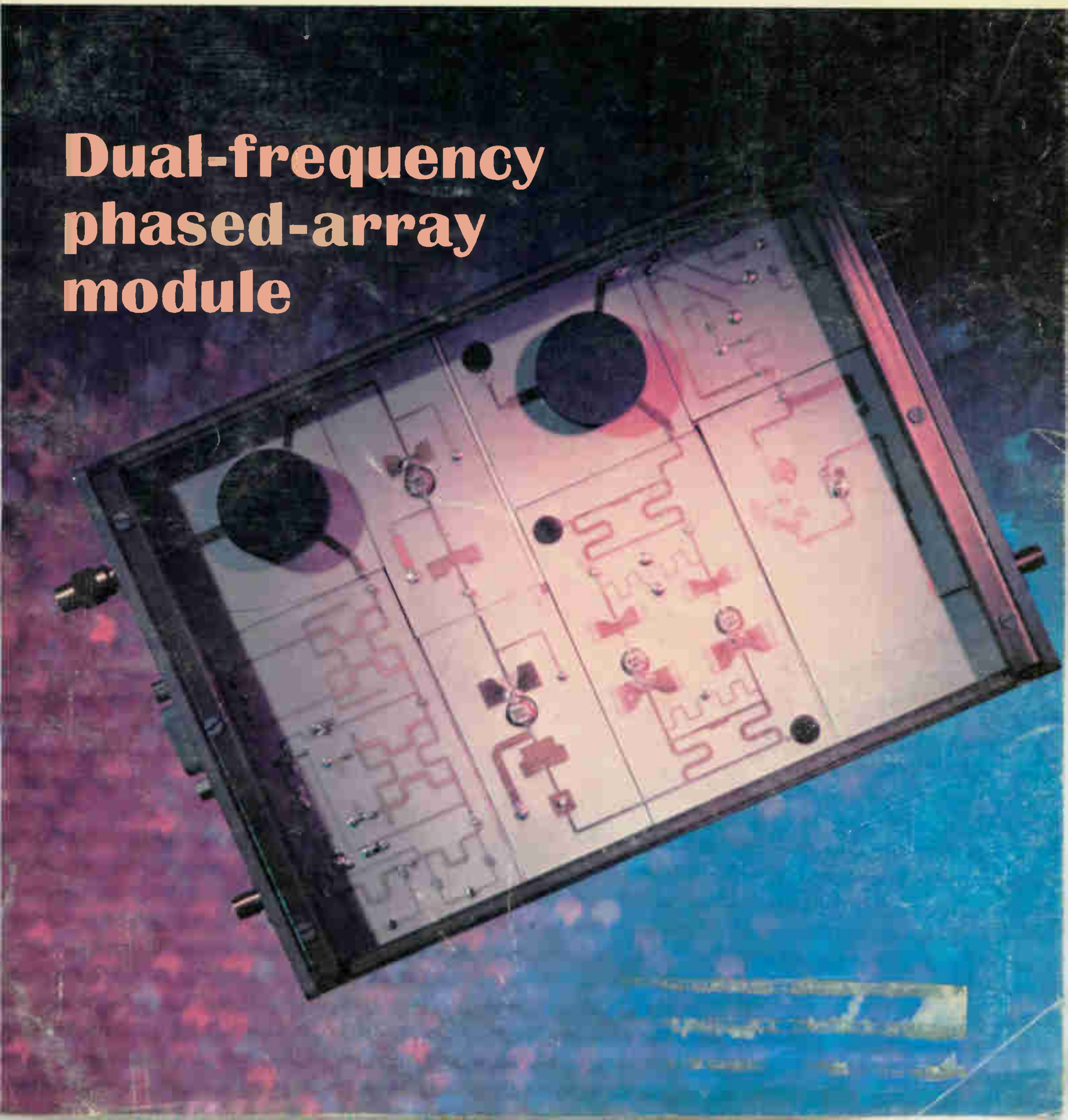
MOS-bipolar speed gap closes 82
Modified models cut CAD costs 90
Off-the-shelf IC's improve voltage regulators 94

$1.00 A McGraw-Hill Publication
July 20, 1970

Electronics®



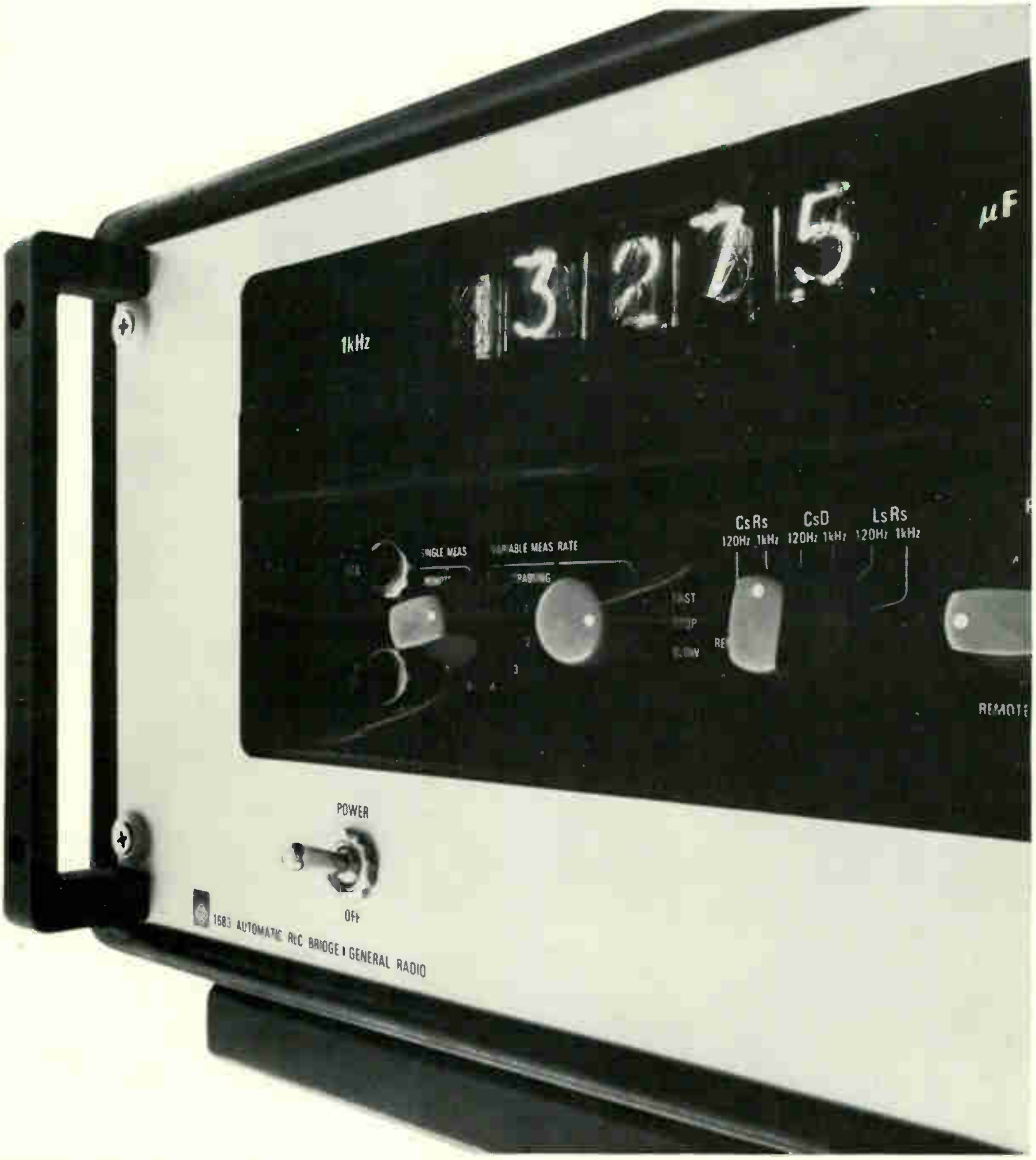
Dual-frequency phased-array module

Suppose you wanted an Automatic RLC Bridge

that could measure up to 2 MΩ resistance, 2000 H inductance, and 0.2 F capacitance, plus equivalent series resistance and leakage current. A bridge with 5-digit resolution for reactance and resistive readouts, automatic decimal point and units of measurement; a 20-measurements-per-second capability; 120-Hz and 1-kHz test frequencies; 5-terminal connections to preserve a basic 0.1% accuracy; a built-in 0 to 3-V bias or external bias to 600 V; optional remote programmability and data output.

And prices that start at $4,215. (in U.S.A.)

Where could you possibly find such a bridge?



1683 Automatic RLC Bridge by **GENERAL RADIO**

West Concord, Mass. 01781 Tel: (617) 369-4400 Europe: Postfach 124, CH 8034 Zurich, Switzerland

Circle 900 on reader service card

HEWLETT hp PACKARD

OSCILLOSCOPE SYSTEMS

What's new in HP Scopes? 18 GHz, dual-channel sampling! New, faster HP diodes now extend sampling capability through 18 GHz. For the first time, you can directly view and measure 18 GHz CW signals (or 20 psec risetime pulses).

But there are more new scope innovations from HP. There's the new, easy-to-use, 250 MHz real-time scope ... and new, direct read-out TDR with ¼" resolution ... and new variable persistence and storage scopes for measurements up to 100 MHz ... and a whole new series of low-cost 500 kHz scopes.

AND, *there are more eye-popping scope ideas just around the corner!*

Next time you see your HP field engineer, ask him what's new in scopes. You'll be surprised by all that's happening to give you better, more economical scope measurements. One thing, we bet you'll get a new (and better) answer, every time you ask!

Are you thinking about a new scope? Are you wondering whether you should continue down the same old road? Or is it time you took a look at another manufacturer? The HP road means going with the demonstrated leader — maker of performance champs.

Call your HP field engineer, right now, if 18 GHz sampling is your interest. Complete 18 GHz sampling system available with delayed sweep, or w/o delayed sweep. If you already have an HP 12.4 GHz sampling system, add the new 18 GHz HP 1430B remote sampler. Write Hewlett-Packard, Palo Alto, California 94304. Europe: 1217 Meyrin-Geneva, Switzerland.

Circle 157 on reader service card

Electronics

Volume No. 43 Number 15 July 20, 1970

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Readers Comment

Soviet economy

To the Editor:
As always, when the Soviet Union gets bogged down in the mire of its communistic economy and wishes to advance it looks to the products and skills of capitalists to bail it out. This time Soviet planners wish to calm "considerable public complaint about inadequate automation of the Soviet economy" by buying from the West computing equipment to produce "the vision of a whole planned economy being run by a vast network of computers all over the country." The achievement of this goal is important to Soviet planners because "the computer has become a political symbol in the Soviet Union. It stands for a rational technocratic control of the economy and, ultimately, Soviet society" [*Electronics*, Jan. 19, p. 137].

And, as always in the past, businessmen in predominantly capitalistic countries are able and willing to help the troubled Soviet regime and eagerly provide the means to keep communism going. (See Western Technology and Soviet Economic Development, 1917 to 1930, Antony C. Sutton, Hoover Institution, Stanford University.) These men give no thought to the principles on which capitalism is based—individual rights; they act only for the range-of-the-moment profit—they call it being practical; and they give no thought to the long range economic and political consequences resulting from violating ethical principles by supporting that which is evil—the suppression of individual rights. Short range thinking makes them accept the erroneous idea that there is a conflict between the moral and the practical and that it is practical to sacrifice one's ideals.

But a proper moral code must be in accord with reality, and immoral actions do have practical consequences. (See Capitalism: The Unknown Ideal, Ayn Rand.) Only by overlooking these consequences can businessmen support a totalitarian regime which is dedicated to the annihilation of capitalism. Communism has proclaimed the long range goal of destroying capitalism by physical invasion, revolution or subversion. The Soviets have repeatedly confirmed their loyalty to this goal by words and in actions. (Recent examples: the violent suppression of capitalistic tendencies in Hungary and Czechoslovakia.)

If capitalism dies it will be by self-sacrifice and suicide; if communism lives it will be with the help of its chosen enemy—capitalism.

Ernst F. Germann
Austin, Texas

▪ Above letter was previously summarized. The original is now being published in full.

In the works

To the Editor:

You say [May 11, p. 41] that Zenith is building tv sets in Taiwan. We are planning a facility there; however, the arrangements, still in the final stages, won't be operational before late this year or early next.

William A. Nail
Zenith Radio Corp.
Chicago

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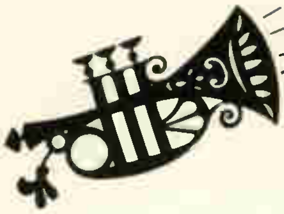
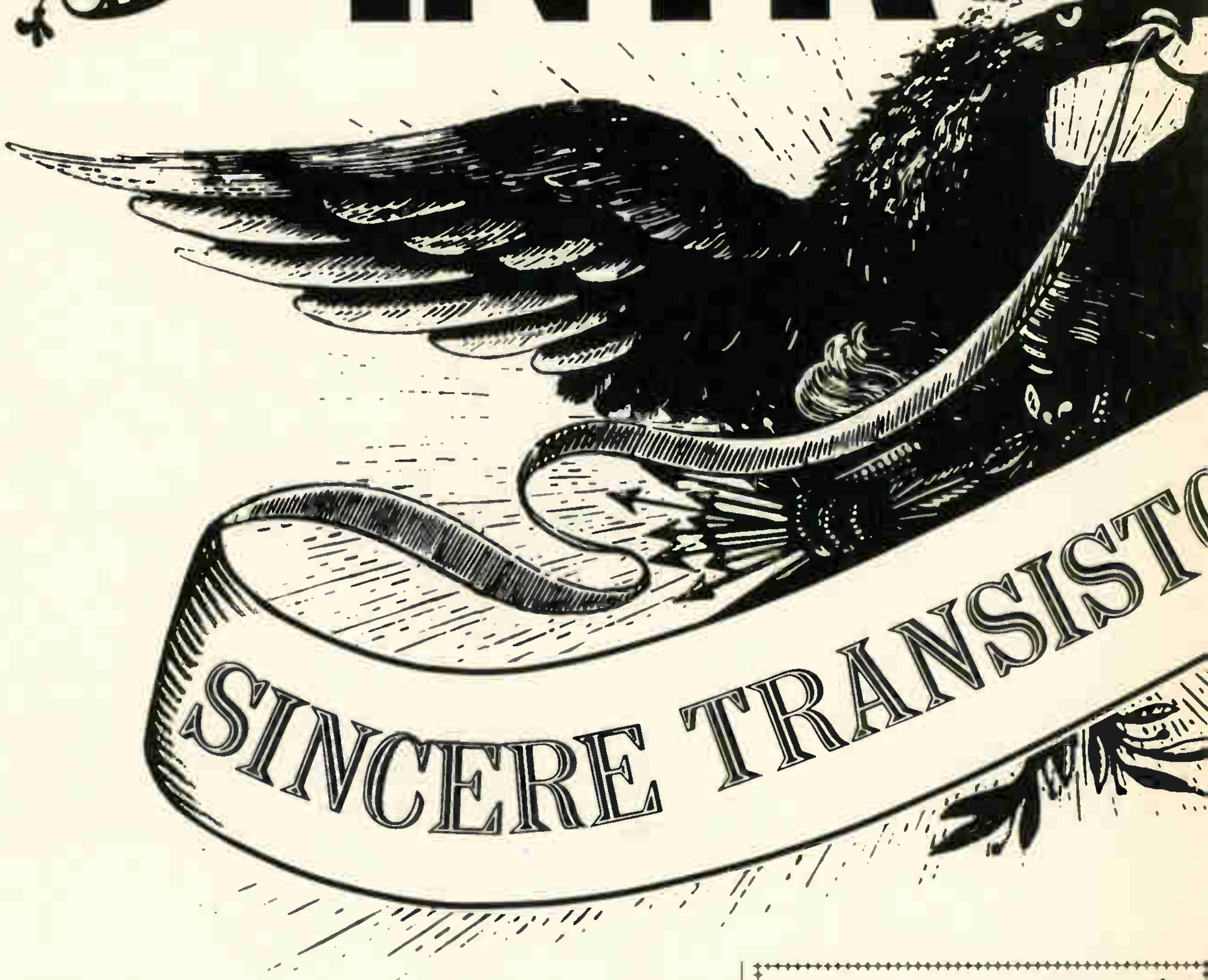




Dear Mister:

Now that transistors are starting to catch on, we've decided to get into the business. Transistors and diodes are a big deal. But to some companies, they're just a nuisance. Why should they bother about transistor customers when they can sell IC's.

Well we, for one, care.

At The Sincere Transistor & Diode Company, we sell the same stuff everybody else does. The difference is our attitude. With us, every customer is a big shot. Whether he buys a million transistors or just a couple dozen.

If the numbers on the following pages look familiar they should be. We've made a deal with Fairchild Semiconductor, to take care of transistor and diode buyers—some of the really important people in electronics. So, Fairchild helps us make transistors and diodes. And we help them care more about their customers.

To order any number of any of the products we've listed, just call (415) 962-5011. Or drop a note to our plant at 313 Fairchild Drive, Mountain View, California 94040. We'll prove that nothing succeeds like Sincere.

Molly Sincere

Special!

LOW LEAKAGE DIODES

DEVICE	TYPE	1-99	100-999	1000-9999	10K
FD300	FD6	.50	.34	.18	.14
FD333	FD5	2.00	1.33	.40	.37
IN456	FD5	.33	.22	.17	.13
IN456A	FD5	.36	.24	.18	.14
IN457	FD5	.35	.24	.14	.11
IN457					
JAN/193	FD5	.35	.24	.19	.15
IN457A	FD5	.35	.24	.19	.15
IN458	FD5	.45	.30	.19	.15
IN458					
JAN/193	FD5	.45	.30	.19	.15
IN458A	FD5	.45	.30	.19	.15
IN459	FD5	.45	.30	.19	.15
IN459					
JAN/193	FD5	.45	.30	.19	.15
IN459A	FD5	.48	.32	.19	.15
IN482A	FD5	.48	.32	.19	.15
IN482B	FD5	.48	.32	.19	.15

Continued on next column

A REAL SIZZLER!

HIGH CONDUCTANCE FAST SWITCHING DIODES

DEVICE	TYPE	1-99	100-999	1000-9999	10K
FD400	FD4	2.25	1.50	.42	.35
FD444	FD4	1.00	.67	.25	.21
IN251A	FD4	.65	.44	.17	.14
IN625	FD4	.30	.20	.13	.10
IN626	FD4	.30	.20	.13	.10
IN627	FD4	.30	.20	.17	.14
IN628	FD4	.60	.40	.19	.15
IN629	FD4	.67	.45	.21	.18
IN643	FD4	.90	.60	.21	.18
IN643JAN/256	FD4	.90	.60	.21	.18

Continued on next column

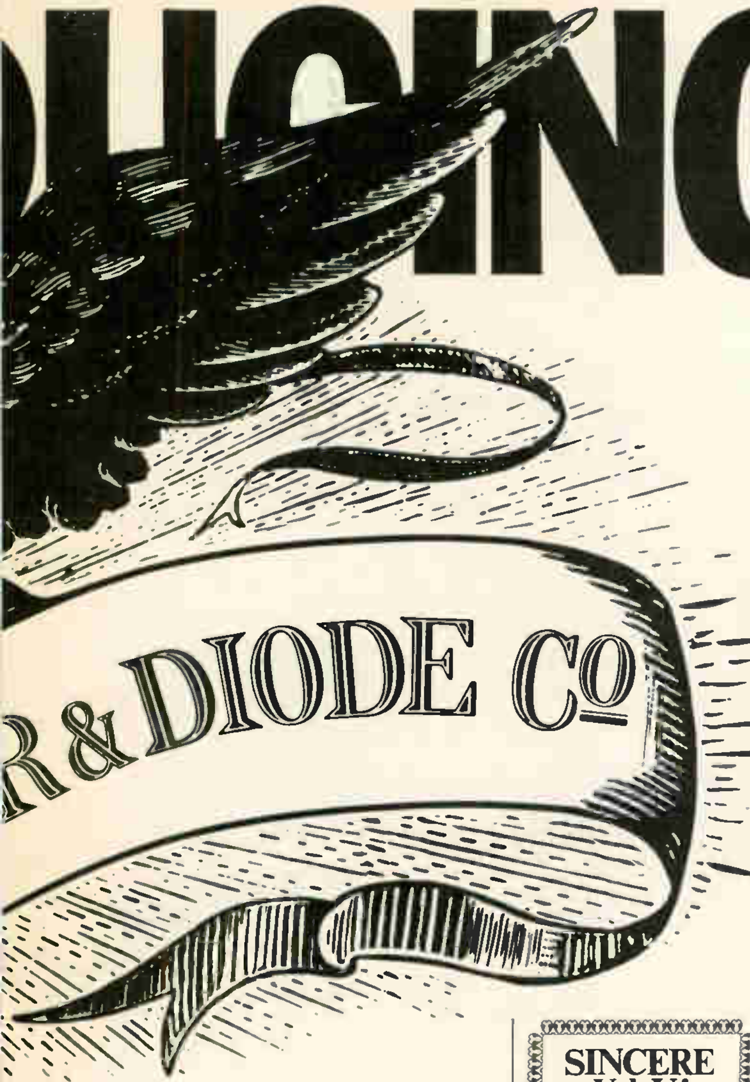
IN643A	FD4	.90	.60	.21	.1
IN658	FD4	1.35	.90	.25	.2
IN658JAN/257	FD4	1.35	.90	.25	.2
IN660	FD4	.45	.30	.19	.1
IN662	FD4	.24	.16	.12	.1
IN662JAN/256	FD4	.24	.16	.12	.1
IN662A	FD4	.60	.40	.19	.1
IN663	FD4	.57	.38	.19	.1
IN663JAN/256	FD4	.57	.38	.19	.1
IN801	FD4	.45	.30	.19	.1
IN804	FD4	1.50	1.00	.25	.2
IN806	FD4	.75	.50	.20	.1
IN807	FD4	.75	.50	.17	.1

IN483A	FD5	.50	.34	.19	.15
IN483B					
JAN/118	FD5	.50	.34	.19	.15
IN483BJANTX	FD5	1.80	1.20	1.10	.90
IN484A	FD5	.50	.34	.19	.15
IN484B	FD5	.50	.34	.19	.15
IN485A	FD5	.58	.39	.19	.15
IN485B	FD5	.58	.39	.19	.15
IN485BJAN	FD5	.58	.39	.19	.15
IN485BJANTX	FD5	1.80	1.20	1.10	.90

Continued on next column

IN486	FD5	.80	.54	.24	.2
IN486A	FD5	.80	.54	.24	.2
IN486B	FD5	.80	.54	.24	.2
IN486B					
JAN/118	FD5	.80	.54	.24	.2
IN486BJANTX	FD5	1.80	1.20	1.10	.9
IN890	FD5	1.50	1.00	.25	.2
IN3595	FD5	1.95	1.30	.70	.5
IN3595					
JAN/241	FD5	3.00	2.00	.70	.5

COMPLETE SELECTION OF TRANSISTORS & DIODES



- COMPLETE SELECTION OF TRANSISTORS & DIODES!
- 137 SMILING SALESMEN TO SERVE YOU!
- IMMEDIATE, OFF-THE-SHELF DELIVERY!
- 100% SATISFACTION GUARANTEED!
- FREE CHICKEN SOUP WITH EVERY ORDER!

