the Model RF-806 is $795. R F Communications Inc., 1680 University Ave., Rochester, NY 14610. **300**



Pulse driver, Model 310, consists of two current drivers housed in a single cabinet. Positive or negative output modules are available, and outputs may be directly mixed in any combination. Amplitude is variable from 5 mA to 1A in two ranges. Rise and fall times are continuously variable and independent of amplitude. Price is $3100. Systron-Donner Corp., Datapulse Div., 10150 W. Jefferson Blvd., Culver City, CA 90230. **301**





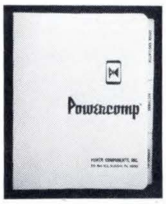


Polyphase ac voltage and current standard, Model AC-162, delivers precision output over the frequency range of 20 to 9999 Hz with amplitude stability of 0.002% and output power of 40 VA each phase. Output is 6 wire, either floating or grounded neutrals. Output voltage is 120, 208, 240, 480 and 600V rms, line to line. Optimation, Inc., 9421 Telfair Ave., Sun Valley, CA 91352. **302**

Logic tester, the computer-controlled "Capable", has 128 programmable pins (expandable to 256) and will test logic cards, LSI or MSI circuits with 192 separate tests per program. No programming need be learned, and an unskilled operator can test virtually any binary logic assembly. Price is $27,500. Computer Automation, Inc., 895 W. 16 St., Newport Beach, CA 92660. **303**

Data Analyzer, Model DQA-10, measures data source oscillator baud rate error, character parity errors, voltage or current levels of the data or logic input signal and digital pulse distortion. It is a companion to the TMG-10 test message generator that simulates a variety of signals with and without degradations. Atlantic Research Corp., Shirley Hwy. at Edsall Rd., Alexandria, VA 22314. **304**

Analog/digital/analog conversion, signal conditioning and digital display products are covered in this 16-page short-form catalog that includes basic specs. Analogic Corp., Audubon Road, Wakefield, MA 01880. **100**

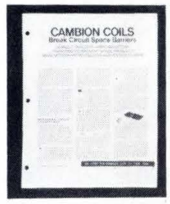


Zeners and rectifiers are covered in this 35-page 1971 catalog. Zener diodes from 3.3 to 200V and as high as 10W are covered, while rectifier and rectifier assembly voltages as high as 15,000V and currents to 10A also are included. Power Components, Inc., Box 421, Scottdale, PA 15683. **101**

Wire and cable is the subject of this 195-page product and technical handbook. It incorporates new data on the high-temperature wire and cable industry. Copies are available on company letterhead to Tensolite, Div. of Carlisle Corp., West Main St., Tarrytown, NY 10591.

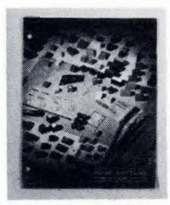
Miniature dry reed relays are covered in this 17-page catalog that explains how to choose the correct new metal-covered Clare Picoreed relay. Fifty-six PC-board types and 40 high-sensitivity, 50 mW types are included. This Engineering Data Sheet No. 971B is available from C. P. Clare & Co., 3101 Pratt Blvd., Chicago, IL 60645. **102**

Pin-and-socket connectors for rack and panel cable applications are described in 32-page Catalog No. 908. Specifications plus application and dimensional data for over 300 items are included. AMP Inc., Harrisburg, PA 17105. **103**

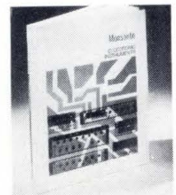


Micro-miniature inductors, believed to be the smallest coils in the world today, are covered in this eight-page brochure. Complete electrical and physical data on five micro-inductors plus a shielded printed circuit variable inductor are covered. Cambridge Thermionic Corp., 445 Concord Ave., Cambridge, MA 02138. **104**

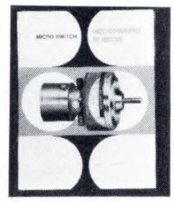
"Recording Instrumentation Selection Guide" contains 16 pages of information to answer all oscillograph recorder questions. It describes the type of instrument to use under various circumstances. Century Electronics & Instruments, Inc., 6540 E. Apache, Tulsa, OK 74115. **105**