SINCERE TRANSISTORS

DUAL AND DARLINGTON TRANSISTORS—METAL CAN

DEVICE	TYPE	1-99	100-999
2N997	NPN-Darlington	10.50	7.00
2N999	NPN-Darlington	14.85	9.90
2N2060	NPN-Dual	6.75	4.50
2N2060A	NPN-Dual	8.70	5.80
2N2223	NPN-Dual	4.95	3.30
2N2640	NPN-Dual	4.50	3.00
2N2642	NPN-Dual	6.75	4.50
2N2722	NPN-Dual	9.00	6.00
2N2723	NPN-Darlington	14.40	9.60
2N2724	NPN-Darlington	15.00	10.00
2N2725	NPN-Darlington	18.00	12.00
2N2806	PNP-Dual	17.25	11.50
2N2903	NPN-Dual	5.85	3.90
2N2913	NPN-Dual	2.25	1.50
2N2915	NPN-Dual	6.00	4.00
2N2917	NPN Dual	3.00	2.00
2N2919	NPN-Dual	5.25	3.50
2N2920	NPN-Dual	9.00	6.00
2N2920A	NPN-Dual	11.20	7.50
2N2972	NPN-Dual	2.50	1.75
2N2976	NPN-Dual	5.25	3.50
2N2979	NPN-Dual	10.00	6.50
2N2980	NPN-Dual	11.25	7.50
2N3424	NPN-Dual	15.75	10.50
2N3727	PNP-Dual	12.50	9.00
2N3729	NPN-Dual	7.35	4.90
2N3800	PNP-Dual	9.00	6.00
2N3804	PNP-Dual	15.00	10.00
2N3810	PNP Dual	15.00	10.00
2N4015	PNP-Dual	12.00	8.00
2N4017	PNP Dual	9.00	6.00
2N4020	PNP Dual	11.25	7.50
2N4025	PNP-Dual	15.00	10.00

Continued on next column

POWER

DEVICE	TYPE	1-99	100-999
2N4237	NPN/PWR	2.25	1.50
2N4238	NPN/PWR	2.75	1.85
2N4239	NPN/PWR	3.05	2.05
2N5681	NPN/PWR	1.80	1.20
2N5682	NPN/PWR	2.50	1.65
2N5334	NPN/PWR	6.30	4.20
2N5335	NPN/PWR	7.20	4.80
2N3439	NPN/PWR	3.70	2.45
2N3440	NPN/PWR	1.80	1.20
2N4234	PNP/PWR	3.00	2.00
2N4235	PNP/PWR	3.45	2.30
2N4236	PNP/PWR	3.90	2.60
2N5679	PNP/PWR	2.20	1.45
2N5680	PNP/PWR	3.00	2.00
2N3054	NPN/PWR	1.20	.80
2N3441	NPN/PWR	2.70	1.80
2N4231	NPN/PWR	2.10	1.20
2N4232	NPN/PWR	2.40	1.60
2N4233	NPN/PWR	3.15	2.10
2N4910	NPN/PWR	1.55	1.05
2N4911	NPN/PWR	1.80	1.20
2N4912	NPN/PWR	2.10	1.40
2N3740	PNP/PWR	2.70	1.80
2N4898	PNP/PWR	1.95	1.30
2N4899	PNP/PWR	2.60	1.75
2N4900	PNP/PWR	2.70	1.95
2N3055	NPN/PWR	1.80	1.20
2N3232	NPN/PWR	2.00	1.35
2N3713	NPN/PWR	4.40	2.95
2W3714	NPN/PWR	4.70	3.15
2N3715	NPN/PWR	4.85	3.25
2N3716	PNP/PWR	6.75	4.50
2N4913	NPN/PWR	2.40	1.60
2N4914	NPN/PWR	2.60	1.75
2N4915	NPN/PWR	4.20	2.80
2N5067	NPN/PWR	1.80	1.20
2N5068	NPN/PWR	2.25	1.50
2N5069	NPN/PWR	2.85	1.90
2N3789	PNP/PWR	7.50	5.00
2N3790	PNP/PWR	8.90	5.95
2N3791	PNP/PWR	8.75	5.85
2N3792	PNP/PWR	9.50	6.35

SINCERE Val-U!

RF-IF AMPS—PLASTIC

DEVICE	TYPE	1-99	100-999	1000-4999	5K
SE3001	RF-NPN	.75	.50		
SE3002	RF-NPN	.75	.50		
SE5001	RF/AGC-NPN	1.40	.95		
SE5002	RF/AGC-NPN	1.40	.95		
SE5003	RF/AGC-NPN	1.50	1.03		
SE5006	RF/AGC-NPN	1.05	.70		
2N3563	RF-NPN	.45	.30	.27	.26
2N3688	RF/AGC-NPN	.45	.30	.27	.26
2N3690	RF/AGC-NPN	.52	.35	.32	.31
SE5025	IF-NPN	.85	.58		
2N3691	IF-NPN	.40	.27	.23	.22
2N3692	IF-NPN	.42	.28	.26	.24
2N3693	AM/FM-NPN	.45	.30	.27	.26
2N3694	AM/FM-NPN	.45	.30	.27	.26
2N4121	RF-PNP	.57	.38	.34	.32
2N4122	RF-PNP	.62	.41	.37	.35
2N3689	RF/AGC-NPN	.45	.30	.27	.26

SWITCH

TO OUR HIGH SPEED SWITCHES—PLASTIC

DEVICE	TYPE	1-99	100-999	1000-4999	5K
2N3639	PNP/HS SW	.38	.25	.23	.22
2N3640	PNP/HS SW	.45	.30	.27	.26
2N3646	NPN/HS SW	.53	.36	.32	.30
SE3646	NPN/HS SAT SW	.30	.20	.16	.14
2N4257	PNP/HS SW	.40	.26	.23	.22
2N4257A	PNP/SW	.50	.34	.30	.28
2N4258	PNP/HS SW	.53	.36	.32	.30
2N4258A	PNP/SW	.60	.40	.36	.34
2N4274	NPN/HS SW	.38	.25	.23	.22
2N4275	NPN/HS SW	.40	.26	.23	.22

Zeners GALORE!

DEVICE	1-99	100-999	1000-9999	10K
250 mW 2.6-200 Volts (88 types)				
IN702-745	.80	.60	.35	.32
IN702A-745A	.90	.67	.40	.36
400 mW 3.3-200 Volts (136 types)				
IN746-759	.80	.60	.35	.32
IN746A-759A	.90	.67	.40	.36
IN957-985	.80	.60	.35	.32
IN957A-985A	.85	.64	.37	.34
IN957B-985B	.90	.67	.40	.36
IN986-992	1.75	1.30	.90	.76
IN986A-992A	2.10	1.40	1.00	.75
IN986B-992B	2.40	1.80	1.25	1.05
500 mW 2.4-200 Volts (183 types)				
IN5221-5264	.53	.40	.28	.24
IN5265	.53	.40	.28	.24
IN5266	.53	.40	.28	.24
IN5267	.53	.40	.28	.24
IN5268	.53	.40	.28	.24
IN5269	.53	.40	.28	.24
IN5270	.53	.40	.28	.24
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IN5268A	.66	.50	.35	.30
IN5269A	.66	.50	.35	.30
IN5270A	.66	.50	.35	.30
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IN5226B	.82	.62	.43	.36
IN5267B	.82	.62	.43	.36
IN5268B	.82	.62	.43	.36
IN5269B	.82	.62	.43	.36
IN5270B	.82	.62	.43	.36
IN5271	.66	.50	.35	.30
IN5272	.66	.50	.35	.30
IN5273	.66	.50	.35	.30
IN5274	.66	.50	.35	.30
IN5275	.66	.50	.35	.30
IN5276	.66	.50	.35	.30
IN5277	.66	.50	.35	.30
IN5278	.66	.50	.35	.30
IN5279	.66	.50	.35	.30
IN5280	.66	.50	.35	.30
IN5281	.66	.50	.35	.30
IN5271A 5272A	.87	.65	.45	.38
IN5273A	.87	.65	.45	.38
IN5274A	.87	.65	.45	.38
IN5275A	.87	.65	.45	.38
IN5276A	.87	.65	.45	.38
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IN5279A	.87	.65	.45	.38
IN5280A	.87	.65	.45	.38
IN5281A	.87	.65	.45	.38
IN5271B	1.10	.85	.60	.51
IN5272B	1.10	.85	.60	.51
IN5273B	1.10	.85	.60	.51
IN5274B	1.10	.85	.60	.51
IN5275B	1.10	.85	.60	.51
IN5276B	1.10	.85	.60	.51
IN5277B	1.10	.85	.60	.51
IN5278B	1.10	.85	.60	.51
IN5279B	1.10	.85	.60	.51
IN5280B	1.10	.85	.60	.51
IN5281B	1.10	.85	.60	.51

Continued on next column

SINCERE TRANSISTOR & DIODE Co

CONTINUES ON NEXT PAGE

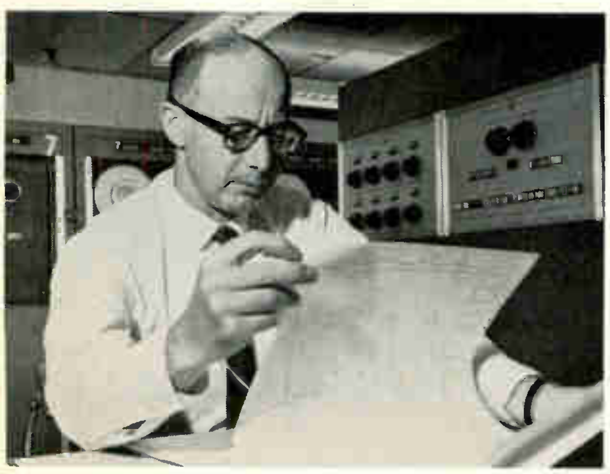
Who's Who in this issue

Brown

The career trajectory of W. L. Brown, author of the article that starts on page 94, has spanned nuclear research, missiles, and academe. Now a professor in the Electrical Engineering Department at San Diego State College, Brown has worked on isotope separation at Oak Ridge, on the Bomarc missile at Boeing, and on the Atlas ICBM at General Dynamics.

Scott Boleky Burns Meyer

Leading the discussion of the article on silicon-on-sapphire memories that begins on page 82 is one of its authors, Joseph R. Burns, who holds a Ph.D. from Rutgers, and who's with RCA's David Sarnoff Research Laboratories, where he's concentrating on semiconductor memories. The other authors, all with RCA Labs, are Joseph H. Scott, a Lincoln University graduate, who works on integrated circuit technology; Edward J. Boleky, an MSE graduate of Princeton, who specializes in digital IC's, and John E. Meyer, who holds an MSEE degree from the University of Pennsylvania, and who has been engaged in research on silicon and thin-film integrated circuit technology.



Greenbaum

Computer-aided design, the subject of the article that begins on page 90, is the latest locus for the efforts of J. R. Greenbaum, its author. A radar instructor for the Air Force during World War II, Greenbaum, who holds an MSEE from Stevens Institute of Technology, joined General Electric in 1955. His first assignments were in nuclear reactor instrumentation, but he's been involved in CAD for the past few years.

Stifle Johnson

If its namesake, the great Greek teacher, were here today, he might wish he could have used Plato, the educational modem described in the article that begins on page 99. The authors, Jack Stifle and Mike Johnson, are with the University of Illinois' Coordinated Science Laboratory. Stifle has been designing digital systems, crt displays, and data communications gear. Johnson has been doing development work on the Plato system.

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When You Are Faced With A Tough Design Problem
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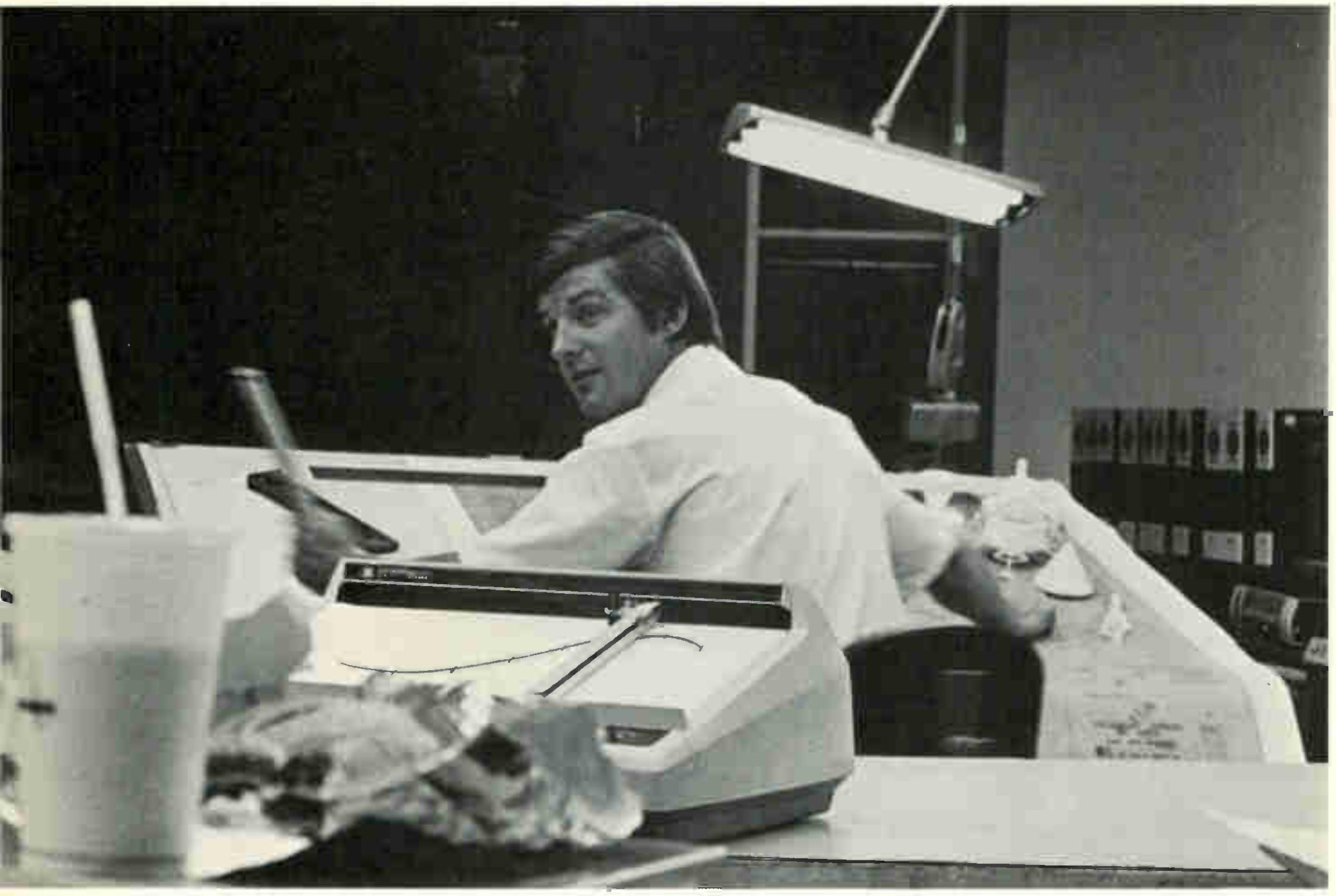

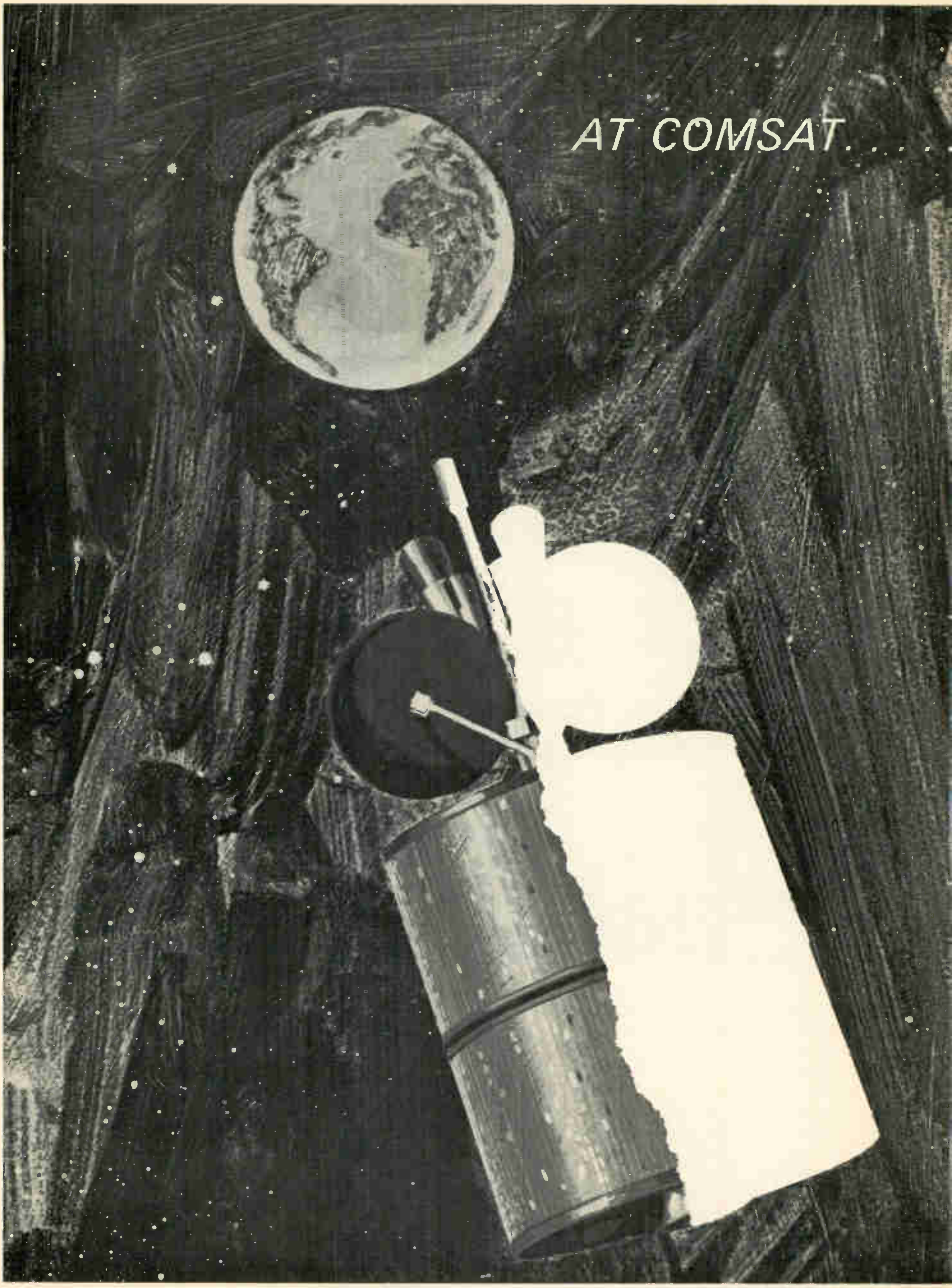
AT COMSAT. . . .

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When COMSAT elected to develop its Time-Division Communications System using digital techniques, it was immediately obvious that system capacity would be limited by circuit speed. That's why they chose Motorola MECL integrated circuits for the job.

COMSAT Laboratories, with the support of INTELSAT, developed an advanced, 700-channel, Time Division Multiple Access system capable of processing and transmitting information to the satellite at a 50 megabit rate. Motorola's Applications Engineering department helped with engineering assistance and the kind of technical information that could be provided only by the people who pioneered high-speed, emitter-coupled logic.

Using high-speed gates, flip-flops and complex functions from Motorola's MECL II line, COMSAT was able to develop general purpose digital logic cards that are actually capable of handling rates of 70 megabits.

More importantly, COMSAT found that these same techniques can be used for 150 megabit units — and there is consideration for logic in the 200 to 500 megabit range.

New, Motorola MECL III circuits can easily handle speeds up to the 300 megabit level, using gates with 1.0 nS propagation delay and flip-flops with toggle/shift frequencies on the order of 350 MHz.

MECL IV circuits, now in development, will yield 500 MHz flip-flops and 900 picosecond gates — thus providing for even higher-capacity communication systems. Other systems such as radar signal processing, audio and video bandwidth compression, digital adaptive reception and digital filtering will also benefit from this advanced line of high-speed integrated circuits.

And, the speed and versatility of high-speed MECL is not limited to digital communication uses. Coming soon are fourth generation computers, ultra-high-speed instrumentation, and a variety of advanced avionics gear — all designed around Motorola MECL circuits.

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MECL III	1.0 nS	350 MHz	16	55 mW
MECL IV	0.9 nS	500 MHz	—	20 mW

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MOTOROLA MECL

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Circle 13 on reader service card

Who's Who in electronics

Collins

"I've been challenged a number of times, but I've never been refused money for programs," says Jeffrey H. Collins, the 40-year-old outgoing director of the physical sciences department in the North American Rockwell Corp.'s Autonetics Research and Technology division. "I'm not leaving Autonetics over any grievance."

Collins, an authority on surface wave acoustic devices, [*Electronics,* Jan. 19, p. 110] will be an Autonetics consultant in that area and in microwave ferromagnetic device work after he becomes research professor of electrical engineering at the University of Edinburgh in Scotland. He was with the electrical engineering department at the University of Glasgow for 10 years before coming to the U.S. "I simply want to get back home," Collins says.

Born near London and educated at the University of London (bachelor's degree in physics and master's in mathematics), Collins faces a new challenge at Edinburgh because he's going to establish an electronics research institute for the East of Scotland electronics industry on behalf of the Scottish Council for Industry. The effort will be partially supported at the outset by the British Science Research Council.

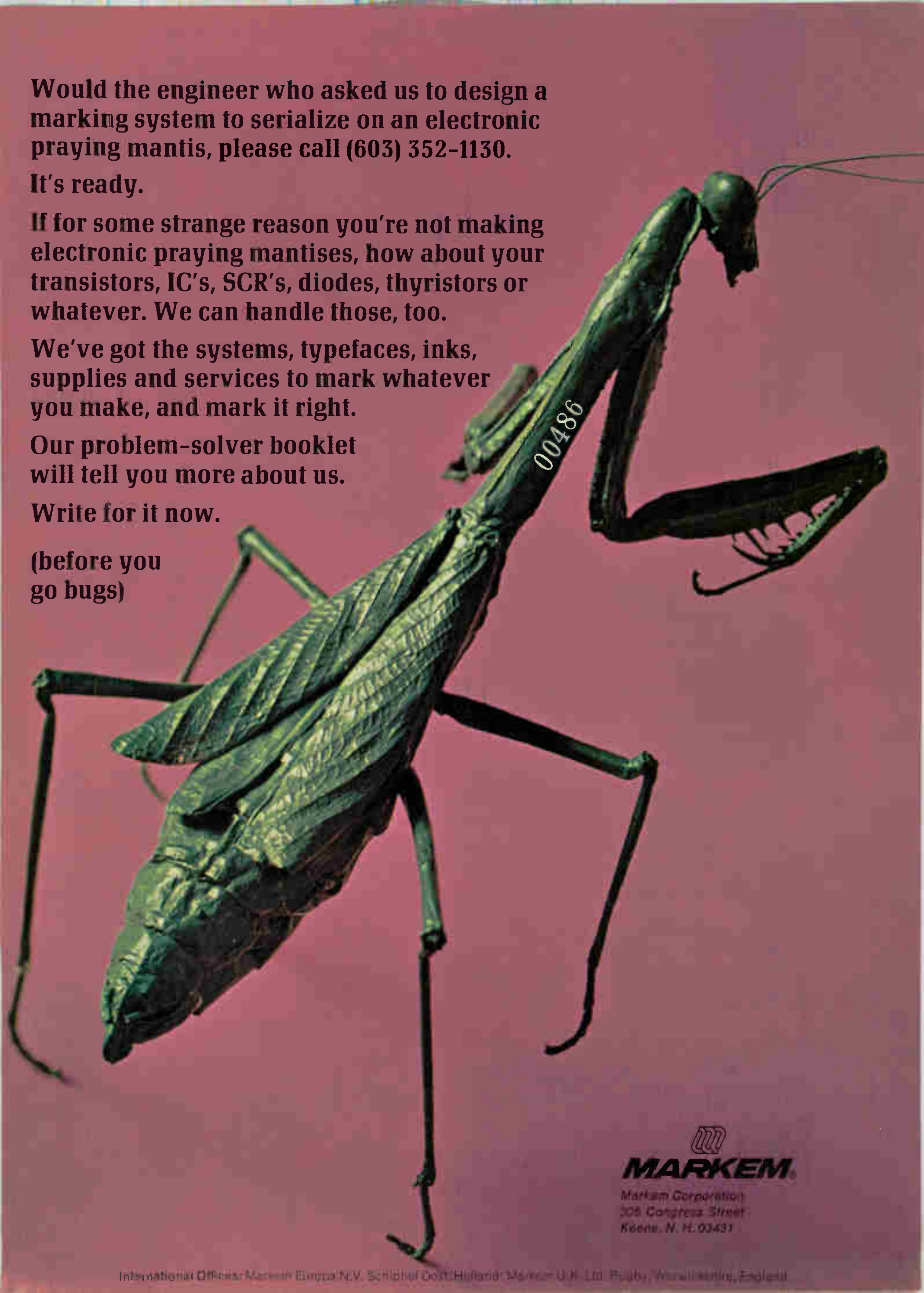
Maxi job. As Collins puts it, "We'll be trying to form a mini-Stanford Research Institute in a mini-Palo Alto. That's what the East of Scotland is. There's a lot of engineering and production, but they need high-level R&D in components and devices."

Reflecting on his Autonetics tenure, Collins says that the physical sciences department has moved out of a difficult position that existed when he came aboard two years ago, and the contractual backlog is now three times greater than it was then. With a chuckle, he observes, "It's better to go while it's good, not with your tail between your legs."

And how will the technologies with which he's been associated fare after Collins leaves early this month? Probably rather well, he thinks. His successor as head of the department, George Pulliam, has been the specialist in materials required for the exotic technologies in the department. While he isn't the device authority Collins is, Pulliam's materials processing knowhow will be augmented by the theoretical device knowledge of a solid state research group that Collins established at North American Rockwell's Science Center during the last 18 months.

"I look forward to working at Itek because it's just the right size and age; big enough to have large resources but young enough to be hopeful about translating ideas into action," says Henry R. Lewis, 45, recently appointed vice president for research and development at the Itek Corp. in Lexington, Mass. "R&D is more exciting in a company interested in moving into new areas."

Itek plans to deemphasize sales to the military, which last year accounted for about 64% of its $153.2 million in sales. By the end of this year two-thirds of its income and half its sales (which should equal last year's) should come from commercial products. Lewis, in his newly created post, would seem to be just the person to turn R&D efforts towards commercial goals. He comes from RCA, where he directed the materials research laboratory and the program for applying holography to prerecorded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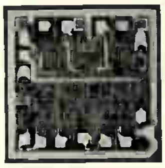


Lewis

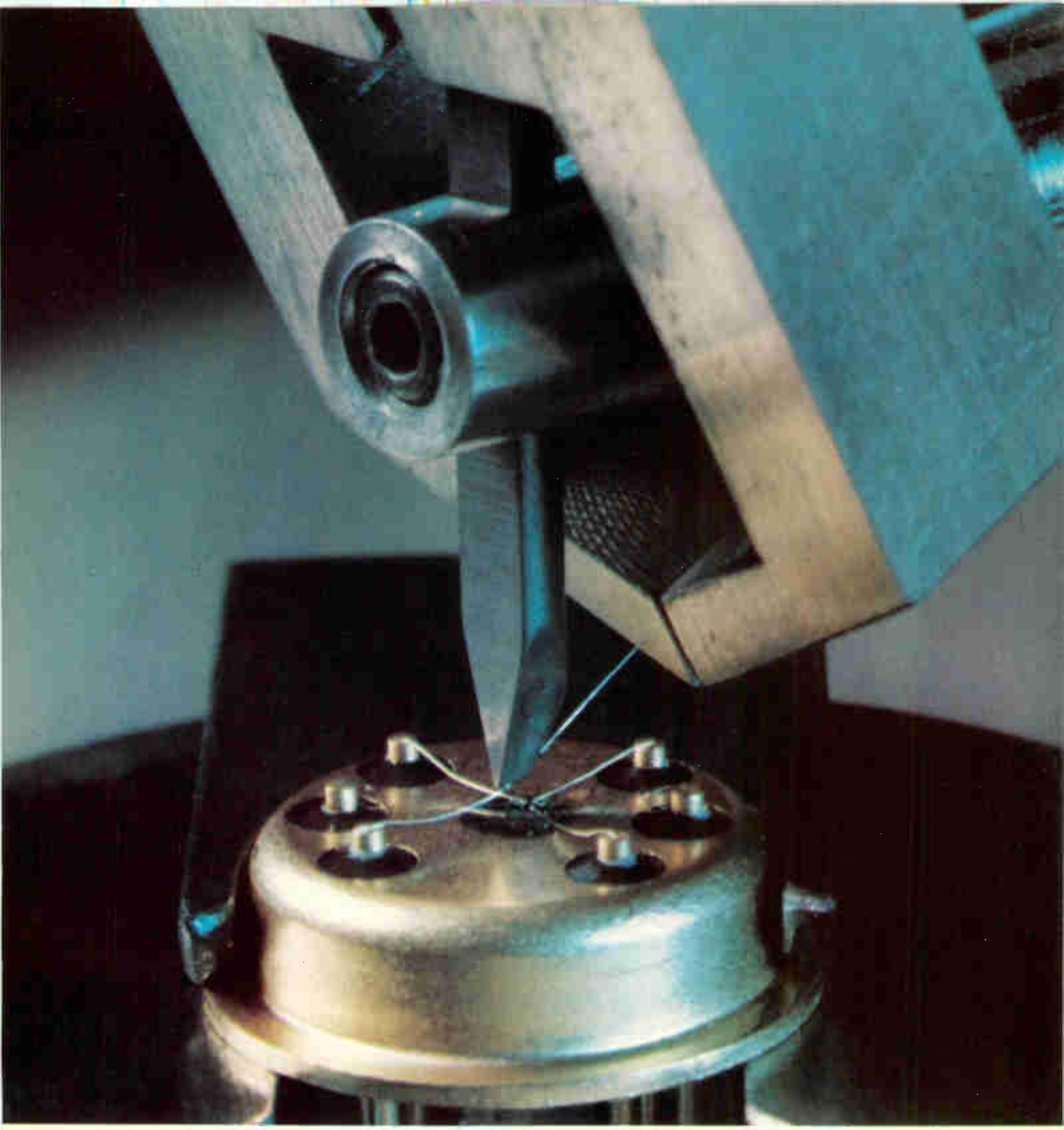
video for home use—to be marketed as SelectaVision [*Electronics*, Oct. 13, 1969, p. 43].

While Lewis claims he's been so busy since joining Itek he hasn't had a chance to sit down and think, there are several broad areas he would like to work on. "Program regulation and image processing, and, in general, learning how to handle and access large amounts of stored material, is one of the large problems technology has to solve now."

Ganging up. More immediately, Lewis would like to see Itek's capabilities in optics, electronics, and materials "put together in the laboratory to a larger extent. These capabilities have been separately applied to separate divisions." He also thinks optics should have a larger impact on Itek.

Lewis also sees possibilities in computer control of machinery, and Itek has formed a joint venture with the Kingsbury Machine Tool Corp. of Keene, N. H., called he Itek-Kingsbury Co., to develop computer controls. "We have a capability for computer programing with our mathematical background," Lewis says, "and we make sensors and circuits involved in making the interface to machinery."

Another new product area which appears promising is titanium dioxide, a photosensitive material developed by Itek's Lexington Research Laboratory, which reverts to its blank state shortly after exposure—like reusable film. Lewis sees applications in graphics.



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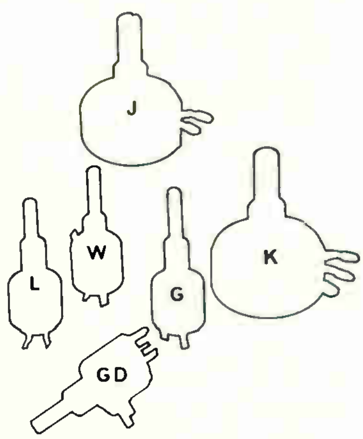
SPECIFICATIONS

	TYPE J—STYLE RV4	TYPE K	TYPE G—STYLE RV6	TYPE L	TYPE W	TYPE GD
CASE DIMENSIONS	5/8" deep x 1-5/32" dia. (single section)	5/8" deep x 1-5/32" dia. (single section)	15/32" deep x 1/2" dia.	15/32" deep x 1/2" dia.	15/32" deep x 1/2" dia.	35/64" deep x 1/2" dia.
POWER at + 70°C	2.25 W	3 W	0.5 W	0.8 W	0.5 W	0.5 W
TEMPERATURE RANGE	−55°C to +120°C	−55°C to +150°C	−55°C to +120°C	−55°C to +150°C	−55°C to +120°C	−55°C to +120°C
RESISTANCE RANGE (Tolerances: ±10 and 20%)	50 ohms to 5.0 megs	50 ohms to 5.0 megs	100 ohms to 5.0 megs	100 ohms to 5.0 megs	100 ohms to 5.0 megs	100 ohms to 5.0 megs
TAPERS	Linear (U), Modified Linear (S), Clockwise Modified Log (A), Counter-Clockwise Modified Log (B), Clockwise Exact Log (DB). (Special tapers available from factory)					
FEATURES (Many electrical and mechanical options available from factory)	Single, dual, and triple versions available. Long rotational life. Ideal for attenuator applications. Snap switches can be attached to single and dual.	Single, dual, and triple versions available. Long rotational life.	Miniature size. Immersion-proof. SPST switch can be attached.	Miniature size. Immersion-proof.	Commercial version of type G. Immersion-proof.	DUAL section version of type G. Ideal for attenuator applications. Immersion-proof.

ALLEN-BRADLEY



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Meetings

Wescon goes a little soft

"The times they are a-changin'," goes the song—and that's how it's going in the program for this year's Western Electronic Show and Convention (Wescon), to be held Aug. 25 through 28 in Los Angeles.

For the first time, a significant portion of the technical program—seven of 27 sessions—will be devoted to minicomputers, computer software, time-sharing, and other aspects of the computer business. The shift reflects the increased importance of computer software and peripherals in the electronics industry, as well as the decision by the Western Electronics Manufacturers Association, one of the show's sponsors, to admit software companies.

Numbers games. The first two computer-oriented sessions, on Aug. 25, will include "Managing the Development of Large Software Systems," and "Evaluation of Proprietary Software." On Aug. 26, sessions on "Minicomputers in Process Industries," and "Hands-on Programable Calculators" will be presented. The next-to-last day, Aug. 27, will be devoted to "Evaluation of Time-Sharing Services," and "The Impact of Interactive Computing Systems on Engineering Problem Solving." The final session on Aug. 28 will cover "Computer-Aided Design Capability of Digital Logic Blocks" and will include papers on computer-aided circuit design, functional testing, printed circuit-board design and testing, and computer-aided LSI design.

Current trends in microwave technology are to be represented. Here sessions will cover "Millimeter Systems, Devices and Guides," and "Solutions to Problems of Low-Noise Amplification at Microwave Frequencies." The former will feature an overview of millimeter-wave systems, a description of a digital transmission system using a circular electric mode waveguide, rectangular dielectric image lines for IC's, and millimeter-wave Impatt power sources. The latter session will discuss recent advances in low-noise transistor amplifiers, new developments in low-noise traveling-wave-tube amplifiers, recent advances in mixers and tunnel diode amplifiers, parametric up-converters in receiving systems, and components for use in high-performance wideband receivers.

A substantial part of the program, five sessions, will cover management and marketing subjects, such as electronic instrumentation distribution trends, the IC overseas, product planning, advances in commercial avionics, and management control systems.

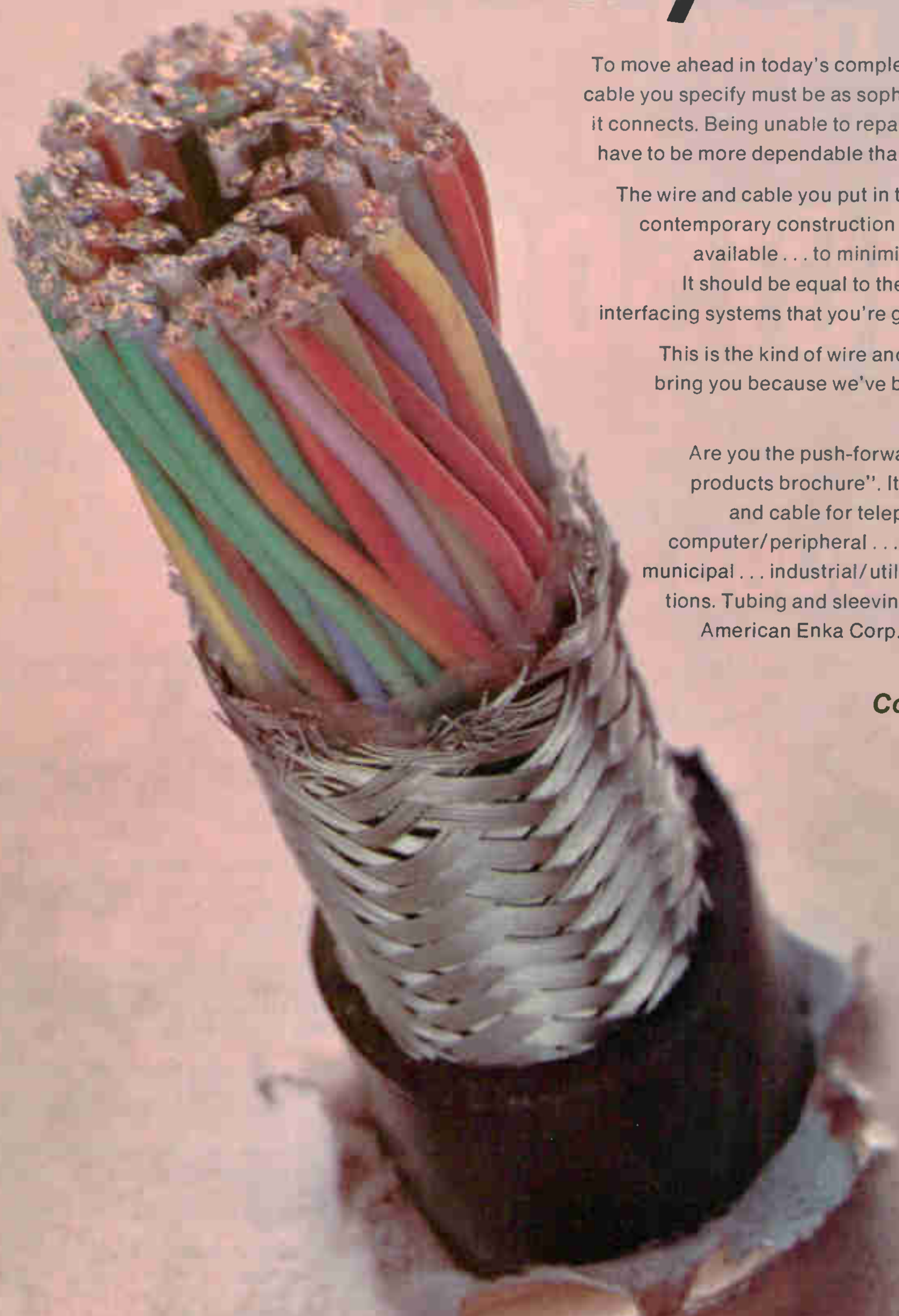
Power to the problem. Another departure this year will be a two-day, four-session symposium on "applying technology to public problems." For several years the Wescon symposium has zeroed in on electronics packaging. Show officials say the change reflects both the current national interest in solving urban environmental problems and increased industry attention to applying technology to new potential business areas. Speakers at the keynote meeting in the Los Angeles Hilton Hotel on Aug. 26 will be C. Lester Hogan, president of Fairchild Camera and Instrument; Max Palevsky, Xerox Data Systems; and Prof. Burton H. Klein of the California Institute of Technology. The subject of the keynote session will be "Problems and Opportunties in the Real World."

The second session will consider "technology and the mobile population," with participation by James M. Beggs, Under Secretary of Transportation; John C. Beckett, government relations manager, Hewlett-Packard; and Albert Hibbs, transportation applications manager, Jet Propulsion Laboratory.

Problems in information utilization will be discussed in a "Technology and Information Exchange" by Peter C. Goldmark, director of CBS Laboratories; John R. Pierce, Bell Telephone Laboratories; Paul

(Continued on p. 24)

The cable that won't hold you back



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Meetings

(Continued from p. 22)

Visher, Hughes Space Systems division; and Daniel E. Noble, vice chairman, Motorola Inc.

In the final session on Aug. 27, "Technology and the Urban Society" will be explored by Floyd L. Goss, chief engineer and assistant manager, Los Angeles Department of Water and Power; Charles Miller, director, Draper Laboratories; Phillip Berry, president of the Sierra Club, and Frank Dimster, director of urban design for William L. Pereira and Associates.

Computer and data processing portions of the technical program will be held at Hollywood Park, and the remainder of the technical sessions at the Museum of Science and Industry. The symposium meetings will be at the Los Angeles Hilton.

For further information contact: Ernest W. Pappenfus, Wescon, 3600 Wilshire Blvd., Los Angeles, Calif. 90005

Calendar

Photovoltaic Specialists Conference, IEEE; Seattle Center, Washington, **Aug. 11-13.**

International Conference on Microelectronics, Circuits, and Systems Theory, IEEE; University of New South Wales, Kensington, Sydney, Australia, **Aug. 18-21.**

AFMA National Conference, Armed Forces Management Association; International Hotel, Los Angeles, **Aug. 20-21.**

Radiation Effects in Semiconductors, Air Force Cambridge Research Labs; State University of New York at Albany, **Aug. 24-26.**

Western Electronic Show and Convention (WESCON), IEEE; Biltmore Hotel, Sports Arena, Los Angeles, **Aug. 25-28.**

Preparation and Properties of Electronic and Magnetic Materials for Computers, the Metallurgical Society, Statler-Hilton Hotel, New York, **Aug. 30-Sept. 2.**

Application of Computers to the Problem of Urban Society, Association for Computing Machinery; New York Hilton Hotel, **Aug. 31.**

(Continued on p. 26)

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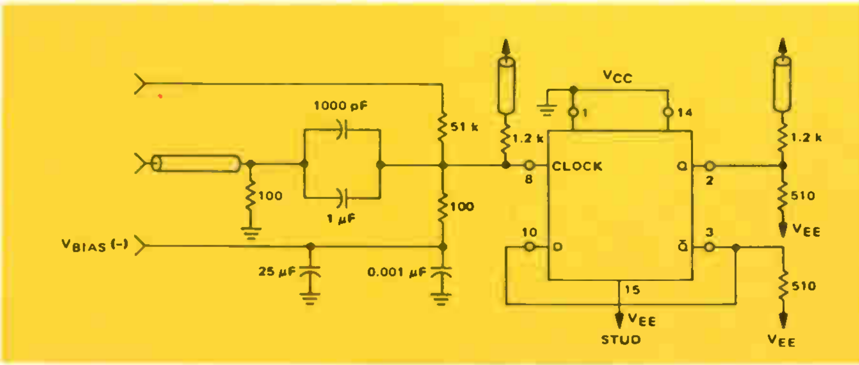

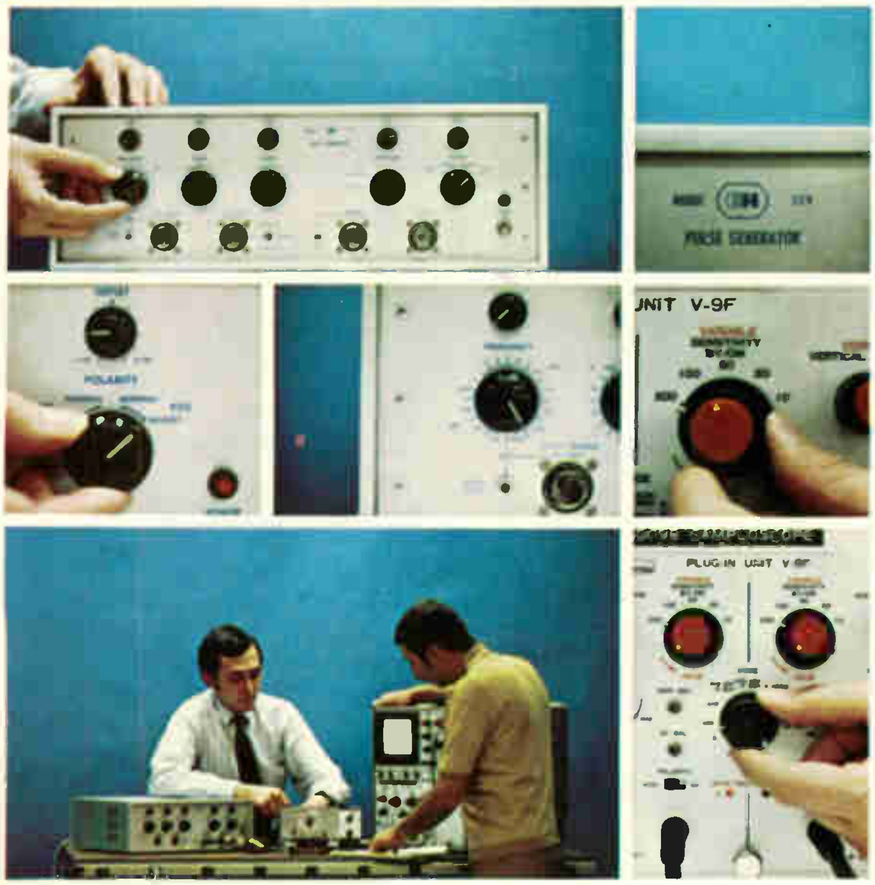

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Meetings

(Continued from p. 24)

AICA-IFIP Conference on Hybrid Computation, IEEE; Technical University, Munich, Germany, Aug. 31-Sept. 4.

Association for Computing Machinery Conference, New York Hilton Hotel, Sept. 1-3.

International Electrical and Electronics Engineering Conference, Korea Institute of Electrical Engineers, Korea Institute of Electronics Engineers, Korea Institute of Science and Technology, IEEE; Korea Institute of Science and Technology, Seoul, Sept. 2-4.

Conference on Microwave and Optical Generation & Amplification, IEEE; Amsterdam, the Netherlands, Sept. 7-11.

International Broadcasting Convention, IEEE; Grosvenor House, Park Lane, London, Sept. 7-11.

Petroleum & Chemical Industry Technical Conference, IEEE; Camelot Inn, Tulsa, Okla., Sept. 14-16.

Annual Technical Symposium, Society of Photo-optical Instrumentation Engineers; Anaheim Convention Center, Calif., Sept. 14-17.

International IEEE/G-AP Symposium and Fall USNC/URSI Meeting, Ohio State University, Columbus, Sept. 14-17.

Conference on Gas Discharges, IEEE; London, Sept. 15-18.

Intersociety Energy Conversion Engineering Conference, IEEE; Frontier Hotel, Las Vegas, Sept. 20-25.

Conference on Engineering in the Ocean Environment, IEEE; City Marina Auditorium, Panama City, Fla., Sept. 21-24.

Conference on Electron Device Techniques, IEEE; United Engineering Center Auditorium, New York, Sept. 23-24.