Molded push buttons for use with switches and keyboards are covered in this six-page catalog. Units contain single or double light cavity, single or multiple station, engraved or double shot-molded characters, gloss or non-gloss. Bulletin No. 2500 is available from Maxi-Switch Co., 3121 Washington Ave. N., Minneapolis, MN 55411. **106**



"Electronic Instruments" is a 64-page book that describes over 45 instruments including digital counters, sine and square wave generators and pulse generators. Monsanto Electronic Instruments, 620 Passaic Ave., West Caldwell, N J 07006. **107**



DC Motor Product Brochure VM covers high-performance dc motors ranging from the small 50W unit to a large unit capable of 215W of power output. These hollow rotor motors can leap from dead stop to 2000 rpm in <1 ms. Micro Switch, A Div. of Honeywell Inc., 11 W. Spring St., Freeport, IL 61032. **108**

"DC Power Supply Kits" is an eight-page brochure that covers 450 regulated and unregulated units. Kits are available with choke or capacitor input and 0.15% or 0.01% regulation. Techni-Kit, Universal Electronics Co., 17811 Sky Park Cir., Box 4517, Irvine, CA 92664. **109**

Keyboard Information File includes everything needed to order or specify electronic data entry keyboards. Two bulletins give detailed specs on key modules and keyboard arrays, while a third provides easy-to-use, step-by-step worksheets for custom designing keyboards. Cherry Electrical Products Corp., 3600 Sunset Ave., Waukegan, IL 60085. **110**

Microwave variable capacitors offering Qs previously unavailable in trimmer capacitors are covered in this product brochure. Johanson Manufacturing Corp., 400 Rockaway Valley Rd., Boonton, N J 07005. **111**

Digital voltmeters, thermometers and accessories, data acquisition components and systems are covered in this six-page brochure from United Systems Corp., 918 Woodley Rd., Dayton, OH 45403. **112**

The causes of magnetic interference and the procedure to follow for successful engineering of magnetic shielding are covered in a four-page brochure. Eagle Magnetic Co., Box 24283, 7421 Crawfordsville Rd., Indianapolis, IN 46224. **113**

RF coaxial connectors now available in tarnish-free ASTROplate finish are described in four-page brochure "Amphenol ASTROplate, The 'Permanent' Finish" (D-Form 181B). Amphenol Sales Div., The Bunker-Ramo Corp., 2801 S. 25th Ave., Broadview, IL 60153. **114**

"DC to DC Power Supply Catalog" contains 20 pages covering over 700 standard models. Supply levels from <1W to 15W are included. Mil Electronics, Inc., Dracut Rd., Hudson, NH 03051. **115**

DC-DC converters, designated the CVM Series, feature pulse width modulation for high efficiency, regulation of 1% and efficiency of 80%. Literature is available from Custom Power, Inc., Box 23117, Houston, TX 77028. **116**

Crossed planar log periodic antennas for frequencies from 100 MHz to 12.4 GHz are covered in this new literature. American Electronic Labs., Inc., Box 552, Lansdale, PA 19446. **117**

A/D, D/A, transducer/digital, special purpose converters and manual and automatic test instrumentation are covered in an eight-page catalog. Astro-systems, Inc., 6 Nevada Dr., Lake Success, NY 11040. **118**

Computer-designed bandpass active filter, Type 41, has a frequency range of 20 Hz at 0.5% bandwidth to 20 kHz at 1% bandwidth. A product bulletin on the $17 device is available from KDI Navcor West, 15551 Cabrito Rd., Van Nuys, CA 91406. **119**

Antenna types such as blades, stubs, horns, slots, and frequency independents are covered in this 16-page catalog from Electronic Resources, Marketing Dept., 4561 Colorado Blvd., Los Angeles, CA 90039. **120**

Thermocouple assemblies are discussed in this six-page brochure. Included are standard, angle type and pipe extended type assemblies. Pyco, Inc., 600 E. Lincoln Hwy., Penndel, PA 19047. **121**

Miniature magnetic components are covered in a six-page short form catalog that lists 36 specific applications and keys the applications to 15 different series of components. Pulse Engineering Inc., Box 12235, San Diego, CA 92112. **122**

Junction and MOS FET chips are offered in either wafer or chip form. Thirty-four standard types for use as single and dual amplifiers, analog switches and current limiters are available. Siliconix, Inc., 2201 Laurelwood Rd., Santa Clara, CA 95054. **123**

Narrow tolerance phototransistors include three silicon planar epitaxial units that are described in CLT 2010, 2020 and 2030 data sheets. Clairex Corp., 560 S. Third Ave., Mount Vernon, NY 10550. **124**

RFI filters and capabilities for design and manufacture of filters to customer requirements are outlined in a four-page brochure available from Electro Cube, Inc., 1710 S. Del Mar Ave., San Gabriel, CA 91776. **125**

A/D converters (8- to 12-bit) based on monolithic IC components are described in Model ADC-Q data sheet. Analog Devices, Inc., Pastoriza Div., 221 Fifth St., Cambridge, MA 02142. **126**

Potentiometric, variable reluctance and differential transformer type transducers and miniature modular power supplies and amplifiers are covered in an eight-page summary brochure. Bourns, Inc., Instrument Div., 6135 Magnolia Ave., Riverside, CA 92506. **127**

Connectors in the "MICROMATE" Series are covered in a four-page test report which describes 15 tests performed on this series of connectors. Copies of Report PIB 7-3 are available from Microdot Inc., Connector Div., 220 Pasadena Ave., South Pasadena, CA 91030. **128**

"Mini-grip" probes designed for use on ICs are the smallest available and are covered in this four-page bulletin. Dept. Probes-1, Data Display Systems, Inc., 139 Terwood Rd., Willow Grove, PA 19090. **129**

Fixed composition resistor established reliability to meet specification MIL-R-39008A is covered in this six-page folder from Airco Speer Electronic Components, St. Marys, PA 15857. **130**

Stepping switches for military and other applications requiring performance under severe environmental conditions are described in Bulletin SP-365. Oak Manufacturing Co., A Div. of Oak Electro/Netics Corp., Crystal Lake, IL 60014. **131**

"Systems and Operation Manual" for the Raytheon 704 minicomputer contains 656 pages written for the requirements of automation and system designers. It is available without charge from Raytheon Computer, 2700 S. Fairview St., Santa Ana, CA 92704. **132**

RFI/EMI filters including Button, L, Pi, T and Bolt Series are described in this 12-page Catalog MF-1. Lundy Electronics & Systems, Inc., Glen Head, NY 11545. **133**

"Ultimate Surfaces for Plating, Resist Adhesion and Solderability" covers the preparation of printed circuits prior to assembly. London Chemical Co., Inc., Dept. EN-2, 240 Foster Ave., Bensenville, IL 60106. **134**

Distribution amplifiers for use in broadcast or closed-circuit TV applications are described in six-page data sheet 6-535. Cohu Electronics, Inc., Box 623, San Diego, CA 92112. **135**

"Power Supplies and Electronic Devices for Industrial, Commercial and Military Applications" is an eight-page OEM Bulletin, Revision 1. Constant Voltage Co., 4114 N. Ravenswood Ave., Chicago, IL 60613. **136**

"Scotch-Weld" (anaerobic type) structural adhesives are covered in a four-page brochure, Z-ANB. Physical properties and performance along with typical applications are included. Adhesives, Coatings and Sealers Div., 3M Co., 3M Center, St. Paul, MN 55101. **137**

Irate Clock Watchers

Readers of these columns include more "clock watchers" than we realized, judging from the torrent of mail received about D. R. Barnhill's "metric clock". (See EDN, Oct. 1, 1970, p. 70). Readers found little fault with Mr. Barnhill's idea of metricizing time, but they had lots to say about the illustration that accompanied his letter.

The illustration was ours, not his – and it's wrong!

The clock in the illustration reads 4.08.82, which is somewhat at odds with Mr. Barnhill's text. He has our apology, and we have a bushel basket of letters, some of which contained further proposals.