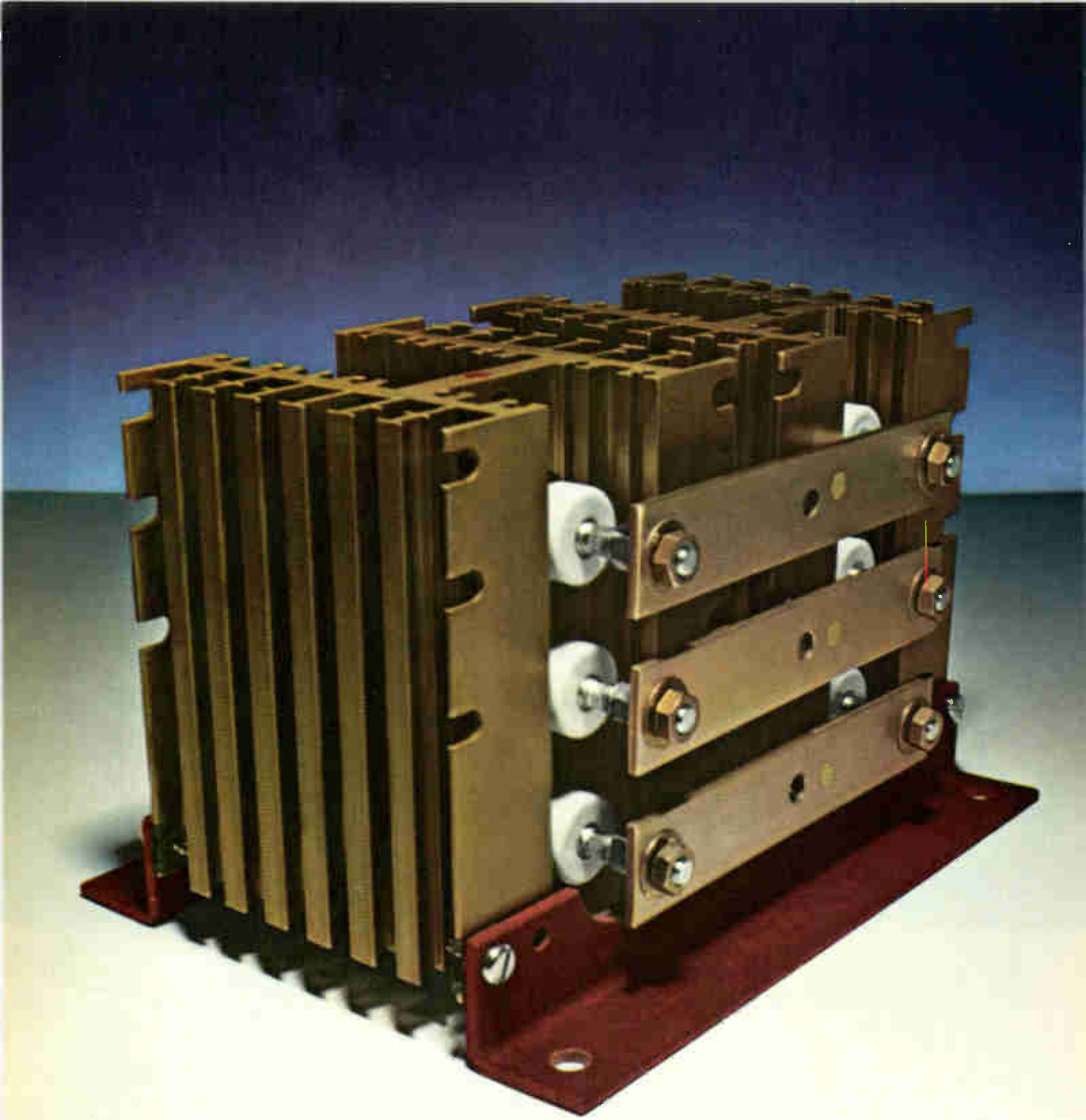
Fall Broadcast Technical Symposium, IEEE, Washington Hilton, Sept. 23-26.

Joint Power Generation Technical Conference, IEEE; Pittsburgh Hilton Hotel, Sept. 27-30.

Conference on Underground Distribution, IEEE; Hotel Pontchartrain and Cobo Hall, Detroit, Sept. 27-30.

Conference on Trunk Telecommun-

(Continued on p. 29)



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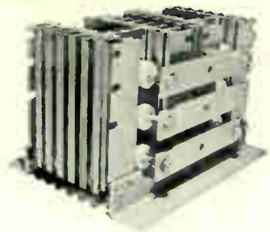

Meetings

(Continued from p. 26)

ications by Guided Waves, IEE; Savoy Place, London, W.C. 2, **Sept. 29-Oct. 2.**

Mervin J. Kelly Communications Conference, University of Missouri and IEEE; Rolla, Mo., **Oct. 5-7.**

Symposium on Feature Extraction and Selection in Pattern Recognition, IEEE; Argonne National Laboratory, Argonne, Ill., **Oct. 5-7.**

Industry & General Applications Group Annual Meeting, IEEE; La Salle Hotel, Chicago, **Oct. 5-8.**

Short courses

Real-Time On-Line Computer Control, University of Wisconsin; University Extension, **Aug. 3-7;** $300 fee.

Development of Real-Time Computer Systems, University of California at Los Angeles; Boelter Hall, Room 4442, **Aug. 3-14;** $420 fee.

Microwave Semiconductor Devices and Circuits, University of Michigan; Crysler Center, Ann Arbor, **Aug. 3-14;** $350 fee.

Simulation Techniques for Mechanical Systems, University of Michigan; Chrysler Center, Ann Arbor, **Aug. 3-14;** $400 fee.

Digital Space Communications, University of Southern California; School of Engineering, Department of Electrical Engineering and University College, Vivian Hall of Engineering, **Aug. 3-14;** $375 fee.

Display Systems Engineering, University of California at Los Angeles; Mathematical Sciences Building, Room 5200, **Aug. 10-14;** $310 fee.

Call for papers

Mexico International Conference on Systems, Networks, and Computers, IEEE; Oaxtepec, Mexico, Jan. 19-21, 1971. **Aug. 31** is deadline for submission of abstracts to Dr. Roberto Canales R., Instituto de Ingenieria, Ciudad Universitaria, Mexico 20, D.F.

International Federation of Automatic Control Symposium on Multivariable Control Systems, Duesseldorf, Germany, Oct. 11-13, 1971. **Oct. 31** is deadline for submission of abstracts to VDI/VDE—Fachgruppe Regelungstechaik, P.O. Box 1139, D-4000 Duesseldorf 1, Germany.

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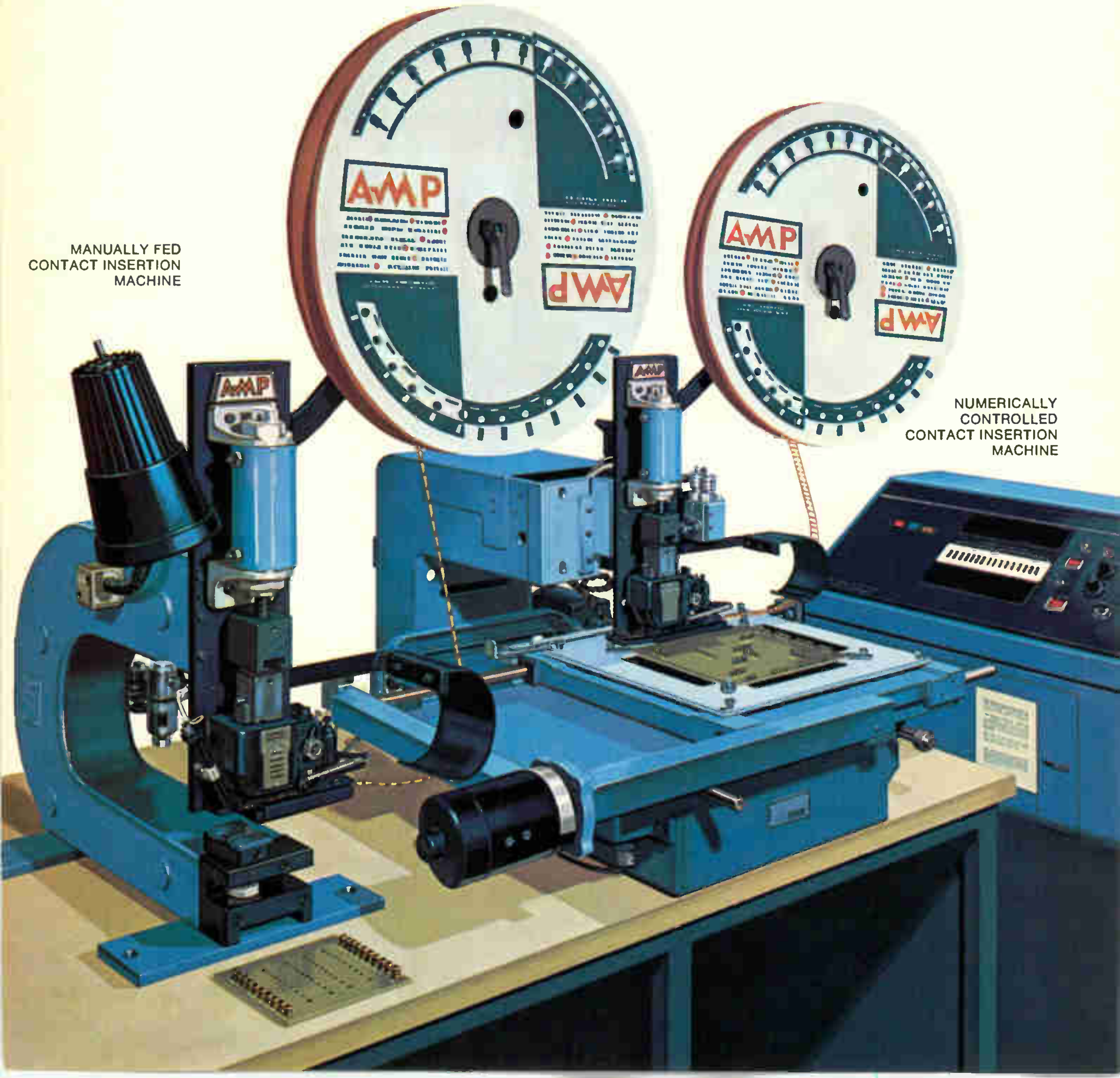

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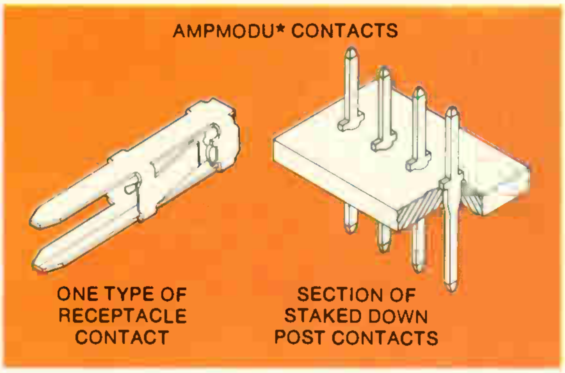

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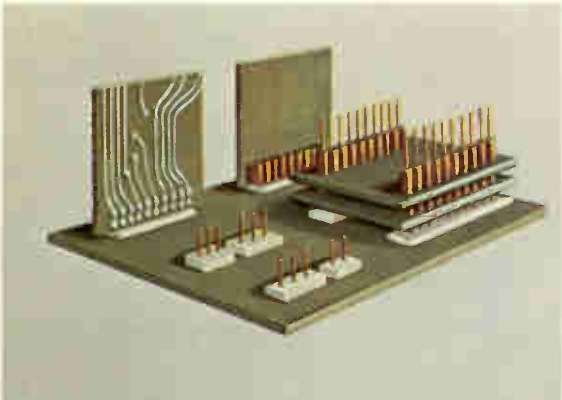

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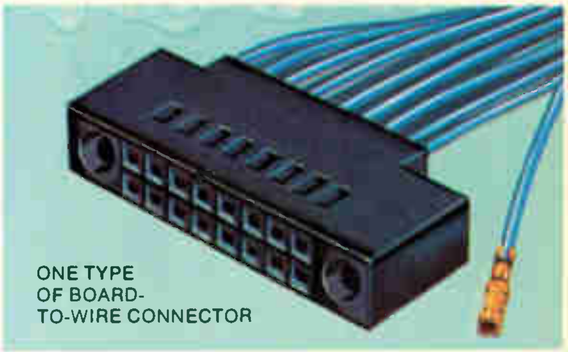
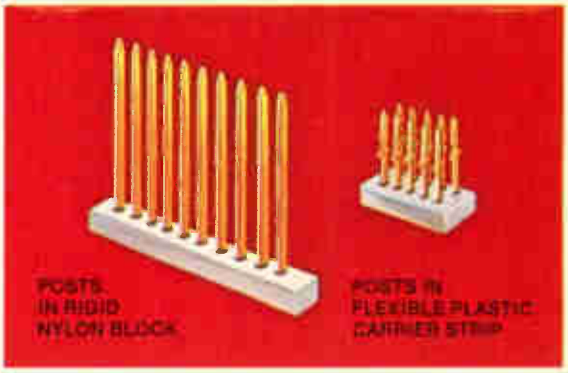
◀ **Versatile, high-speed tooling**
You can stake these receptacles automatically at speeds up to 4000 per hour. Machines can be provided for application as fast as the operator can position the board, or for complete numerical control.



For board-to-wire interconnection
And these receptacles aren't limited to being stuck to boards. Some can be crimped to wires and housed in connector blocks. Others can be crimped to coaxial wires. And there's even a version that can be terminated to flat cable. All of this can be done by automatic machines.



For machine-wireable interconnection
The mating posts come in two versions: .031 x .062 and .025 x .025 in a variety of lengths. These can be furnished in a nylon block or in strip form to be inserted at random locations. The other end of the posts is available for wrap-type or our own unique TERMI-POINT★ automatic point-to-point clip wiring method.

That's our system—posts and receptacles that you can arrange virtually any way you want, and a complete line of application tooling to apply as many as you want. This precision relationship between tooling and contacts is the way we consistently lower your applied costs. We call it Economation.

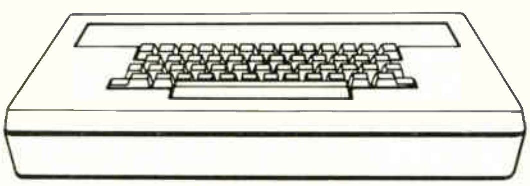
Find out more about the AMPMODU interconnection system and its application tooling. Write to **Industrial Division, AMP Incorporated, Harrisburg, Pa. 17105.**

AMP
INCORPORATED

Circle 31 on reader service card

We've formed a small movement to eliminate keyboard downtime.

The only moving mechanical parts of our new keyboard are the plungers. And they barely travel 3/16 of an inch.



Everything else is all solid state. So there's no need for mechanical linkages, electromechanical parts, contacts or any of the moving parts that normally wear out and result in expensive downtime.

The reliability of our all solid state keyboards will play an important role in helping you beat the economics of downtime. Especially during critical operating periods.

But if you ever do need application assistance, experienced MICRO SWITCH field engineers are standing by to provide the back-up help you'll need to solve your individual problems.

MICRO SWITCH can supply all standard and custom key arrays. Each with the same touch and spacing as a regular keyboard.

Let's get together and discuss keyboard reliability or any other part of the business you consider important. Dollars. Technology. Compatibility. Delivery. They're all important to us. Call or write us and see.

MICRO SWITCH

FREEPORT, ILLINOIS 61032

A DIVISION OF HONEYWELL

Electronics Newsletter

July 20, 1970

TI said to lay off 5,000 from payroll

Texas Instruments apparently has joined the burgeoning list of big companies forced by sagging sales to furlough a large chunk of its work force. One story racing around Dallas is that TI has axed 5,000 out of a total of 30,000, and that the number includes salaried personnel as well as production workers. TI would say only that there has been "some rebalancing of workloads through reassignment."

At the same time, TI officials were making plans for a big splash at the Fall Joint Computer Conference in Houston, Nov. 17-19. The firm will have 1,200 square feet of exhibit area—its most ever—leading to speculation that TI might be ready to take the wraps off the big, general-purpose machine it plans [*Electronics,* Feb. 2, p. 34].

Signetics looks to linears for boost . . .

As the recession deepens, some semiconductor houses lay off workers, others cut prices, and still others look for new product lines. Among the latter is Signetics, primarily a digital house with only about 10% of its business in linears. But with the expected introduction of 12 linear IC's next month (five proprietary and seven second-source) the company hopes to change is ratio to 50-50. The reason, according to one Signetics spokesman, is that TTL's are beginning to sell for less than they cost to make, "so to make some money we're turning to linears."

. . . as Fairchild slashes its op amp prices

The op amp price battle is on. Though demand for linear IC's has held up in a generally soft semiconductor market, Fairchild is knocking 50% to 66% off 100-lot prices on most of its popular linears—the 741, 748, and 749 op amps, and the 723 voltage regulator.

As one Fairchild spokesman put it, "we are going to be the price leader in linears, and we can do it now that our new, automated facility is on-line."

Navy's advice: hold off on LSI metalization

Navy program managers are advising IC manufacturers to hold off on research into the processing of large scale integrated circuits until the full details of a promising new metalization technique are divulged. The technique, developed by Texas Instruments under a contract from the Navy's Advanced Airborne Digital Computer Program, is said to eliminate pinholes and cracks in oxide layers—a common cause of failure in LSI arrays. In the technique, wafers are metalized with aluminum. The wiring patterns are then protected with a photoresist, and the non-protected portions of the aluminum are anodized, thus becoming insulating layers.

Blood-pressure gage arrives from space

Companies are continuing to apply space-program experience to medical electronics. SCI Electronics of Houston, which cut its teeth on biomedical instrumentation for the manned space program, will announce a new medical instrument line this fall. A key unit will be a blood-pressure monitor for hospital intensive-care wards that uses the old technique of pumping up a cuff around the arm and listening for the point at which the pressure stops the blood flow.

However, the monitor's operation is based on a phenomenon in the blood-pressure waveform that SCI says it has discovered only recently. The waveform is sensed by a piezoelectric microphone, analyzed, and converted to a binary-coded decimal format for both diastolic and systolic pressures. The data can be used to drive a display or can be fed to a patient-monitoring computer. SCI says its system can replace surgically inserted catheters or the recently developed ultrasonic pressure-measuring devices [*Electronics*, Dec. 8, 1969, p. 43].

Microwave CAD program unveiled

Amcap, a computer program that could make complex microwave circuits easier to design than with ECAP's approach to lower-frequency devices, has been developed by Environmental Computing of Lowell, Mass. Earlier microwave computer aids have been limited to design of simple circuits; a coupler has too many parts for most other programs. By contrast, Amcap can help design and analyze devices with more than six ports and 100 active or passive circuit elements—even more if memory beyond the minimum 18,432 words of core is available.

Amcap works from audio frequencies through the millimeter-wave region. Also, instead of printing out its analytical data in so-called node voltage, Amcap prints out performance data in terms readily used by microwave engineers: insertion loss, standing wave ratio, impedance, and others up to a total of 20. Finally, Amcap can simulate operational inputs, allowing an engineer to optimize a circuit without leaving his teletype console.

Computer features varied logic blocks

A line of computers with fluid architecture may be ready in as little as six months, and special models for digital signal processing applications are now being delivered in four to six months by Stein Associates of Lexington, Mass. Using blocks of logic—that the company calls Blogics—connected by cables via a patch panel, a user can configure machines ranging from simple general purpose computers to fast Fourier computer peripherals, and digital filters.

The Stein approach differs from the logic module approach—its Blogics are far more complex, comprising, for example, four-input multiplexers, four-input data registers, gated high-speed parallel adders, and others. Depending on the speed of the application, memory can be either core or semiconductor. But the user need buy only the amount of computer he needs, and connect it—or change it—to suit his purpose.

Spokesmen expect costs to be lower than average for given applications; a 1,024-point fast Fourier machine using 10 Blogic modules would cost less than $20,000; a fast Fourier machine with 30 times the speed would use 36 Blogics and cost less than $100,000.

First approval seen for GE-Honeywell

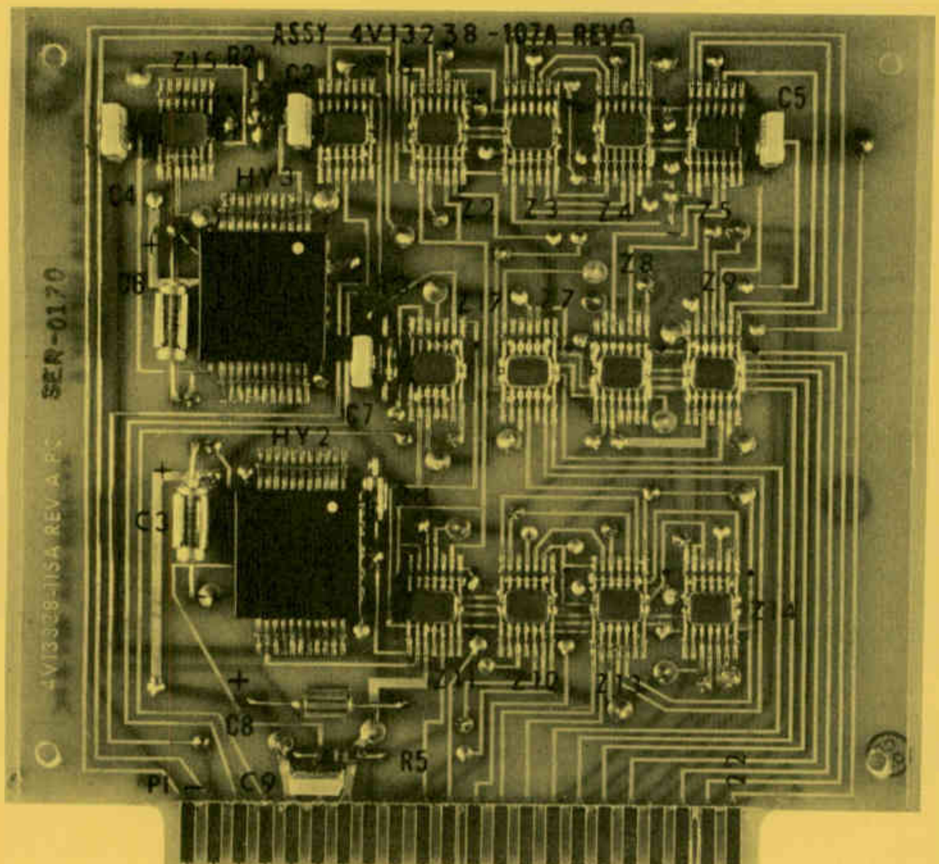
With Honeywell staffers preparing to introduce executives of the planned Honeywell-GE computer combine, insiders wonder if approval from the two boards of directors might be imminent. And if the boards come through as expected, only two obstacles remain. One is the possibility that Bull-GE might be taken over by the French national computer company, Compagnie Internationale pour l'Informatique [*Electronics*, June 22, p. 183]. This is said to be unlikely, although the Pompidou government asked CII to bid hard against Honeywell-GE. The other is U.S. Government rejection of the merger.

Component and Circuit Design **IDEAS** FROM SYLVANIA

CUSTOM ASSEMBLIES

From circuit boards to complete assemblies, we've got the capabilities.

Before you get to final design, talk to us. We'll show you the best and least expensive way to produce your system.



Circuit board assembly for avionics system made and tested at our Muncy, Pa. facility.

Because we've got the experts, we are willing to accept any challenge on the design and assembly of printed-circuit cards. First of all, we make our own circuit boards—single-sided, double-sided and multilayer. We also have the equipment to insert components on the board. And we are experienced at designing specialized equipment to test out the finished assembly.

The result? A completely integrated facility that can take care of all of your circuit assembly headaches. And we have the production facilities to produce your assemblies in volume.

Because of our wide range of capabilities, we can start with you at any point in the design/production schedule. We'll sit down with you at the beginning of design, or we'll make the board that you designed. We'll insert components, if you want, or give you the finished board for component insertion in your own plant.

Talk to our engineers right at the beginning of your design. They'll show you where to relax tolerances to get a better yield and lower cost. They'll analyze thermal conductivity to give you a layout with better heat dissipation. In fact, they will even run a temperature profile of the entire board and give you a prediction of its reliability. In short, they can cancel out potential problems long before your equipment gets to the production stage.

If you have your board already designed, we'll take over from there and produce them in any volume you require. At that point, we can either deliver the boards to you or turn them over to our component insertion people. They'll set up a production line that will turn out your completed circuit board assemblies at high speed.

And again, at the end of that production line our test equipment people will take over and set up specialized test equipment to make sure that each assembly meets your specifications.

In short, we have the capability to pick up at any point in your design cycle, and drop out wherever you wish.

What more can we offer?

CIRCLE NUMBER 300

This issue in capsule

MICROWAVES

Better step-recovery diodes improve multiplier design.

Multiplier efficiency is increased by diodes having minimum transition times and lower thermal resistance.

Our new step-recovery diode family is designed for use in both low- and high-order multipliers. The devices are oxide-passivated, mesa epitaxial silicon diodes mounted in the 023 package. Modern bonding techniques have been used in attaching the chip to the package to obtain low thermal resistance. Minimum transition times are obtained by careful control of the intrinsic layer thickness and resistivity.

In multiplier applications, the diode stores charge and appears as a low impedance when driven into forward conduction by one half of the RF signal. On the second half of the cycle, the diode conducts until the stored charge is removed. It then switches off very rapidly at a speed determined by the transition time. Ideally, in multiplier design, the transition time should be less than the period of the output frequency.

Another important factor in multiplier design is the minority carrier lifetime. It is desirable that this lifetime be greater than the period of the input frequency. This lifetime is the time required for all charge stored on both sides of the PN junction during the forward biased state to be returned across the junction when the RF signal reverses phase.

Figures 1 and 2 show the relationship of minority carrier lifetime and maximum transition time to frequency. With these charts and the table of data on our new step-recovery diodes you can see exactly what our diode family can do for you in your next design.

The chart in Fig. 3 shows the junction capacitance variation with bias voltage for three types of microwave diode: microwave tuning varactors (MTV), punch-through varactors (PTV) and the step-recovery diode (SRD). These curves show the step-recovery diode characteristics in comparison to the other types. CIRCLE NUMBER 301

Step-recovery diode characteristics

Type	V_B (1) Volts min	C_{j-6} (2) pf min	C_{j-6} (2) pf max	τ (3) ns min	T_t (4) ps max	Θ_{th} °C/watt typical	C_{jo}/C_{j-6} max	f_{c-6} (5) GHz min
DV B-6101	30	0.3	0.5	10	100	30	1.6	400
DV B-6102	45	0.5	1.0	25	250	20	1.6	300
DV B-6103	60	1.5	2.5	60	400	15	1.6	200

Test Conditions:
(1) $I_R = 10\mu A$
(2) 1 MHz and $V_R = 6$ volts
(3) I_{fs} 10 mA and $I_R = 6mA$
(4) $V_R = 10$ volts and $I_F = 10$ mA
(5) 1 GHz and $V_R = 6$ volts

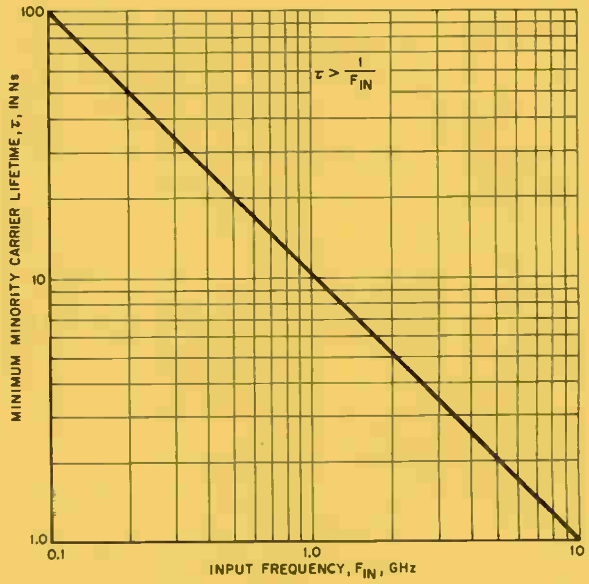


Fig. 1. Minimum minority carrier lifetime compared to multiplier input frequency.

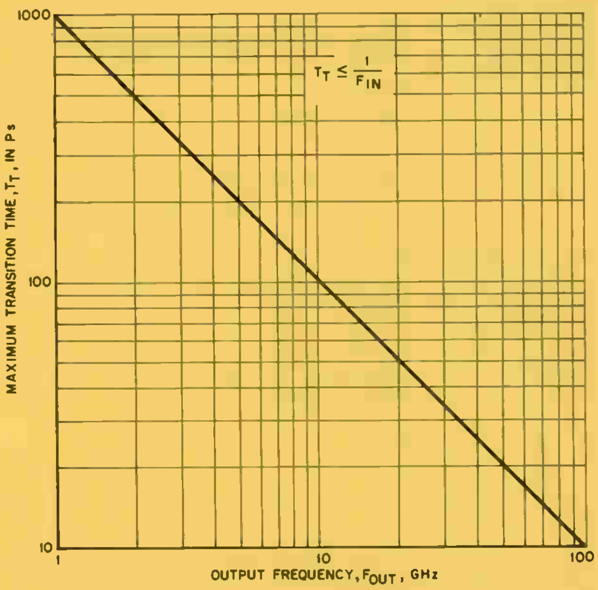


Fig. 2. Maximum diode transition time compared to output frequency of multiplier.

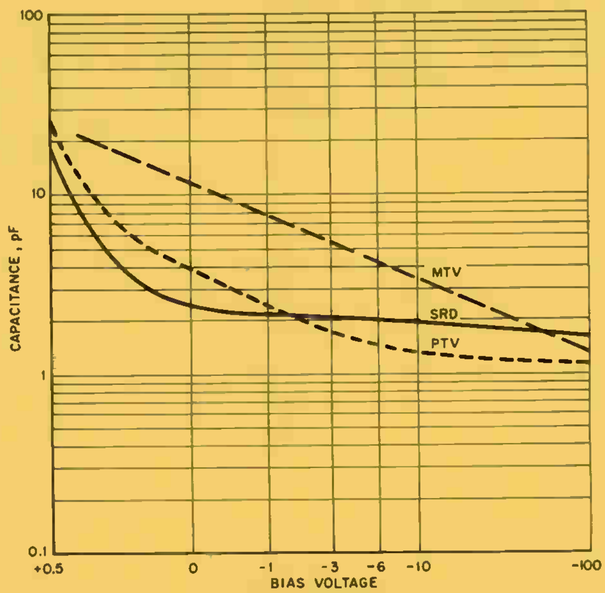


Fig. 3. Capacitance characteristics of three types of microwave diodes.

HYBRID MICROELECTRONICS

Flexibility is the key to hybrid packaging.

Trying to force everything into a "standard" package can destroy the advantages of hybrid circuit design.

There is no such thing as a "standard" hybrid microelectronics package. In fact, to impose such restrictions on a designer would defeat one of the most important features of this technology. Design and packaging flexibility is one of the key advantages of the hybrid approach.

The trick is to let your environmental and system parameters dictate what would be the optimum package. Then talk to our hybrid circuit engineers to develop the most efficient and least expensive approach to meeting your requirements.

The design flexibility we can provide is illustrated in the photographs. The first example is a character generator. This is one of a family of devices in a stroke type display system. Over 100 different types of circuit are used in a single display system, and each device differs in the values of the input, or summing, resistors. The general circuit is shown in Fig. 1.

As an additional requirement the amplifier had to be hermetically sealed and replaceable within the module. The amplifier also had to be set at a level to match the other amplifiers in the system. This required dynamic trim of the finished device.

Because of our long experience in this field we have the equipment to do this resistor trimming quickly, accurately and easily and—perhaps most important—at minimum cost.

A final, and important, requirement of the design was that, due to system packaging constraints, the entire module had to be in a dual in-line configuration.

Because of the large number of differing precision resistors required for the range of modules, our engineers designed a substrate that would accommodate more than one module type. This approach had many economic benefits.

The amplifier is constructed using a hermetically sealed TO-5 can for the semiconductor elements of the amplifier. This package is entirely replaceable. After the amplifier is mounted on the substrate containing the precision resistors the amplifier output is adjusted. This is done by monitoring the amplifier output while trimming one of the resistors on the substrate. When the proper output value is reached, the character generator is ready for mounting in custom-designed header. The final product is shown in Fig. 2.

A second example of the flexibility of hybrid packaging is shown in Fig. 3. Here, the requirement was for a hybrid module that would identically replace the discrete component assembly shown.

The hybrid assembly could, of course, be made much smaller, but because of the direct replacement requirement, the hybrid circuit is designed into the same package. In addition to being more economical, the hybrid circuit also offers advantages in size, weight and system reliability.

These are only two examples of how we can apply our hybrid packaging technology to design problems. Do you have a design right now that might be improved by the use of hybrids? Talk to our engineers. You'll be surprised at what they can save you in both work and money.

CIRCLE NUMBER 302

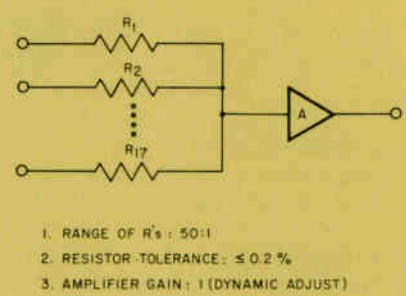


Fig. 1. General circuit of character generator.

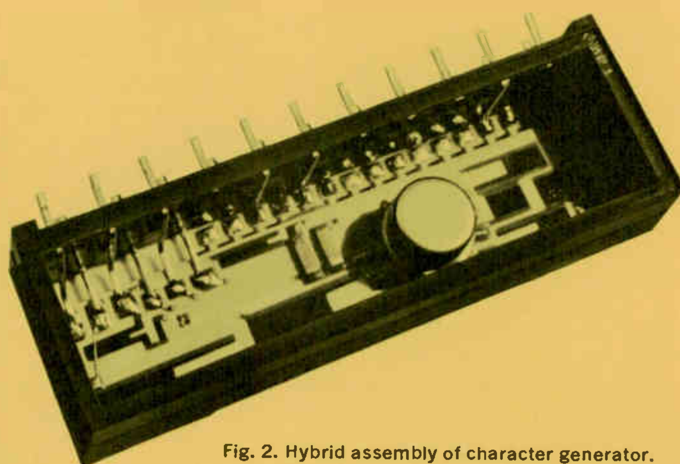


Fig. 2. Hybrid assembly of character generator.

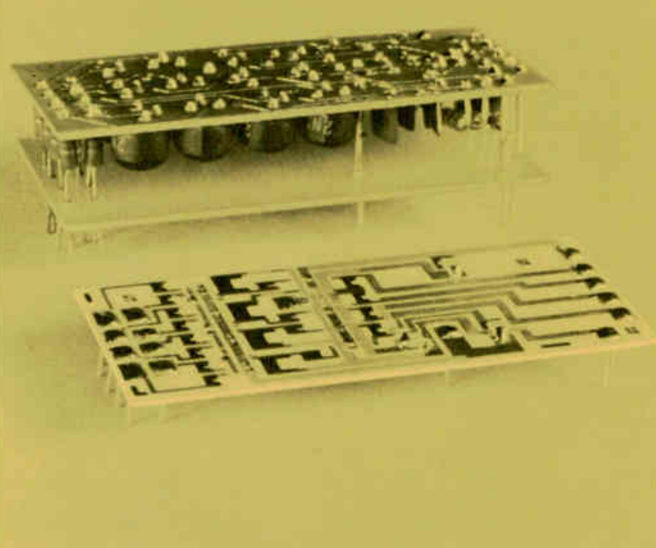


Fig. 3. Discrete component assembly and its equivalent hybrid circuit.

INTEGRATED CIRCUITS

Take advantage of Gray code in your counter designs.

Use of Gray code for counters offers some desirable features that you can't get from binary systems.

If you want up/down counters that give you ease of construction, reduced noise, reduced errors in reading, and a system that won't overflow, you should think about using Gray code.

The key advantage of Gray code is that only one bit can change at a time. Thus, if the clock pulse should occur while the counter is being read, the maximum error in the reading is only "one". Noise on the power line caused by flip-flops changing state is also reduced. This decreases power drain in high-frequency operation.

In addition, you can't generate "sliver" pulses with Gray code as is the case in binary operations. It is also very easy to change the direction of counting in a Gray-code counter. You simply invert parity. Another advantage is that the Gray-code counter stops counting when it reaches its maximum value, whether it is counting up or counting down. If this doesn't happen to be a valuable feature in your design, simple logic can be provided to eliminate it.

The logic diagram of a four-bit Gray-code up/down counter is shown in Fig. 1. Parity of the number is generated in an SM-120 parity generator. The parity generator outputs can be inverted by adding a "1" at pin 6 of the SM-120. The maximum value and zero are decoded at pins M_X and Z, respectively. These signals can be used as enable inputs for additional stages of Gray-code counters, or as controls at the input of the first stage to eliminate the hang-up at maximum or zero.

Figure 2 shows how two Gray-code up/down counters can be connected to produce an eight-bit counter. If pins M_X and Z of the last stage are logically "ORed" with pins P and $\bar{P}$ of the first stage before they are connected to pins

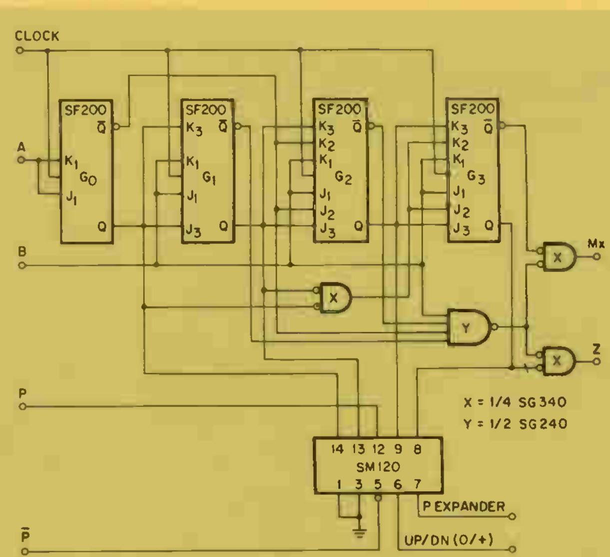


Fig. 1. Four-bit Gray-code up/down counter.

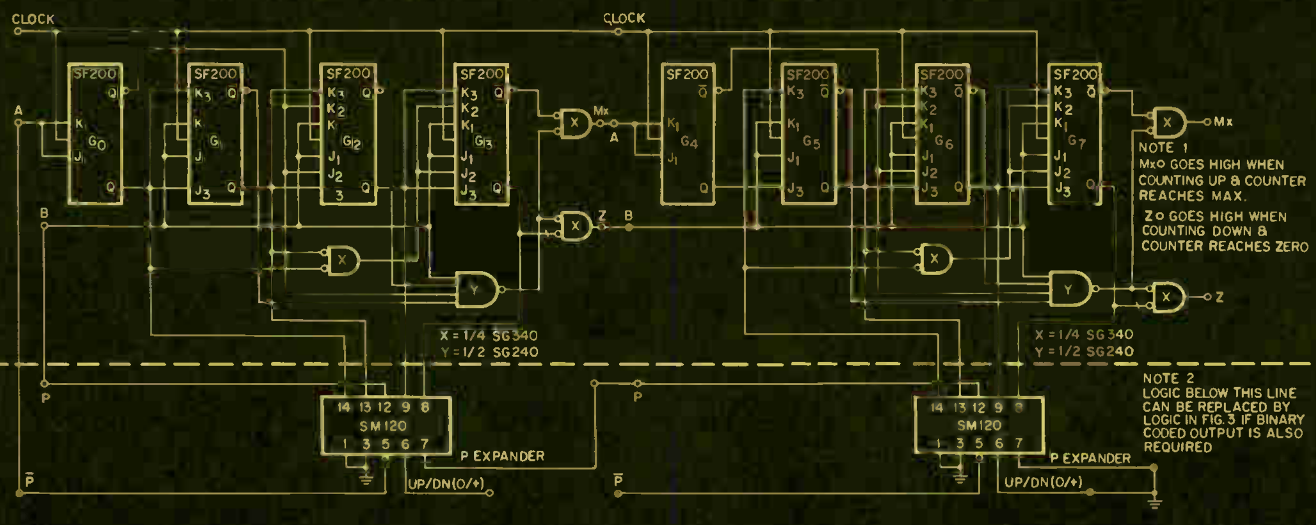


Fig. 2. Connection of two four-bit counters to make an eight-bit counter.

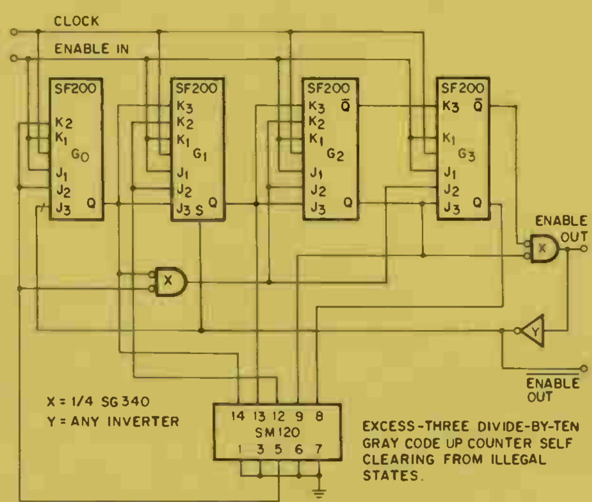


Fig. 3. Logic diagram of excess-three divide-by-ten Gray-code up counter.

A and B, the counter will not hang up at the maximum or zero values.

An excess-three divide-by-ten Gray-code up counter is shown in Fig. 3. This counter will not hang up at its maximum value of 12, but will go to the minimum value of three. The last stage of this counter has a square-wave output. An important point in this design is that all illegal states in this design are self-clearing.

This Gray-code excess-three counter can be very useful in logic systems using decimal notation where the excess-three code is desired. Also, when used in conjunction with excess-three Gray-code to ten-line decoders, this counter has many advantages over straight binary systems.

If it is necessary to clear the counter to a Gray-code three (binary zero) a negative pulse applied to the clear inputs of G_0, G_2, G_3 and to preset input of the flip-flop G_1 will do the job.

Our application note #24 covers the design of Gray-code counters in greater detail. If you are interested we will be glad to send you a copy. CIRCLE NUMBER 303

CRT MODULES

Integrated display module fills computer terminal needs.

Our 12-inch display package fits in nicely with Infoton's system for local or remote computer time-sharing.

Sylvania 12-inch monitor module chassis.

Infoton Vista 1 Computer display terminal.

Infoton needed a CRT display for their Vista 1 and Vista 2 computer display terminals. They came to us and picked out our off-the-shelf 12-inch CRT module. By doing this, they saved themselves a lot of design time because our module comes complete with all-solid-state power supplies, video and blanking amplifiers. They also saved a lot of money, too, because we build these modules at a lower cost than most people can.

These advantages, combined with Infoton's expertise and design know-how enabled them to offer a reliable, flexible unit at a highly competitive price. In fact, the low cost of Vista 1 and 2 will make display terminals available to educational institutions that previously could not afford them for computer aided instruction.

The Infoton units are designed for time-sharing applications in such places as brokerage houses, airline reservation systems and medical information systems.

Because Infoton designed their own cabinet, they used our 12-inch monitor in the chassis form shown in the photograph. However, if you need it, we can supply the monitor complete with its own attractive cabinet.

We can also custom tailor display modules to your needs. Because we build CRTs, we know their characteristics and can pick the best one for your job. And because we know CRTs, it doesn't take our design engineers long to come up with the proper drive circuitry. The result is fast turnaround, flexibility and lower cost for you. In addition, you get exactly the right display system for your application.

In fact, about all you have to do is give us the X, Y and Z input voltages and any special requirements you have, and we will get right back to you with the specifics on design and cost for the exact display module you need.

CIRCLE NUMBER 304

DIODES

Diode arrays contribute to low-cost, high-speed computers.

New family of computers use 16-diode arrays to cut assembly time and increase memory switching speed.

Two new medium-size computers, introduced by Systems Engineering Laboratories, use from 600 to 800 Sylvania 16-diode arrays as core selectors in their memory system. The advantage to SEL was lower assembly cost, higher speed and greater reliability. In addition, these high-speed computers use Sylvania-developed SUHL logic throughout.

Both of these 32-bit computers have a high throughput. The input/output transfer rate is 1.66 million words per second. Because of the modular design and task orientation, these computers are equally suited to real-time, patch processing and general purpose scientific applications. In most cases, they can handle all three at the same time.

The core memory, where the 16-diode arrays are used, can be obtained in capacities from 8,192 to 131,072 words. The arrays are mounted in dual in-line packages.

The arrays, which are available in both common anode and common cathode configurations are shown in Fig. 1. Their typical characteristics are shown in Fig. 2. They provide high forward conductance, fast recovery, low capacitance and tight tolerances. These units have a forward current rating of 300 mA and a power rating of 300 mW per diode.

Reverse recovery time of the diode arrays is a maximum of 60 ns, even under extreme switching conditions with a forward current of 300mA and an I_r or 30 mA. Typical recovery times under the same conditions are in the 35 ns range.

Because of the manufacturing process used to produce these arrays, electrical characteristics are closely matched over a wide temperature range.

In addition, units are available with 2 to 16 diodes. All of these arrays are available in 10 or 14 lead dual in-line packs or in flatpack configurations. They all meet MIL-S-19500 standards.

CIRCLE NUMBER 305

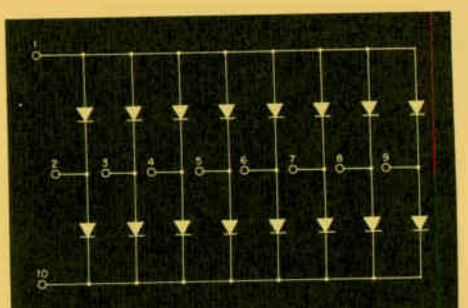


Fig. 1. Circuit configuration of 16-diode array.

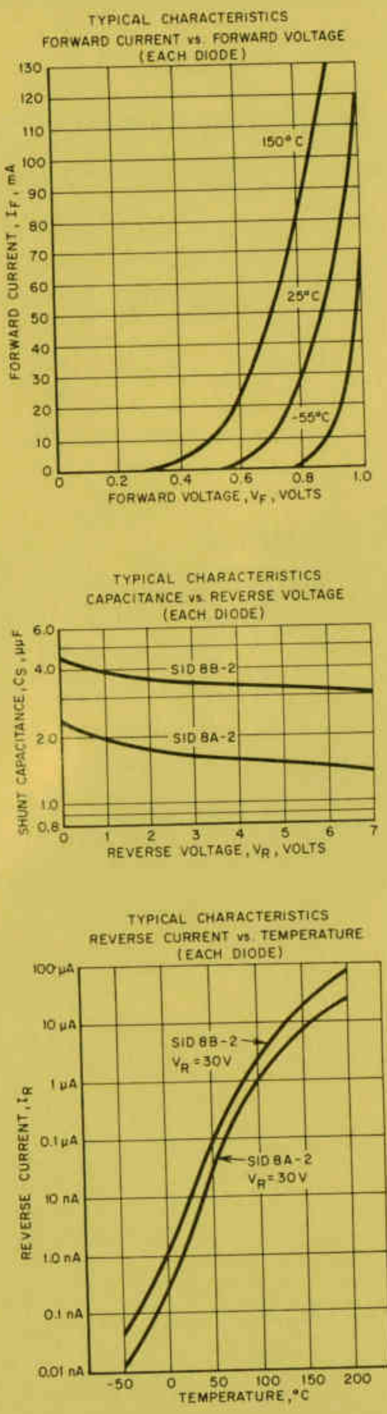
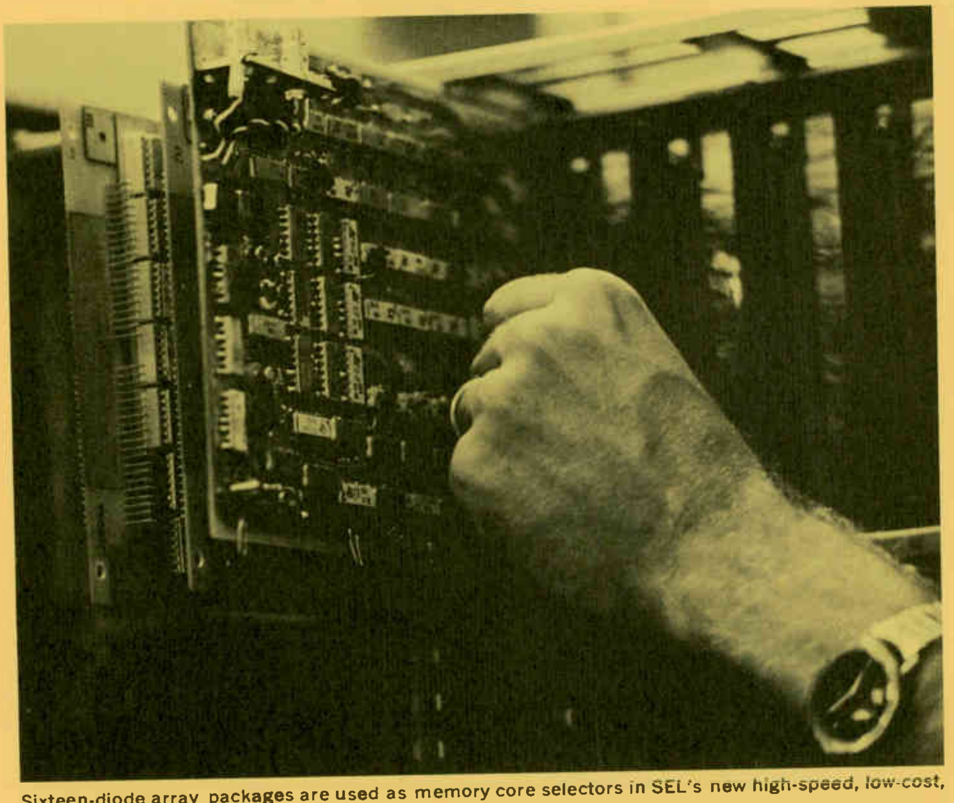


Fig. 2. Typical characteristics of diode arrays.