Dear Sir:

D. R. Barnhill's suggestion to metricize time is received with clamorous approval here.

We have no need, however, for "hours", "minutes" or "seconds", all of which is terribly confusing and artificial. Since we must fix on a national standard, why not use a day, deciday (dd), centiday (cd), milliday (md), microday (μd) and so on? The conversions are easily established:

NEW TIME	**OLD TIME**
Day (d)	Day
Deciday (dd)	2.4 hours
Centiday (cd)	14.4 minutes
Milliday (md)	86.4 seconds
Microday (μd)	.0864 seconds

Months, may I add, are also quite superfluous. Time in the new notation might easily be expressed as a decimal. For instance, 358.940 is simply 10:30 p.m. on Christmas Eve!

J. R. Breton
NUSC/NLL New London, CT

Gentlemen:

. . . Incidentally, 24 hour time is never referred to as (example) 2200 *hours*. The 2200 is sufficient.

C. H. Bartlett
Jacksonville, FL

Dear Sir:

(Trouble reading Mr. Barnhill's clock) . . . is also the trouble common to power-company meter readers – that of determining whether or not the time is actually 4.08.42 (sic) or 4.07.42. Perhaps a digital readout will be the only way to avoid ambiguity.

James Wright Belville, III
University of Florida
Gainesville, FL

Editor Boe:

You did a service to common sense and order by letting everyone see Mr. Barnhill's ideas. But for **my** circle I took the (also) common-sense stand of "one circle" = unity, divided decimally as far as useful/practical. (The day is "unity", too, and should be ONE DAY, divided decimally.) One time around is one circle, naturally. Any portion of this is a decimal part up to the limit of "1". And hang the Babylonians and that awkward number, 360!

Temple Nieter
Evanston, IL

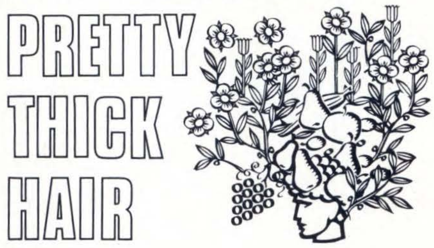
(Ed. Note: Does this imply that sin 0.25 = 1.000? One impact of metrication might be a boom in republishing textbooks and tables!)

Misleading

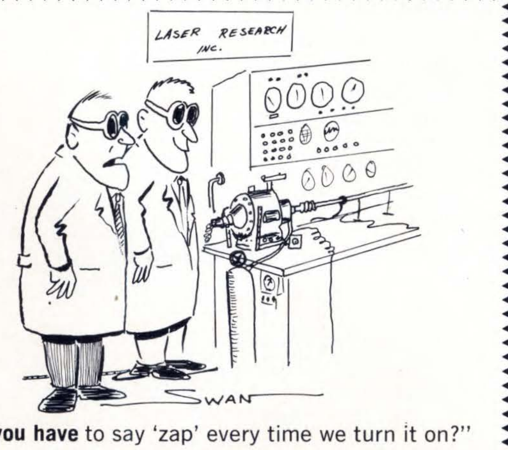
Dear Mr. Boe:

On page 33, paragraph 1 of "Hybrids Today" (EDN, Oct. 1, 1970), there is a statement which is somewhat misleading: "According to Computer Microtechnology, a cross-license agreement permits Fairchild to implement CMI's patented all-aluminum beams." To keep the record straight, the basic patent for aluminum beam lead technology was awarded to John Schroeder while an employee of Fairchild Semiconductor. Computer Microtechnology is the first company to implement this technology under a cross-license agreement with Fairchild.

David C. Conrad
Vice President, Marketing, CMI



Reader at General Time's Research Center points out that EDN's news story on "Supercon" VSF 400-filament superconductor (about the size of a human hair) would read much better if each filament were 0.007 *mm* in diameter, instead of 0.007 *inches*. Otherwise a hair would be 2.8 inches in diameter!



"**Do you have** to say 'zap' every time we turn it on?"

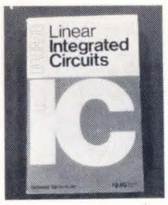
Printer Developed Down Under

Robert A. Chapman writes from Australia that he's seeking a U.S. buyer for his newly-invented electrostatic printing process. He says he can demonstrate printout of 12,000 characters/second and that experimental results indicate speeds up to 2.4 million characters/second, 120 wide. It prints on paper or other material without pretreatment and is capable of color and continuous tone. If interested, write him at PO Box 55, Kilsyth, Victoria, Australia.

I don't trust these electronic fellers when they talk about milliamperes – that's a thousandth of something you couldn't see in the first place.

– Josh Billings Jr.

Linear Integrated Circuits



RCA/Solid State Div., Somerville, N. J.; 416 pages, 5-1/2 by 8-1/2 in; $2.50 (optional).

This is an update of RCA's LIC manual, extensively revised and expanded to keep up with the state of the art. Beginning with basics of the subject, such as fabrication, packaging, mounting and interconnection techniques, it progresses rapidly to several new sections. Notable among these are a new application guide that indicates circuit types recommended for specific applications, a chapter on the effects of monolithic fabrication on circuit design, and chapters that deal with diff amp circuits, operational voltage amplifiers, operational tranconductance amplifiers and special-purpose circuits.

The manual will be helpful to circuit and system designers who must determine optimum specifications. It will also aid educators, technicians and others who have a basic understanding of solid state devices and circuits. For more information. Circle No. **320**

Direct Transistor Substitution Handbook

H. A. Middleton; Hayden Book Co., Inc., New York, N.Y.; 224 pages; 6 by 9 in; illus.; paper; $2.95.

Reference guide provides computer-selected substitutes for nearly 12,000 different transistors currently used in entertainment, industrial and commercial equipment. Close, conservative tolerances yield almost 130,000 substitutions, graded from "good" to "best". All substitutions take into account both electrical and physical parameters. Illustrations include more than 200 base drawings and a lead arrangement chart. For further information. Circle No. **321**

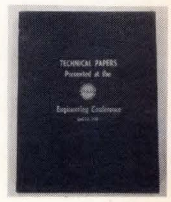
Decade Market Forecast

"Electronic Industry Market for Advanced Technology Manufacturing—1970/1980" Theta Technology Corp., Peer Bldg., 530 Silas Deane Hwy., Wethersfield, CT. 06109. $825 per 2 copies.

This report projects the growth of the electronic industry through the 70s, pinpointing those key product areas whose rapid growth will dictate electronic manufacturing equipment needs. Detailed forecasts are given of the changing demand for a wide range of manufacturing equipment, including such areas as equipment for artwork generation, assembly and packaging, automated testing, computers (maxi and mini), CAD, computer graphics (including CRTs), computer output microfilm, diffusion, electrochemical machining, electron beam processes, flexible printed cable, furnaces, holography, lasers, numerical control fabrication, optical character recognition (OCR), photoexposure equipment, photofabrication, plating, riveting and staking, and wire preparation. For more information.

Circle No. **322**

Proceedings—1970 NAB Engineering Conference



Tab Books, Blue Ridge Summit, Pa.; 224 pages; 8-1/2 by 11 in; softcover; $10.00.

A complete transcript of all the technical papers presented at the 1970 National Association of Broadcasters Engineering Conference is typeset in uniform style. It includes all the photos, slides and drawings that illustrated the talks, and its subject matter spans a broad range of interest. Some papers, such as those on time and control code for video tape editing, the CBS color corrector for encoded video signals, and modular digital-controlled routing switcher, will be of intense interest to the designer. Other articles appeal more to a non-technical audience. For more information.

Circle No. **323**

ABCs of FETs

Rufus P. Turner; Howard W. Sams & Co., Inc., Indianapolis, Ind.; 1970; 96 pages; 5-1/2 by 8-1/2 in, softbound; $2.95.

Listed as Catalog 20789, this reference presents detailed principles of FET operation, with stress on the application of FETs in practical circuits. The language is simple and straightforward, and the presentation is exhaustive, beginning with basic theory in the first chapter and progressing through tests and measurements to design considerations and typical applications. This is one of those basic books that form a well-used portion of the engineer's reference shelf.