Sixteen-diode array packages are used as memory core selectors in SEL's new high-speed, low-cost, medium-size computer.

IDEAS

TELEVISION

We've done it again! A brighter color tube.

Using a brighter phosphor and a black mask, we've got a new tube that gives sharper contrast and 103% more brightness than our 1968 tube.

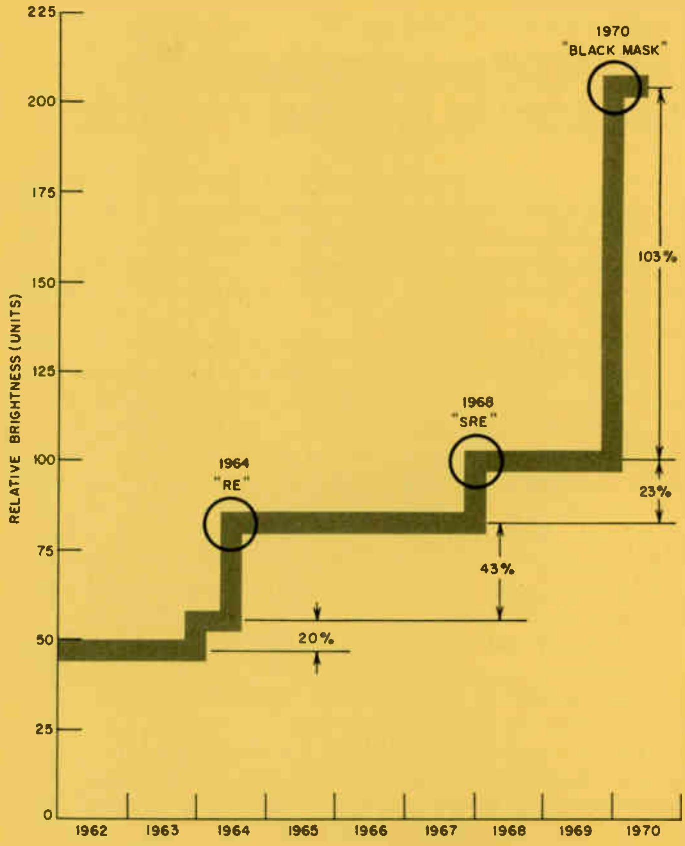
Sylvania has been the traditional leader in color tube brightness and contrast. The reason is simple: we have better phosphors and better methods of deposition. Recently, we introduced a new phosphor system that was competitive with other manufacturers' tubes which use "black" systems to improve brightness without loss of contrast.

Now, we have developed an entirely new *color bright 85*® "Black Mask" picture tube which combines our superior phosphor system with a new black masking technique. The result is a picture tube that combines the best of all possible worlds: a 103% increase in brightness over our 1968 tube, improved color purity and the highest contrast in the industry.

We've always held the edge in phosphor brightness because of the inherent advantages of our phosphor production techniques and our patented phosphor dusting system. The "black" systems, on the other hand, enabled other manufacturers to approach the brightness and contrast of our tubes because the black systems reduced reflectants and allowed the electron beam to cover the entire phosphor dot without splash-over.

When you combine our phosphors with the advantages of a black mask, you get a tube that's 103% brighter than the tube we introduced in February 1968. You also get vastly improved contrast with greater color purity than ever before.

To give you an idea of why Sylvania's *color bright 85* line has traditionally led the brightness race, take a look at the graph. Sylvania developed the first rare earth europium phosphor screen system in 1964. The whole industry followed. And until the development of the black-mask system, they couldn't come near us.



Sylvania brightness increases through the years.

Now, by combining our high brightness MV phosphors with Sylvania's Black Mask technique, we're in front again with the highest contrast in the industry.

Other picture tube manufacturers are using black system methods to reduce the reflectivity of the color tube. Our approach has been to increase the light emitted from the phosphor screen by the development of better phosphors. Both approaches work. But, what do you get when you combine them? The best tube. And Sylvania has it.

CIRCLE NUMBER 306

SEE OUR SPECIFICATIONS IN VSMF MICROFILM CATALOG FILE

Use Sylvania's "Hot Line" inquiry service, especially if you require full particulars on any item in a hurry. It's easy and it's free. Circle the reader service number(s) you're most interested in; then fill in your name, title, company and address. We'll do the rest and see you get further information by return mail.

BUSINESS REPLY CARD

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Dept. E 4 4 4

MANAGER'S CORNER

Hybrid Microcircuits: A packaging concept

Too often, design engineers think of hybrid microcircuits as just another component to plug into their system. If they do, they are wrong. Properly designed and applied, a hybrid circuit is a complete subsystem. To think of it in any other way is to lose many of the advantages of this design approach.

Basically, the hybrid microcircuit is a packaging concept that employs thick- or thin-film passive components coupled with either discrete or chip active devices mounted on a ceramic base. The hybrid module is packaged in either a hermetic or non-hermetic enclosure or a combination of both. There are an endless number of package forms that can be employed. This packaging flexibility is a primary advantage of the technology. In addition to size, weight and reliability advantages inherent in hybrids, they are now economically comparable to a discrete version when volume is significant.

In general, any electronic circuitry that cannot justify a monolithic approach is a potential hybrid application. Hybrid packaging complements monolithic designs as a second level of system integration. We see the emergence of the film passive substrates as the next generation of PC board. This, coupled with low-cost chip placement, such as beam-lead devices, will further broaden the economic justification for the use of hybrids.

Sylvania now offers standard off-the-shelf modules ranging from IF amplifiers to digital high-speed networks and power drivers. These modules are packaged in commonly used forms such as flat packs and TO-5 cans. It makes sense to examine these standard devices first in a new design. However, a custom hybrid can make economic sense if the usage can justify the tooling. As a guide, hybrid prototypes charges generally are of the same magnitude as the fabrication of a discrete module with PC board layout.

One area which is becoming increasingly important is hybrid MSI—or multichip digital modules employing TTL devices and a film interconnect pattern. Sylvania believes that multichip modules or hybrid MSI will allow the designer a new dimension in system design.

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Product Sales Manager, Hybrid Microelectronics

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Awacs avionics suppliers start waiting

IBM leads computer race, but Goodyear's associative processor might mount challenge; radar to be subject of fly-off

With its selection of the Boeing Co. as prime contractor for the airborne warning and control system (Awacs), the Air Force got its 707-320C aircraft out of the hangar. But as far as avionics suppliers are concerned, it will be at least two years before the program gets off the ground. And when and if it flies, Awacs will be in what Gen. James Ferguson of the Air Force Systems Command calls a core configuration—the service's newest euphemism for austere.

"This core configuration," explains Gen. Ferguson, "contains only the absolute minimum equipment to perform the surveillance and control function with provisions for growth and added capabilities as future operational needs arise." Though the Air Force plans to develop Awacs for both continental air defense and tactical air control, the total cost in terms of 1969 dollars is now estimated at $2.1 billion, down sharply from earlier projections ranging from $11.7 billion to $13.7 billion.

This new low Awacs price doesn't factor in the cost of the interceptor to be used with the 42 Boeing 707-320C command posts the Air Force wants to buy. The service is not studying adaptations of Grumman's F-14 or the McDonnell Douglas F-15 for the role. As both are still in development, the USAF has not ruled out other aircraft, except for the modified F-106. Whatever selection is made, the interceptors will add several billion dollars to the final package cost.

Six years. The $87 million sought for fiscal 1971 Awacs spending will cover two aircraft, two brassboard system demonstration radars for tests—one each from Westinghouse Electric and Hughes Aircraft—plus "a minimum of instrumentation and displays" and long lead time funds for computer software development. But, even though the Air Force has promised the Pentagon that it will not develop new hardware for Awacs, it will be 1976 before an operational system is achieved. The "fly-before-buy" radar tests themselves will take about 28 months before a choice is made between the Hughes medium-pulse repetition C-band system and the Westinghouse pulsed doppler, high-pulse repetition system operating at S-band.

Whatever the Air Force selection, the new go-slow schedule is discouraging to sources within the service. Says one of them: "Even if we get a system operational by 1976, that will be 13 years after the program was conceived. And that's got to be some kind of record."

Big wait. Beyond the competing radars, avionics choices are still years away. Though IBM's Federal Systems division has been the leading Boeing subcontractor for a data processor and for command/control/communications integration, there is no guarantee an IBM processor will fly in the final system. Hazeltine and ECI are seen in relatively more secure roles as team members, the former for displays plus iff transponders and interrogators, the latter for communications systems.

With final definition of computer specifications still two to three years away, associative processors, such as Goodyear's plated-wire machine [*Electronics*, July 6, p. 40] appear a good bet. Developed under contracts to the Air Force materials laboratory, the Goodyear multimode system can track up to 128 targets in a coverage area 32 miles on a side, with a selectable range window four miles wide. Either airborne or ground moving targets can be tracked and displayed, Goodyear says, a feature which would make the system applicable to either the strategic or the tactical role of Awacs. And, despite the promise to avoid development of new hardware, Goodyear's might well be fully developed and available by the time a specification is ready.

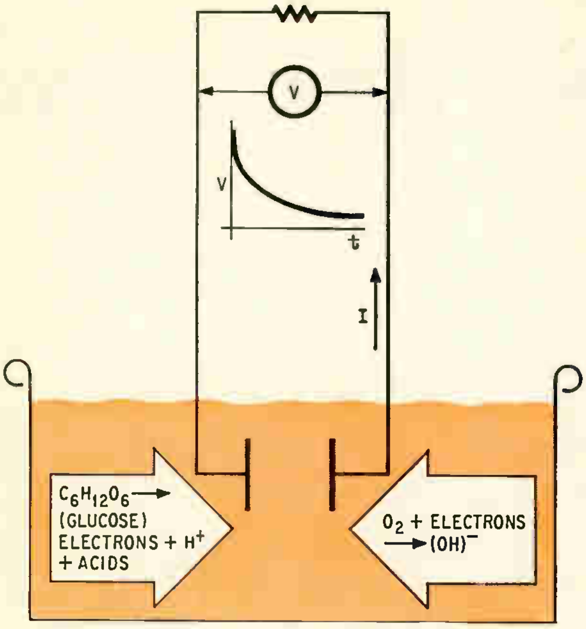
Medical electronics

Blood power

Artificial hearts are still experimental, but surgeons one day might well be using them to replace diseased hearts. However, before that can happen, researchers will have to find a way to generate the 10 to 20 watts of power needed to drive these implanted pumps. One seemingly far-out suggestion: use a person's own blood as an energy source by putting a pair of special electrodes into his bloodstream to make a fuel cell.

Scientists already are taking the first steps toward such a blood-powered fuel cell. At the Leesona Corp.'s Leesona Moos Laboratories, chemist Jerry Fishman and physicist Jean Henry have built a primitive cell that runs for hours and delivers 20 microwatts.

Selective catalysis is the key. While blood carries an almost countless variety of compounds, each Fishman-Henry electrode catalyzes one and only one reaction of one and only one compound. Each electrode is coated with gold-palladium alloy. The anode's coat is 55% gold, the cathode's is 85%. In blood, the anode breaks down



Blood into current. By selective catalysis of blood's oxygen and glucose, fuel cell produces electrons at one electrode, takes them up at other.

glucose—a sugar—into hydrogen ions, an acid, and electrons. At the cathode, the blood's oxygen takes up electrons to form hydroxyl ions. When there's a load across the electrodes, electrons flow from the site of the glucose reaction through the load to the oxygen electrode.

Flow-through. For their first pair of electrodes, Fishman and Henry Teflon-bonded the Au-Pd materials to 1-centimeter-square sheets of a noble metal. Since then the two men have found a way to electrochemically deposit the alloys. This increases the alloy area in contact with blood, and when the active area goes up, so does the cell's output.

Fishman says that it will be possible to deposit the alloys on filaments, out of which electrodes can be woven. These flow-through electrodes would have an even larger active area for a given electrode size.

Keeping the electrodes small is important because, as Fishman and Henry see it, more than one pair will be needed to power an artificial heart. Any load connected across a blood-powered cell causes the cell's output to jump to some peak voltage and then decay with a time constant on the order of 1 second. The way to get high average power, says Fishman, is with an array of electrodes and a switching network that sequentially connects electrode pairs to the artificial heart.

Switching helps in another way. When the electrodes run continuously, hydrogen and hydroxyl ions build in the cell. They not only degrade the electrodes but could conceivably upset the body's acid-base balance. The less time electrodes are on during a given period, the lower the ion concentration around them, and the easier it is for the blood itself to stay balanced.

NIH nod. The Leesona cell is still in the research stage. Tests have been run with beakers and tubes; animal tests won't begin until late this year. However, Fishman and Henry have demonstrated the feasibility of a blood-powered cell, according to Roger Powell, an official at the National Institutes of Health's artificial heart program.

Leesona isn't the only firm getting NIH money to study blood as an energy source. Scientists at the Esso Research and Engineering Co., Pennsylvania Research Associates, Tyco Laboratories, and the Union Carbide Corp. also are at work on the project.

Safe analysis

If the average patient knew how many accidental electrocutions were caused by surges of electricity that pass from a wall outlet through medical instrumentation—estimates run to 1,200 yearly—he might balk at being hooked to a diagnostic instrument without special insurance. A company in Irvine, Calif., the International Biophysics Corp., is providing that insurance in the design of its new differential oxygen analyzer, slated to be offered later this month.

The instrument uses four simple d-cell batteries for power, preventing "ground loops" from getting to the patient from the power supply. It also will isolate the patient from surges. For example, if the instrument is driving a chart recorder plugged into a wall outlet, the instrument will decouple the patient from any surges backing up through the differential oxygen analyzer.

Workhorse. The instrument limits the current to the patient to a maximum of 2 microamperes, well below the 10 μa specified as a safe load. What's more, the unit isn't limited to medical applications. It can employ electrodes for a variety of jobs ranging from measuring the oxygen content in air or water for pollution-control purposes, to monitoring the oxygen level in fruit-transporting containers to prevent spoilage.

But Kenneth Halvorsen, the company president, expects the instrument to be used first in the medical field, which is why great pains were taken to assure safety. One immediate potential application is in open-chest surgery. When the patient is placed on a heart-lung machine, one electrode can be put on the incoming side of an oxygenator and another on the output side to determine the difference in the two levels, and therefore how much oxygen the patient is absorbing. This differential is important because too much oxygen—hyperventilation—can destroy the heart muscle.

Stanford Spracklen, vice president for research and engineering, says that the unit operates on a polarigraphic principle. Here, current flowing from anode to cathode through an electrolyte in the electrode is proportional to the amount of oxygen present in the specimen. "This is precision measurement in the nanoampere area," Spracklen explains. "One sensor we'll be making will work at 10 nanoamps full scale and we'll be resolving 0.05 nanoamp to come up with a differential measurement."

Low drain. Dealing with such low-level currents for precision measurements dictates precise amplification. International Biophysics officials say they've cornered the market on one manufacturer's linear IC operational amplifier that can handle the low input currents and give very low current drain—

No zap. Electrode at left for differential analyzer is to measure oxygen partial pressure in fluids or gases. One in hand is for vein or artery measurements.

less than 100μa for the total instrument.

That's why it can operate on battery power; the batteries for the analyzer are expected to last a year.

The company believes that the unit is the first differential oxygen analyzer that can take measurements at two points and also give a differential measurement all in the same instrument. The most sophisticated version, including alarms for oxygen levels that are too high or low, will sell for $525, less than a third the price of similar instruments that use differential photometric rather than polarigraphic measurement techniques. The electrode for making measurements in gases and fluids adds another $85 to the price.

Advanced technology

Garnet not forgotten

Once you've learned the composition of magnetic bubble material, they're sure to change it on you. Last year it was the orthoferrites, with chemical formulas like $Sm_{0.55}Tb_{0.45}FeO_3$, to name just one. Now, the garnets are here [*Electronics*, June 8, p. 39], with compositions like $Gd_{2.3}Tb_{0.7}Fe_5O_{12}$.

The difference isn't just chemical. Bell Telephone Laboratories, early to recognize the worth of garnets for bubble material, has used this composition to grow bubble substrates by the flux method that have storage densities of about 10 million bits per square inch. This stacks up against the SmTb orthoferrite densities of only 25,000 bits/in^2. Since the cost per bit for processing information is closely related to the number of bits that can be packed on a chip, the Holy Grail—prices less than one cent per bit—may be just around the bend. And Bell's new garnet material has a staggering storage capacity compared with the newest disk storage capacity—in the 10^5 bits/in^2 range which is lower than the garnet bubbles by a factor of 100.

Left to its devices. Bell isn't just sitting on its garnets. Now that the new higher density garnets are available to its systems men, Bell is going full blast on a low-cost mass memory that could be used for central office operations. To show the feasibility of such a setup, an experimental magnetic bubble repertory dialing system is in the design stage.

Information could be stored in T-bar tracks forming closed loops, and selected bits transferred into a communication loop and subsequently brought to a read/write port. Thus, relatively short access times may be realized without a large number of read and write circuits.

Bell already has a small experimental repertory dialer working. Using 2-mil-thick orthoferrite platelets, which support 1.5-mil-diameter bubbles, this small-scale version of a repertory memory stores four numbers of 25 binary bits each in four memory loops. It also has a read loop and a bubble generator-annihilator. The memory and read loop are nearly identical, each consisting of T-bar propagating circuits and each connected to a common communication channel by a gate in the form of a hard magnetic film added to the propagating circuits. The films are switched by current pulses in gold conductors.

Computers

EDP for ABM

Expansion of an American ballistic missile defense system is still as much a problem of technology as it is of politics. Thus, while Congress and the White House dispute policy, the Army's Advanced Ballistic Missile Defense Agency (ABMDA) quietly pursues new data-processing technologies for a future system.

One of the agency's classified efforts involves development of data processors with speeds far faster than those of the supercomputers soon to be deployed at the two existing Safeguard ABM sites. To achieve these higher speeds, ABMDA is investing most of its data processing money in three projects—strap-on modules, faster mainframes, and software improvements.

Number, please. Bell Telephone Laboratories is building strap-on modules that would take over some of the tasks performed by the central ABM computer. The associative processor modules, scheduled to be delivered in a few months, will have logic that will perform processing for every few hundred words of memory, an Army official says.

Each of the modules will track one particular object headed for the U.S. after a preliminary determination by radar of warheads, decoys, and launching vehicles. The Army official says Bell Labs will turn the project over to another contractor soon after the breadboard is delivered, presumably because of AT&T's expressed desire to get out of the ABM business.

Another approach would adapt

the fastest machines being built today to the task of tracking airborne objects, deciding which are enemy missiles and firing interceptor missiles. That's why the agency now pays about $1 million a year to the Control Data Corp., Texas Instruments, and the University of Illinois to develop antimissile defense software for their experimental machines, which are many times faster than existing supercomputers.

No contest. Once the software is developed for the University of Illinois' Illiac 4, Control Data's STAR, and TI's advanced scientific computer, kernels of an ABM problem will be fed to the machines and benchmarks will be established. Despite appearances, the Army official insists, the program isn't a runoff between the contending computers, but rather an effort to establish a data base on the performance of three contending architectures. The Illiac 4 approach uses 64 processing units operating under the control of a Burroughs 6500 while STAR uses pipeline architecture in its arithmetic units [*Electronics*, March 30, p. 52]. The design of TI's computer is one of the best kept secrets in the computer industry.

Another effort aims at increasing the throughput of existing supercomputers—such as the IBM 360/195 and the Control Data 7600—by improving software. Both IBM and Control Data are currently under contract to develop a more responsive software that makes better use of memory and the processor itself.

Saving interface

The want of a standard computer peripheral interface, says the government, has cost it $100 million. As a result, Federal officials have resolved to do something, touching off a small war between mainframe makers and independent peripheral manufacturers.

In itself, the loss claimed recently by the General Accounting Office is nothing new. Comptroller General Elmer B. Staats reported last year that the government could have saved $100 million on peripheral equipment if a standard interface were required, because of the difference in price between units that weren't plug-to-plug compatible manufactured by independent companies and the compatible units made by mainframe houses.

The news, however, is the revelation before Sen. William Proxmire's subcommittee on economy in government that Washington plans to set a Federal standard unless industry comes up with its own.

In testimony before the panel, James P. Nigro, acting director of the National Bureau of Standards Center for Computer Science and Technology, disclosed that the NBS budget request for the next fiscal year will include $300,000 to $400,000 for development of the standard. If it's realized and approved by the President, computer firms would have to provide the interface or give up the lush 9% of the market the government represents.

Budgets, of course, can be cut. But Nigro's request is strongly backed by both Staats and, judging from its testimony before the committee, the Department of Defense, and support like that will carry considerable weight if the request reaches Capitol Hill. At the hearing, Proxmire even discussed the possibility of a supplemental appropriation that would permit the bureau to begin work on the interface this year.

Response. The remaining question is how the computer makers will respond to the serious threat of a Federal standard. The American National Standards Institute has been working on a peripherals standard since 1967, but nothing has come out, largely because of a deadlock on whether the standard should be for an interface between buffer and peripheral units or for the input/output channel.

The mainframe manufacturers favor the former on the grounds that it would grant the user greater flexibility in hanging peripheral equipment onto the computer. The peripheral manufacturers are holding out for the cable interface, which the Bureau of Standards also prefers, because it could be developed much more easily. The peripherals people maintain that the channel interface proposal is just a delaying tactic that will give the mainframe makers more time to sell their high-priced units.

One way or the other, something has to give. It could be the ANSI group working on the standard, or it might be the government.

Companies

Road to the Rockies

With the condition of the economy today, one might wonder why a company would decide to go to the expense of establishing a subsidiary. In the case of the infant TRW Colorado Electronics Inc., some insight may be gained from a list of the companies it expects to compete with. Bernard Dell, TRW/CEI's manager of operations, expects to bid against the likes of Collins Radio, RCA, Philco-Ford, and Motorola's Government Electronics division for volume production of new space electronics, avionics, and ground electronics hardware.

"We felt we needed the capability to penetrate markets we weren't penetrating," Dell observes in outlining the rationale for establishing TRW/CEI, "to capture a larger

Mapping the route

Why did TRW decide to establish its Colorado Electronics Inc. in the Rockies? First of all, the company decided to forgo the Los Angeles area because of high salaries there. A further incentive was the firm's desire to maintain a sharp division between the R&D type of production typical at TRW Systems and the volume production expected from the Colorado subsidiary. Also, support in terms of machine shops and other nonelectronic operations was considered, as was the fact that the Denver-Boulder-Colorado Springs area is attracting more and more electronic firms. These, along with other criteria, led to Colorado Springs.