Indexes

Advertiser's Index

Subject Index to Articles

Index to Ads, Products and Literature

Application Notes

"Position Counts" is the title of a free-loan 15-minute, full-color sound film on numerical control positioning systems. Several generation, interconnection and assembly operations common to PC manufacture are covered. A four-page brochure gives more details. The Superior Electric Co., Bristol, CT 06010. **90**

Zero axis switching is the subject of a three-page application note on employing solid-state relays. Questions such as "What is it?", "Why does normal switching cause RFI?" and "What can you do about it?" are both asked and answered in this note. Zenrad Controls Co., 1575 A.P.S., Santa Barbara, CA 93103. **93**

"Control Handbook" 1971 edition contains 408 pages offering a practical guide to solid state control logic. It is written for specifiers, designers, manufacturers and users of electronic or mechanical logic. A free copy is available from Dept. P, Digital Equipment Corp., Maynard, MA 01754. **96**

"Loran-C Timing Handbook" contains 30 pages on the Loran-C system and its application to practical problems of time and frequency synchronization. Both articles and applications information are included. Aerospace Research, Inc., 130 Lincoln St., Boston, MA 02135. **91**

Mercury-wetted contact relays for PC boards are covered in 27-page Manual No. 860. Graphs comparing contact noise and jitter between the old industry standards and new types show improvement often exceeding 8 to 1. C. P. Clare & Co., 3101 Pratt Blvd., Chicago, IL 60645. **94**

Lapped substrates of alumina or beryllia for thick film hybrid circuits is the subject of Technical Bulletin A-24. It is written to assist engineers in designing and processing hybrid circuits. Accumet Engineering Corp., 25 Broad St., Hudson, MA 01749. **97**

"DC Power Supply Handbook 90A" contains 138 pages divided into six main sections: Definitions, Principles of Operation, AC and Load Connections, Remote Programming, Output Voltage and Current Ratings, and Performance Measurements. Inquiries Manager, Hewlett-Packard Co., 1601 California Ave., Palo Alto, CA 94304. **92**

Interactive time sharing program, MICAP, for solving a wide variety of circuit problems covering the range from microwaves down to acoustical frequencies requires no knowledge of computer programming and enables the user to retain control over the program at all times. Tymshare, 525 University Ave., Suite 220, Palo Alto, CA 94301. **95**

"Component Oven Designers Catalog" is written specifically for the equipment design engineer requiring a temperature-controlled environment. Definitions and illustrations provide a sound basis for rapid and accurate temperature control specifications. Oven Industries, Inc., 1106 E. Simpson Rd., Box 229, Mechanicsburg, PA 17055. **98**

Reprints Available **in this issue are offered as follows:**

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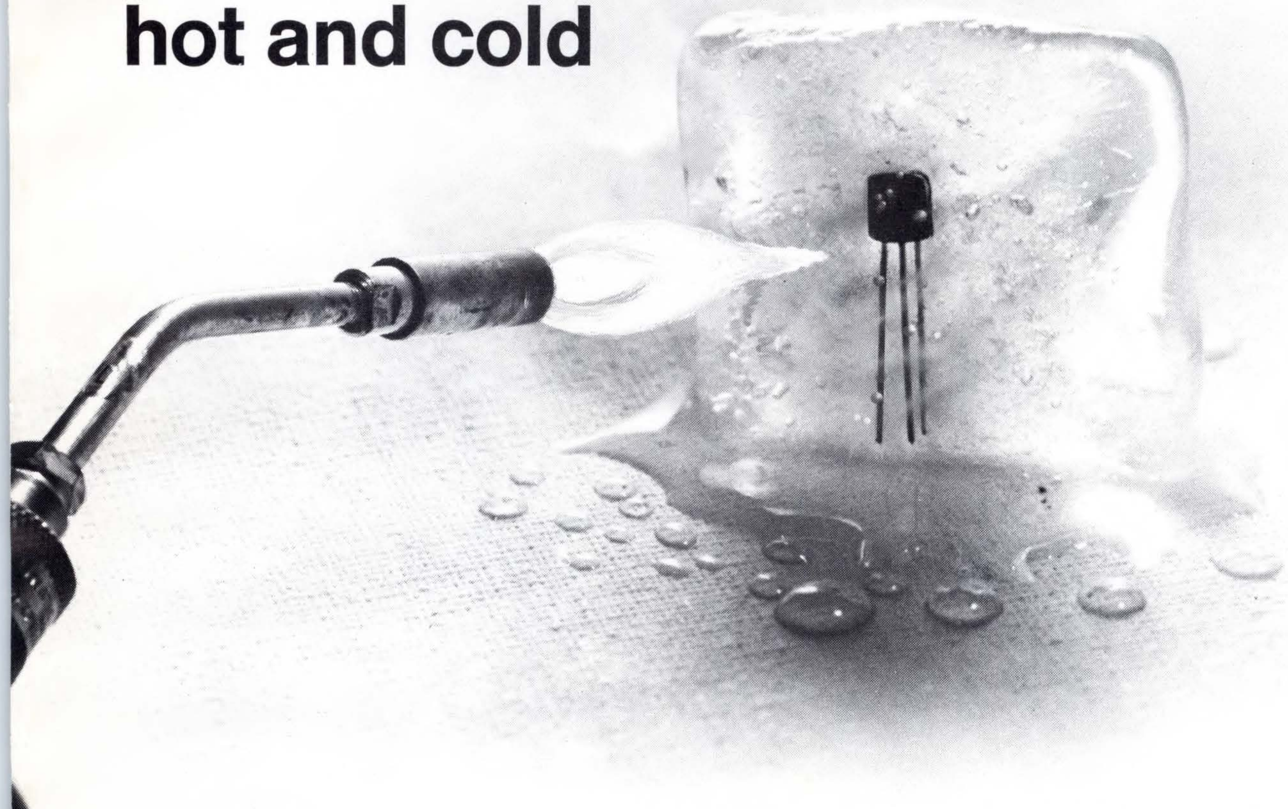
L62	Plastic ICs Entice Military	43
L63	Build a Sawtooth Generator with Three ICs	49
L64	DC Feedback Stabilizes Bias on FET/Bipolar Pair	51
L65	Twelve Tips for Proposal Writers	53

General Electric's new epoxy TO-18 transistors run hot and cold



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PD mW	I_C mA	NPN JEDEC Type	NPN h_{FE} I_C=.1 V_{CE}=1V	NPN h_{FE} I_C=300 V_{CE}=2V	NPN h_{FE} I_C=800 V_{CE}=5V	NPN Noise fig. dB (max)	PNP JEDEC Type	PNP h_{FE} I_C=.1 V_{CE}=−1V	PNP h_{FE} I_C=300 V_{CE}=−2V	PNP h_{FE} I_C=800 V_{CE}=−5V	PNP Noise fig. dB (max)
400†	500	2N6000	50	40		3.0	2N6001	90	35		3.0
400†	500	2N6002	130	80		2.0	2N6003	210	50		1.5
400††	500	2N6004	50	40		3.0	2N6005	90	35		3.0
400††	500	2N6006	130	80		2:0	2N6007	210	50		1.5
500††	800	2N6010	45	85	45	5.0	2N6011	70	65	45	3.0
500††	800	2N6012	90	160	50	3.0	2N6013	180	135	70	2.0
500†††	800	2N6014	45	65	15	5.0	2N6015	70	60	35	3.0
500†††	800	2N6016	90	60	15	3.0	2N6017	180	125	55	2.0

† BV_{CEO}=25V; †† BV_{CEO}=40V; ††† BV_{CEO}=60V

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GET708	2N708	GET2222	2N2222	GET3014	2N3014
GET914	2N914	GET2222A	2N2222A	GET3638	2N3638
GET929	2N929	GET2369	2N2369	GET3638A	2N3638A
GET930	2N930	GET2484	2N2484	GET3646	2N3646
GET2221	2N2221				

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