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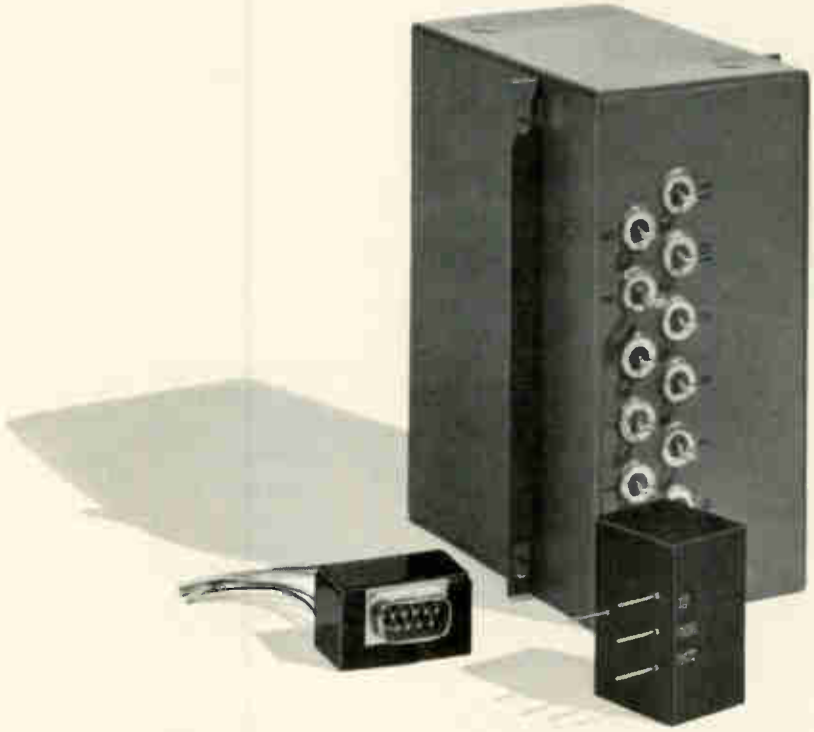

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The boss. Says TRW/CEI's Dell: "We'll have . . . technical resources plus a group oriented toward manufacturing processes."

share of these markets for TRW." While TRW Systems Group has a production capability, it's characterized by high-technology, few-of-kind, intricate hardware ranging from communications satellites to specialized high-speed analog-to-digital converters for data communications.

Think and do. Dell believes the new company, which expects to grow to 200 employees within 18 months and have an annual sales rate of up to $4 million after two years, will "have the best of both worlds. We'll have a full complement of technical resources available on call at TRW Systems, plus a group oriented toward manufacturing processes."

TRW/CEI has leased a 20,000-square-foot facility in Colorado Springs. "We'll be staffing with people experienced in making the transition from R&D and low-volume production to high-volume production," Dell notes. Typical quantities will range from about 50 to 10,000 units of a given piece of hardware. "Our people," Dell continues, "will be able to team with TRW Systems people to influence the design from the start" and make the hardware more easily manufacturable.

The new firm's first contract is from TRW Data Systems to build 5,000 keyboard assemblies for a department-store credit-verification system. Beyond that, TRW/CEI is bidding against a number of outside companies to manufacture electronic communications gear that TRW Systems needs. "If TRW is successful in penetrating the navigation satellite receiver market, TRW/CEI will probably manufacture the receivers," Dell adds.

Space electronics

Balloons and birds

Mixing balloons with satellite experiments finally could resolve the questions slowing deployment of aeronautical services satellites. The former NASA Electronics Research Center, now the Department of Transportation's Transportation Systems Center, delivered as a parting shot a report recommending a series of balloon/transponder experiments to be followed by launch of a small group of experimental satellites.

But with the hiatus caused both by the switch in control of the center and by some antenna delivery problems, the first balloon probably won't go up until early next year. NASA's Office of Advanced Research and Technology would fund these flights.

Leo M. Keane, head of the special projects department at the Cambridge, Mass., center, foresees two series of balloon experiments to shape final questions that the satellite launches would answer. In the first series of up to five balloon launches, aircraft would receive signals simultaneously from both L-band and vhf transponders aboard the balloons.

Spade work. "In this first series we'll be measuring how signal-noise ratio, data error rate, and voice intelligibility vary between L-band and vhf," says Keane. "With such data, we then can add a guesstimate for ionospheric effects to come up with a pretty close idea of needed link margins. And specifications like these will translate readily into satellite hardware."

The second series will deal with navigation. As planned, the balloons would use L-band frequencies only and probe the effect of ocean multipath on ranging accuracy. Once again, data would be logged aboard aircraft flying below the balloon's altitude of 100,000 to 120,000 feet.

The transportation center team already has some data on ranging accuracy from its experiments with the ATS-5 satellite. Last spring a team sailed aboard the tanker Manhattan and used ATS-5 to obtain lines of position said to be accurate to within less than a mile [*Electronics,* May 25, p. 33].

"But the ship was slow moving, and we were able to use a 3-foot-diameter antenna," says Keane; "by contrast, the test aircraft will be well above the water, flying at high speed, and using low-gain antennas." Also, the center plans to gather data on the amount of background electronic noise such an airborne navigation-communication system would have to overcome; high radio interference would probably necessitate a more powerful satellite.

All the balloon experiments will take place over the Pacific, a condition Keane doesn't like. The sea conditions—and therefore multipath—will be less severe and variable than those for the Atlantic. But the instrumentation, launch facilities, and aircraft are all out west. Still, he feels, the data gathered from the second balloon series, when combined with that from the Manhattan, will firm up navigation radio link margins about as well as the other five launches will clarify communications needs.

Constellation. After the data from 10 balloon launches is in hand, the team recommends the launch of three spin-stabilized, geostationary satellites. As foreseen, each would carry electronics for one voice channel, one 1,200-bit-per-second data channel, plus spherical and hyperbolic ranging gear. Of course, data from the

balloons or ATS-5 could change the list. Also, no agency has yet backed or set a time for the satellite experiment.

Meanwhile, the center's team has concluded that narrow-band f-m looks best for high intelligibility (95%) voice transmission with the smallest investment in antenna size and transmitter weight. Data relay would be by differentially coherent phase-shift keying, which reputedly yields a good tradeoff in equipment complexity and weight.

Commercial electronics

Rent-a-laser

"We're operating our laser facility as if it were a nuclear reactor or particle accelerator," says Leonard R. Solon, vice president and technical director of Hadron Inc. "People bring in and set up their experiments and we turn on the laser to give them the high-intensity radiation they need."

At a minimum charge of $200 for one hour's use of the laser room, that radiation can be expensive, especially when each laser "shot" costs at least $35 more. But it's a good buy, according to Solon, because the customer gets to use the world's highest powered, commercially available laser, which costs almost $400,000 to install. The laser, the VD/VK-640, can produce an output energy at 1.06 microns of up to 500 joules in a 30-nanosecond pulse, equivalent to a peak power of 17 gigawatts. In addition, the laser can pump 100 joules in a pulse as short as 1 nsec and the result is a smashing 100 Gw peak.

Grande. Hadron, in Westbury, N.Y., handles the American distribution of the neodymium-glass laser manufactured by a French company, Compagnie Générale d'Eléctricité (CGE). The laser's high power and brightness is particularly useful for generating high-temperature plasmas, and for observing accelerated photolytic chemical reactions. And CGE used the unit's intense heat last fall to cause a controlled thermonuclear fusion reaction in a very-high-temperature plasma.

With its high price tag, the system hasn't exactly been walking off the shelves. By renting out the laser, Hadron hopes potential customers may find the laser useful enough to make them want to buy their own.

"Right now we're touching the most innovative and creative people," says Solon. "Once these pioneers break ground, there will be a second wave of engineering and industrial organizations who'll move in to use the laser."

Hadron says a number of organizations have used the facility—mostly for classified projects—since it was made available two months ago. These users include Lockheed Missiles and Space division and Battelle Memorial Institute. And last month the company even had a buyer. The Naval Research Laboratory in Washington decided to convert, for $214,000, the smaller Hadron/CGE system it already has to the big 640.

Meetings

Leaving the scene

Indications are that although West Coast companies are returning, attendance by eastern firms at Wescon, to be held Aug. 25 through 28 in Los Angeles, will be off more than 50% from last year. Of 121 eastern exhibitors from 1969, only 51 said they would attend. Wescon officials say that overall booth space is down 10% from last year [*Electronics,* June 8, 1970, p. 34]. Show officials expect the trend to hold, reflecting the biggest drop since 1965, another bad business year. Tight money is the reason.

Because new contracts are few and far between, mostly due to government spending cutbacks and the general state of the economy, company representatives say that such shows as Wescon are being carefully evaluated. Those companies that say they are attending, are showing mostly items that are improved older products or a first for that company, but not for the industry. And some exhibitors with booths will forgo the traditional hospitality suite, while still others report that, although they will attend the show, they will have a suite instead of a booth.

Communications

Half-price headset

Two years ago a salesman for a major mobile-radio manufacturer walked into a Justice Department agency with a pitch to equip the nation's 300,000 police with a helmet-mounted transceiver developed for the Army.

At first the meeting went well. Law Enforcement Assistance Administration officials liked the way the radio freed the policeman's hands for driving his motorcycle, drawing his gun, or wrestling with a drunk. But then came the hard question: "How much does it cost?"

"Between $800 and $1,000 in quantity," was the answer. LEAA officials laughed the salesman out of their office.

Serious. Today, a Long Island, N.Y., company is quietly demonstrating a similar unit with an under-$500 price tag which it is convinced is no laughing matter even though it is well above the $150 to $200 that the police community wants to pay for transceivers. Leonard Dairo, project engineer for Dyna Magnetic Devices of Hicksville, N.Y., says the New York City Police Department plans field tests of the company's D566 transceiver later this summer. And inquiries about the radio are coming in from departments as far away as the Virgin Islands.

The Dyna Magnetics transceiver, like the devices earlier developed by most of the major military communications firms, is voice actuated by a solid state switch with variable attack and delay. Yet it differs in that it has no external antenna or microphone boom, which could be snapped off by an assailant, Dairo says.

To get rid of the external microphone, the company turned to an

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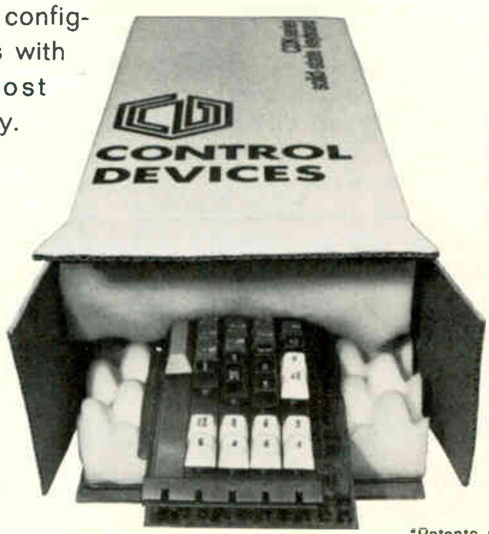

...but we part with them willingly

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inertial microphone it was already producing for use in battlefield telephone transmitters. When held against the top of the head by the helmet's weight, the device picks up sound transmitted through the user's skull. And because it is well insulated by the thick plastic helmet, the microphone is insensitive to ambient noise levels as high as 120 decibels, he says.

Dairo declined to say where the vertically or horizontally polarized antenna is hidden inside the helmet. But presumably criss-cross strips of copper foil glued to the interior of a demonstration model serve this purpose. A whip antenna is also available for extended-range communications.

Up to a watt. The 2-ounce transmitter module for the unit will be available in five models ranging in output from 100 milliwatts to 1 watt. The unit is crystal controlled with frequency stability to 15 ppm, the firm says. Its single-channel operation, however, fails to meet multichannel requirements cited by a number of police officials in discussing their radio requirements.

The receiver for the D560 is also single channel and boasts freqency stability equal to the transmitter's. Dual-conversion circuitry is employed in the two-once unit, which together with the transmitter module will be packaged in the neckband of the helmet. The transceiver package also will function as protection for the policeman and is said to be able to withstand heavy blows. Receive-only models also will be available.

Power is supplied by mercury or nickel-cadmium cells. Minimum battery life is eight hours, based on cycle duty of 80% standby, 10% receive, and 10% transmit, the firm says. If an optional push-to-talk switch is added, however, battery life can be extended considerably by switching over a voice-actuation mode only when it's needed.

Doing its bit

Bell Labs has developed a way to transmit data at double the speed of existing Bell System data gear. However, there's a catch: the data set is designed for the analog network, and with today's emphasis on digital transmission, customer demand may never materialize.

The new wideband system was described at the International Conference on Communications in San Francisco by A.M. Gerrish and W.J. Lawless. Operating at its maximum data rate of 108 kilobits per second, it has more than twice the capability of the Bell 301D (40.8 kb) and the Bell 303 family (50 kb). The experimental wideband set transmits synchronous binary data over group bandwidth facilities. The as yet unnamed set can operate at speeds of 72, 90, and 108 kb and can be used for, among other tasks, baseband transmitters and analog trunks with digital extensions.

On the basis of thus far limited tests on a real transmission facility, performance is expected to be on a par with that of the 301 and 303 series. However, at the 108-kilobit rate, quality is expected to be lower with a 10^{-4} average bit error rate.

Compares. Operation at 72 kb yielded transmission efficiencies of 92% to 99.9% over a length range of 2 kb to 80 kb per block. Average efficiency with a block length of 8 kb—1,000 characters in ASCII code—was 99.5%. This compares with the 301B data set operating at 40.8 kb on a similar transmission facility. Performance at 90 kb was approximately equal to that achieved at 72 kb, while operation at 108 kb yielded transmission efficiencies of 15% to 89% over the same block lengths; the average efficiency with an 8-kb block was 70%.

The new wide band data set consists of a baseband unit, a single-sideband modem, a line termination and test unit, and optional automatic equalizer and error control units. Data coming in to the baseband transmitter runs through a 20-stage scrambler to provide a random data output. The signal goes to an error control unit and then to a serial-to-parallel converter and coder. For binary operation—72 kb per second—the signal passes through the circuit directly; for ternary operation—108 kb per second—three binary digits are coded into two binary-coded ternary digits.

For the s-p converter and coder, the signal goes to a partial-response precoder, where symbol-by-symbol decoding prevents error propagation. The precoder's output is sent to a digital-to-analog converter where a multilevel output is generated—three levels at 72 kb and five levels at 108 kb. The signal is shaped by a filter and summed with a sinusoidal tone at 36 kilohertz—the tone is used to derive the sampling clock. The composite signal is the output of the Bell Labs unit's baseband data set.

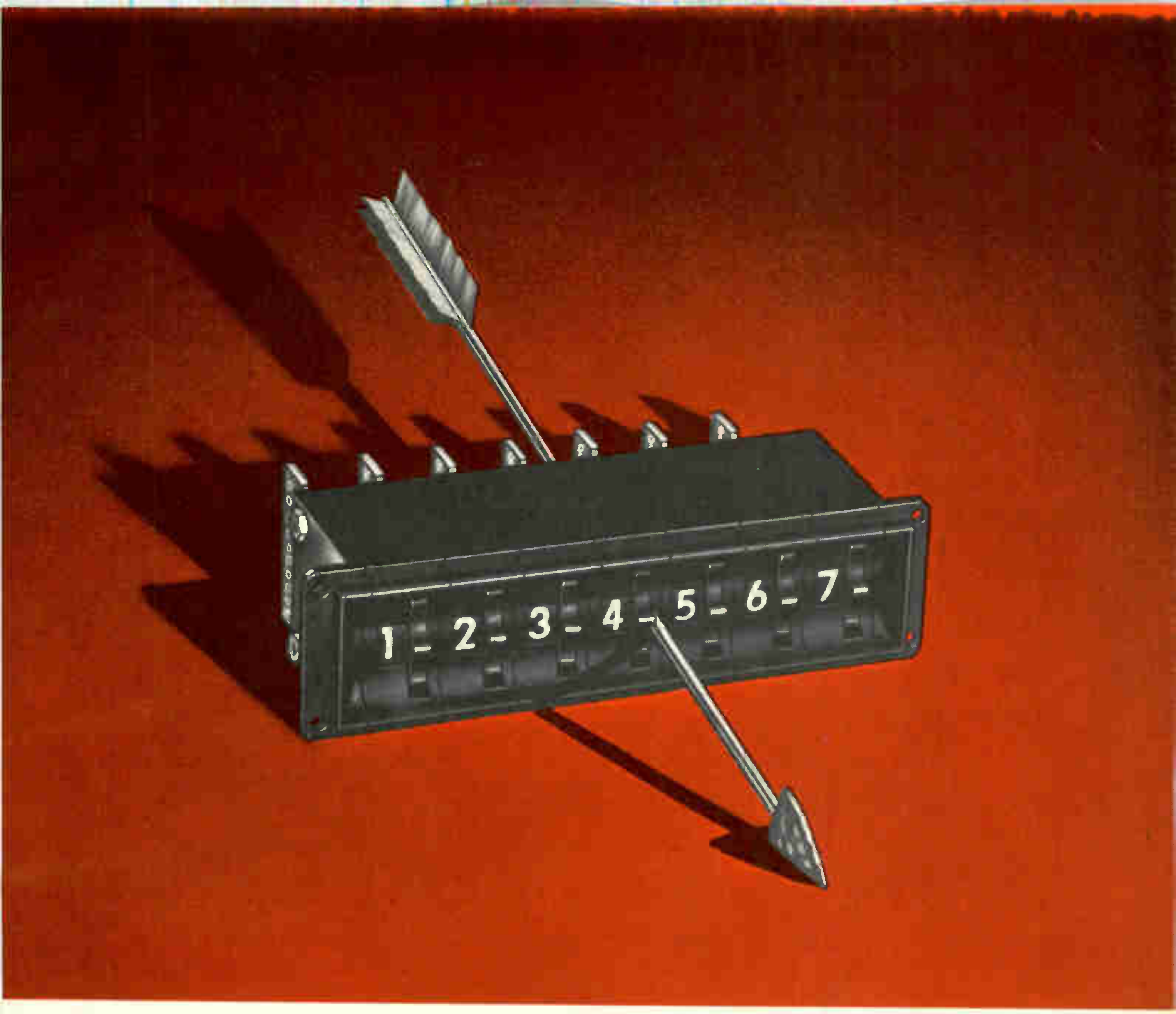
Riding the wave

For years, Comsat engineers have said that digital transmission is the wave of the future in orbiting communications relays. Not only are digital circuits much simpler and cheaper than analog circuits, but just as important, they use less power.

The engineers soon will be able to prove what they've been saying. Comsat is testing a Philco-Ford device to see if one of the largest parts of Comsat's business—relaying video signals—can be performed successfully using digital techniques to get the signals from ground to space and back again.

The six-month test, due to end around December 1, is evaluating a color flying-spot scanner and a recording device similar to the Imiac units Philco-Ford builds for the military to convert pictures to computer data. The purpose of the test, says Richard A. Schaphorst, a Philco-Ford visual communications research manager, is to see if the units provide high enough resolution and color registration for video relays.

Squeeze. During the test, the scanner will digitize color and monochrome transparencies. The digitized signals will then be recorded and tested against Comsat's resolution and registration standards. Every effort will be made to compress the bandwidth of the



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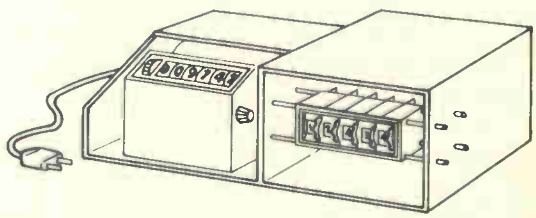

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Circle 55 on reader service card

video signal while preserving picture quality, he says.

If the tests are successful, says Schaphorst, speeding up the process to digitize the 30 pictures a second needed in video transmission should not be much of a problem.

At this point, neither Philco-Ford nor Comsat is making bets on the outcome of the tests. But in the long haul, Schaphorst says, video signals relayed via satellites will be digital. "And once you have digital video signals, it makes an awful lot of sense to make all your traffic digital. All you have to do is multiplex in your voice, facsimile and data," he says.

Government

ATS setback

NASA has taken a step backward to set its most recent record with the Applications Technology Satellite program. The achievement is nothing less than NASA's first withdrawal of a contract award to General Electric for the F and G advanced communications satellite in the ATS series. The action came in the wake of a protest by the losing bidder—the Fairchild-Hiller Corp.—that NASA had accepted a post-deadline bid from GE in March after NASA officials had leaked information on Fairchild-Hiller's design and price to GE.

The complaint led to an investigation by the General Accounting Office, investigative arm of the Congress, which confirmed acceptance of the late bid by NASA but noted, "There is no evidence of a leak." More important than GE's complaint that it didn't like the GAO "innuendos" in the absence of firm proof, the company was more disturbed by the GAO's recommendation that the award be reconsidered—one which Thomas Paine, NASA administrator and former GE executive, promptly accepted by withdrawing the award and announcing a recompetition between the two companies.

Outcome. Speculation that the ATS-F and G satellites eventually will be canceled and a new program undertaken was the subject of much speculation in Washington after the dispute. In view of the NASA study and report to GAO which GE says extracted much of its technical data, and the subsequent delivery of the NASA and GAO studies to both competitors, GE now argues it doesn't see how a fair recompetition can be undertaken.

As Daniel Fink, vice president of GE's Space division, puts it: "This now gives Fairchild-Hiller a great deal of technical innovation regarding our stuff which is exactly what NASA was accused of doing earlier. At the same time, the report itself was the first place that I believe the official prices were mentioned, or at least the relative dollars. Relative cost was mentioned, and specifically it states that GE was 2% lower than Fairchild-Hiller." As Fairchild-Hiller knows its bid, Fink argues that it can easily figure GE's bid with a bit of arithmetic. Estimated value of the contract, still in negotiation at the time of withdrawal, was about $50 million.

On evaluation of the two competitors, the initial rating of Fairchild-Hiller's technical proposal was 699 and GE's was 664. The margin slipped to 683 to 570 after preliminary oral examination by the NASA Selection Evaluation board, and then GE came out on top by one point with a total score of 687 after about 10 days of fact finding with each company. While the board concluded that the proposals were "technically equal" and differences in initial price proposals were minor an Administration cut in the NASA budget caused the ATS-F and G timetable to slip so the agency requested new bids.

GE says it then "went home convinced that the tactic, the technique had to be minimum cost to give them [NASA] a legitimate, able-to-achieve program" in view of the budget constraints. This, the company says, resulted in its lower price after a new round of negotiations with 14 major subcontractors.

While NASA has yet to specify the extent of its recompetition and its timetable, GE's Fink believes the space agency "feels they have to bend over backwards" in the new round on ATS. "Where GE is concerned, this is doubly true," he adds, because of Administrator Paine's 19-year GE affiliation.

For the record

Layoff? The Hewlett-Packard Co., which boasts that it has never had to lay off workers, has managed to in effect cut its work force while maintaining that record. Some 11,000 of H-P's domestic employees will simply take off one day every two weeks without pay—and salaries of all corporate officers will also be reduced. Unaffected will be the Colorado Springs division, which makes oscilloscopes and pulse generators; the San Diego division, x-y recorders; the Avondale, Pa., division, analytical instruments; and the company's 3,400 foreign employees.

Official. The North American Rockwell Corp. has made the dual announcement that the former Autonetics Products division has become a separate commercial microelectronics company and has signed a follow-on contract with the Sharp Corp. of Japan [*Electronics*, June 22, p. 34], for MOS/LSI arrays that go into Sharp's Micro-Compet calculator. The new firm is the North American Rockwell Microelectronics Co., and the additional business with Sharp is valued at more than $30 million through 1972. The initial contract, which runs through next January, was for nearly $30 million and encompassed more than 2 million devices. The follow-on order is also for more than 2 million devices, but company officials aren't disclosing the exact dollar figure or the precise number of devices. The contract covers the same five basic circuit functions included in the original order, although some of the arrays have been redesigned to make them smaller.

Ad infinitum. Suffer the country two more proposed congressional

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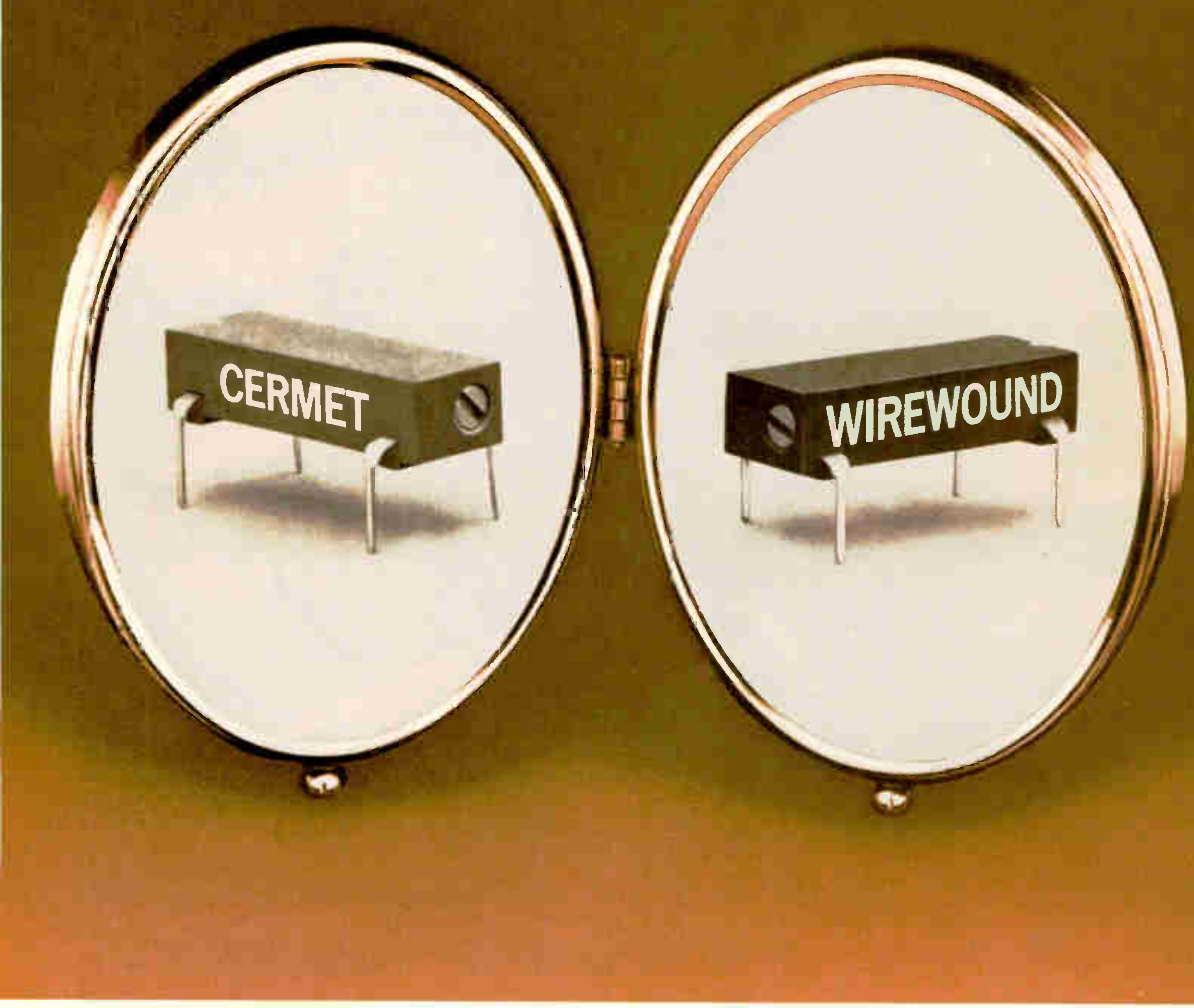

#30-1

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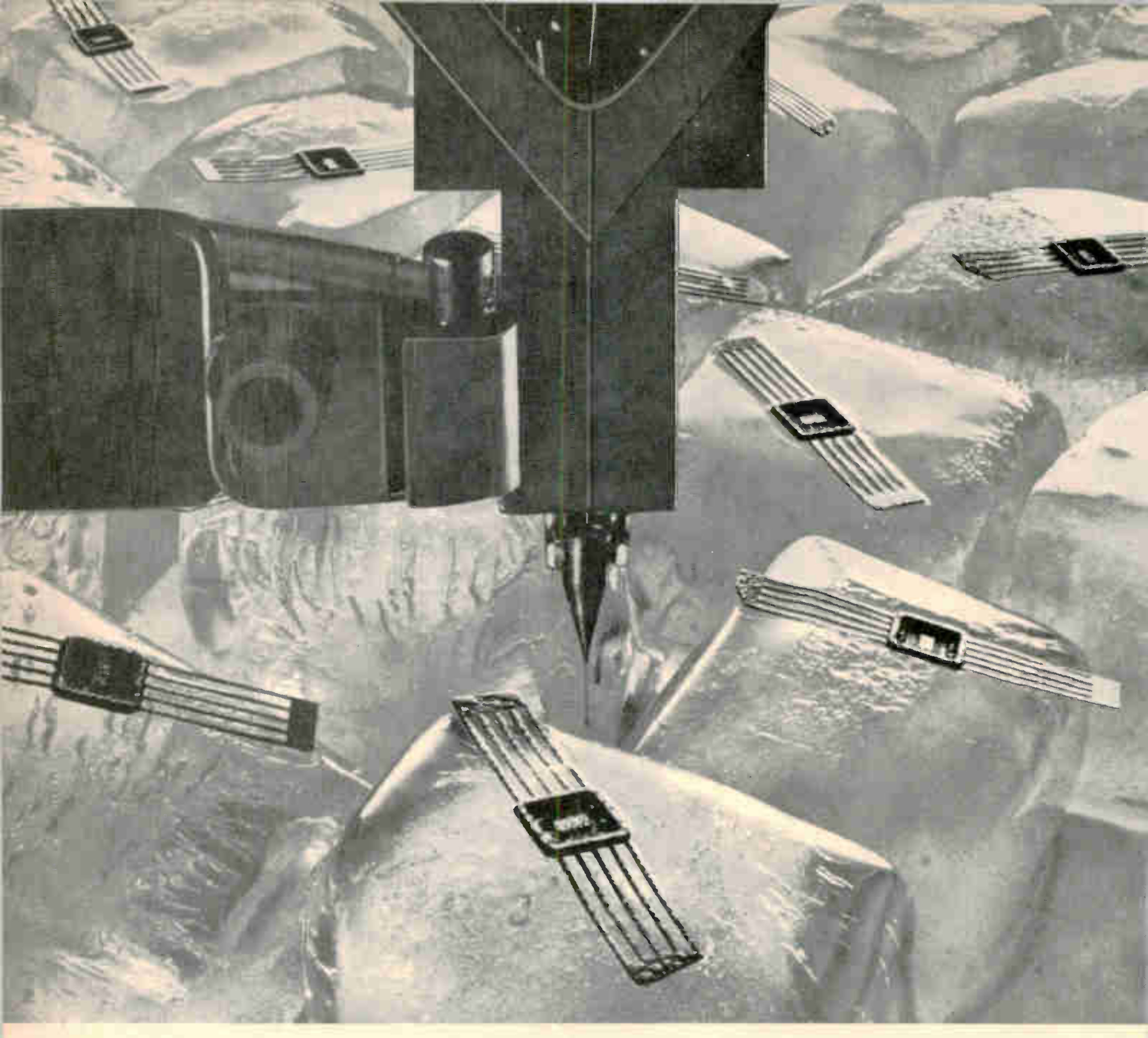

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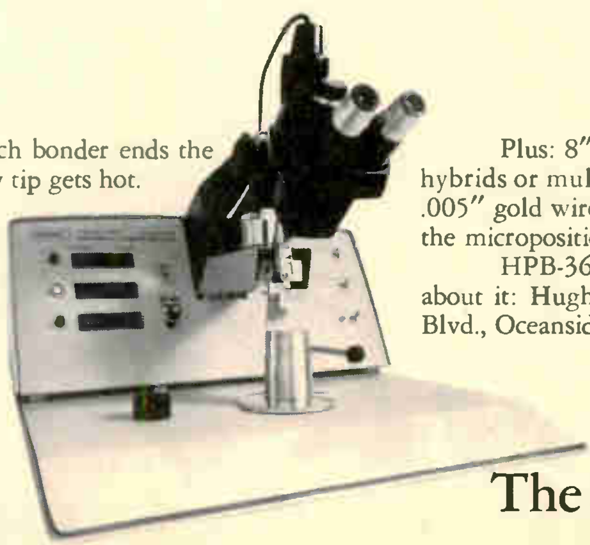

Figure it out. Hughes' new ball and stitch bonder ends the warm-up phase of production. Only its capillary tip gets hot.

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commissions. The Independent Technology Assessment and Environmental Data Collection Commission, introduced by Sen. Warren Magnuson (D., Wash.) in his Commercial Technology Assessment Act, would develop an early warning system to alert government, industry, and the public about possible economic, environmental, and social costs entailed in new commercial technology.

The National Commission on Libraries and Information Science survived a House-Senate conference and would, among other things, determine the status of library and information resources and services, develop plans for meeting those needs, and promote R&D to improve library and information-handling capability as "essential links in the national communications networks."

Datran to 11 Ghz. The Data Transmission Co. (Datran) has a new design scheme for its 35-city microwave data network, aimed at subduing frequency interference objections by common carriers. In amendments to its original proposal to the Federal Communications Commission, Datran proposes to move transmission from 6 gigahertz to 11 Ghz in some congested areas, and to build 16 additional repeater stations to handle the shorter-range transmission at 11 Ghz.

Datran says the design amendments should, by removing objections to possible interference caused by the proposed network, prompt the FCC to act on its application. The network would be operational 18 to 30 months after FCC approval, says Datran.

LEAA to lose four eyes. The troika leadership of the Justice Department's Law Enforcement Assistance Administration is expected to be reduced to a one-man show after Senate action on an already-passed House bill. Current law provides for three administrators, who must unanimously agree on LEAA issues, no matter how trivial, before crime-control grants are made to state and local governments. That situation led to the resignation of former administrator Charles Regovin [*Electronics,* April 27, p. 115].

Digital 3 R's. Microwave Communications Inc. will be ready to plan point-to-point microwave service for about 85% of the nation's colleges and universities by November, when it will have analyzed input from schools on requirements. Some require only low-speed data with Teletype use, others want crt readouts and computerized class instruction, and some will need the network only part time. An MCI proposal to interconnect educational broadcasting stations and university libraries is pending at the FCC.

Court action. At least one engineer is among the 50 former employees of the Boeing Co.'s Everett, Wash., plant who are suing the company—they claim they were laid off despite promises of from three to 10 years' employment. Eleven suits have been filed, asking damages ranging from $30,000 to $100,000, and another 39 are due to be filed by the Everett law firm of Griffin & Bortner.

The plaintiffs charge that Boeing recruited them last year from other nations and elsewhere in the U.S., only to let them go last month. The complaints say that none of the plaintiffs was familiar with "the cyclic nature of Boeing's employment history or that this employment would be based upon the future sales success of the defendant's aircraft."

Ironically, most of the suits were filed before the announcement that Boeing had won the contract for Awacs, which could be worth $2 billion over the next half decade and eventually increase the company's work force.

Add one. L-Squared Industries, the MOS device maker formed last year by Arthur Lowell, ex-MOS chief at Autonetics, has agreed in principle to acquire a mineral exploration consulting and managing firm. The company, Monarch Enterprises of Washington, D.C., will become a subsidiary of L-Squared, which is in Santa Ana, Calif.

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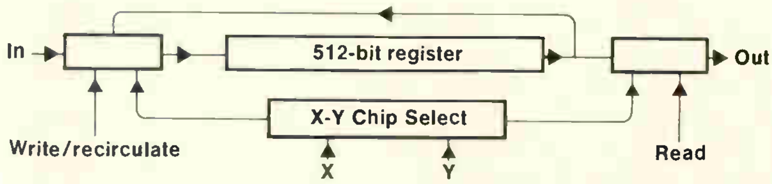

Model 1405 is guaranteed to operate to 2 MHz. Data inputs, data outputs and all control signals are fully compatible with DTL and TTL logic. Clock capacitance is less than 80 pF. Capacitance at all inputs is typically a low 3½ pF and guaranteed not to exceed 5 pF.

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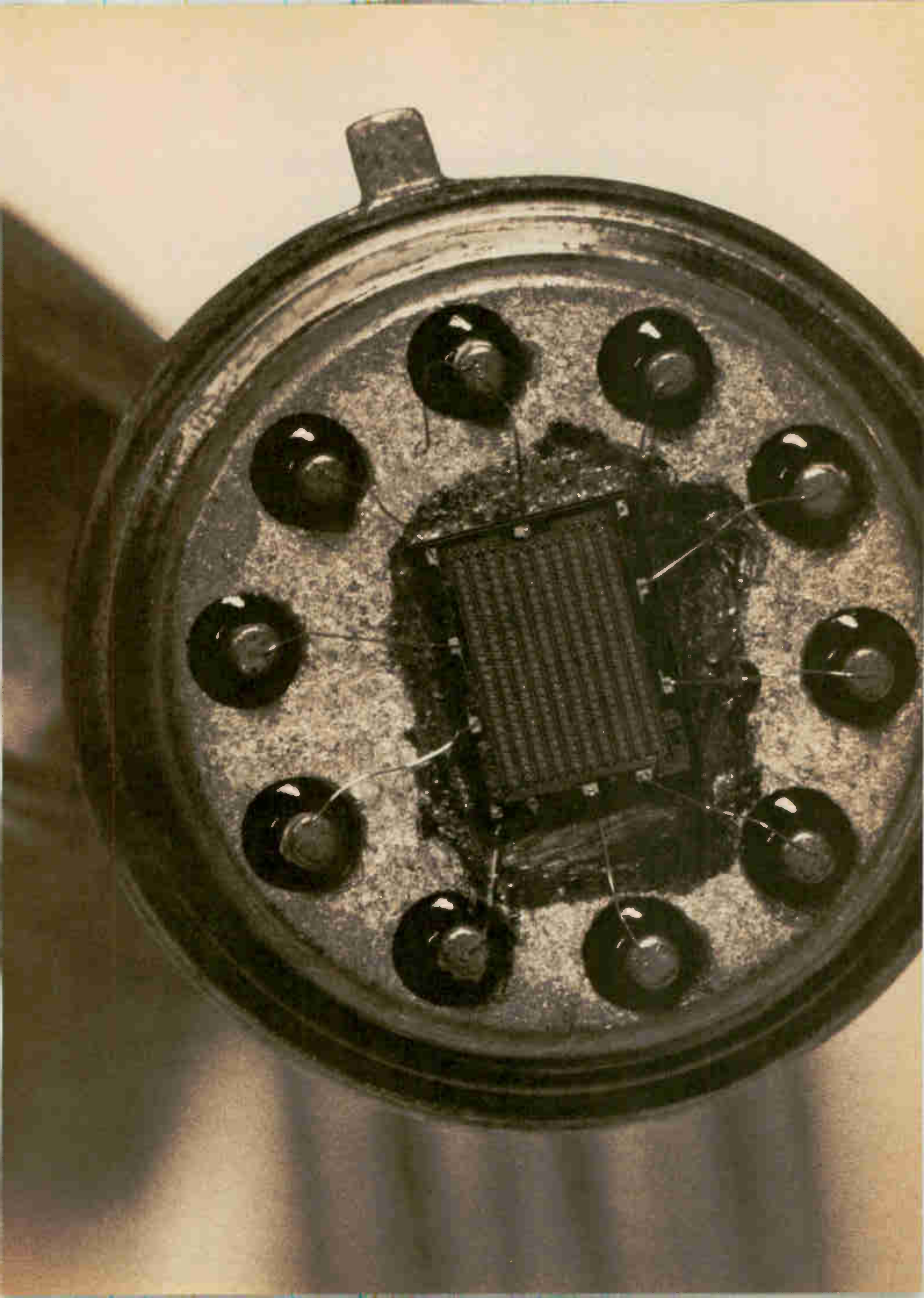

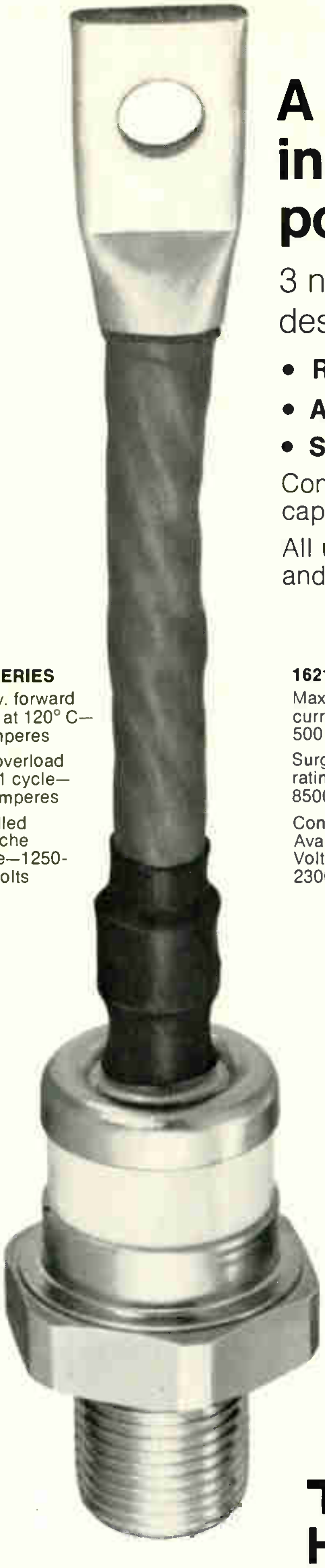

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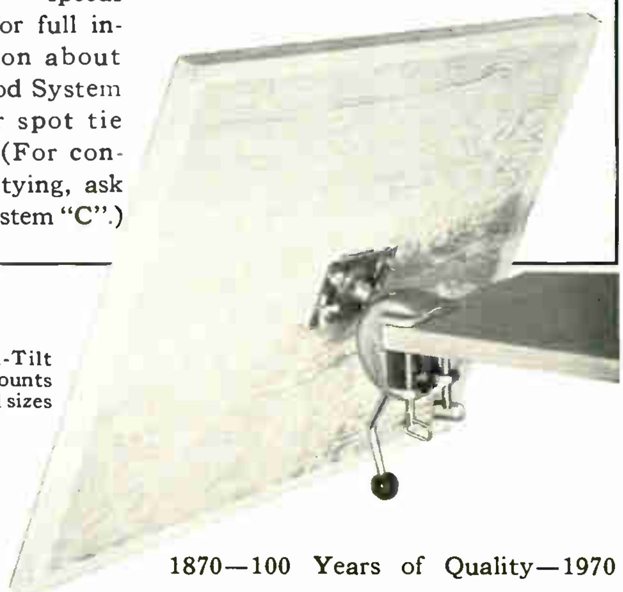

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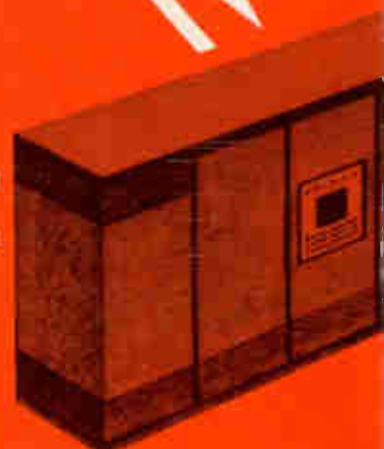

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Washington Newsletter

July 20, 1970

Defense and space firms try to soften new cost controls

Government electronics contractors are still fighting Congressional attempts to impose tough cost controls. Although resigned to adoption of uniform cost accounting systems—following overwhelming Senate passage of a bill to requiring such systems in all defense and space contracts—the contractors are trying to get House adoption of the Senate measure. The industry fought uniform accounting tooth and nail when first proposed by Sen. William Proxmire (D., Wis.), but the upper chamber's bill is nowhere near as tough as the House version, sponsored by the powerful Rep. Wright Patman (D., Texas).

Though the Senate scrubbed a loophole exempting prime and subcontractors with less than $25 million in annual Government sales—a provision sponsored by the Western Electronics Manufacturers Association—it didn't touch the provision that accounting standards could be established and monitored by an independent five-man board named by the U.S. Comptroller General. The House bill, on the other hand, puts the stringent General Accounting Office in charge of accounting standards.

Regardless of the compromises that industry can salvage from Senate-House negotiations, the application of uniform accounting principles is expected to make contract costs much more visible, contractor overhead charges much less flexible, and engineering expenditure controls much more restrictive.

New agencies will boost environmental electronics use

Application of electronics to environment problems and in oceanography is expected to accelerate now that the White House has issued an executive order creating the Environmental Protection Agency and the National Oceanic and Atmospheric Agency. Both organizations will receive only the fiscal 1971 money appropriated for the groups from which they will be formed in August. But their administrators, still to be named, are sure to push multiple system studies and hardware-oriented projects to gain visibility and public acceptance—and the leverage to ask for more money in fiscal 1972.

Air Force pursuing modular airborne data processor

To see if most airborne multiprocessors can be fashioned out of a standard set of computer modules, the Burroughs Corp. is being funded by the Air Force Avionics Laboratory to build three types of data processing modules. If the approach is successful, standard modules could be assembled into computers for every type of aircraft from light tactical systems through attack bombers. Under the $469,000 award, Burroughs is scheduled to deliver by December 1971 a processor module, a switching matrix, and a unit that can be used for either input or output. A separate award is pending for development of four 16-kilobit plated wire memory modules.

Burroughs will use Fairchild 100-gate micromosaic arrays and 300-gate discretionary wired circuits to keep volume down to 1.8 cubic feet for an 800,000 instructions-per-second triplexed processor. The Avionics Lab's program is aimed at the same cost and logistical problems as the Navy's more ambitious Advanced Airborne Digital Computer, a modular machine that would be used in all Navy planes from 1975 through 1985 [*Electronics*, July 21, 1969, p. 52].

Washington Newsletter

Will DuBridge survive as science adviser?

Speculation is growing that Lee DuBridge, director of the Office of Science and Technology, will not last much longer as science adviser to the President. DuBridge, lacking the political expertise of some of his predecessors, is reportedly being ground down by criticisms of his performance and the absence of policy guidance by the White House. Though no one can confirm that DuBridge plans to leave, sources close to the office concede that he is dismayed by his inability to determine White House science policy and unhappy at being left to his own devices.

NASA tradeoffs may curtail funds for space stations

Plans for interim space stations that would fly in the mid-70's may cause cutbacks in a potential bonanza for the electronics industry, the National Aeronautics and Space Administration's $5 billion space station program. Many NASA planners are arguing that because NASA funding is leveling off, the space shuttle, designed for use in launching and resupplying the space station, will not be able to fly until the 1977/1978 slot set aside for the space station. Thus, they contend, smaller stations carrying more austere electronics would provide the only means of maintaining a manned space exploration effort.

Eight proposals for interim space stations are reportedly under consideration, and all would use some of the remaining seven Saturn 5 boosters. Use of the Saturns, however, would require cancellations of Apollo flights. The two strongest contenders for the boosters are a second Skylab, which would provide a second platform for scientific experiments in 1974, and a six-man "intermediate" space station that could fly in 1976. If the latter gets the green light, the 12-man space station would have to be pushed back into the 1980's.

FCC sets rules for cable systems

Eying the internationally interconnected cable grids of the future, the Federal Communications Commission has opened a new CATV docket to consider technical standards for the industry.

The CATV area abounds with unresolved standards problems. One proposed FCC standard would require two-way transmission capability in cable systems. Such a two-way capability should provide at least the capacity for a single 4-kilohertz message and be available for sharing with other subscribers—for example, between the home and banks or newspapers. The FCC also wants 40-channel systems in major urban areas and 20-channel systems in suburban and rural areas.

Radio allocations may blossom into states' rights issue

If one Deep South state has its way, the Administration's "southern strategy" would be extended even to radio frequency allocations. Arguing that the Federal Communications Commission has failed to employ a state-oriented systems approach to frequency assignments, the state is pushing for the granting of frequency blocks to states for reallocation by local authorities for intrastate use. Pending official publication of a systems engineering study by the state, the FCC refuses to disclose anything about the state's identity—except that it is southern.

While this revolutionary approach would permit reassignment of, say, forestry frequencies to police departments in areas where there are no forests, communications suppliers predict possible chaos. They see themselves making different models of each piece of equipment—at much greater cost—to suit the peculiar requirements of each state.

LINEAR

The best of Linear

For the past several months, we've presented a profusion of facts, specs and applications on Linear Integrated Circuits.

It's time for a recap. Just in case anybody missed something they shouldn't have.

The following two pages contain the most significant product information we've presented in this ad series. Not that everything else wasn't important.

But, if we only had one ad to run this year, this is the ad we'd run.

Introducing the World's First Monolithic J-FET Input Op Amp

Punch-through op amps are obsolete.

Fairchild's new µA740 now offers 150 pA (max.) current into either input. While some manufacturers are talking about super beta or punch-through transistors with current gains of 1000, Fairchild technology now makes possible J-FET devices with equivalent betas of over 15,000. And, they're completely compatible with standard monolithic processing.

The µA740 is a simple two-stage design similar to the µA741, but employs J-FET input transistors to obtain extremely low input currents.

µA740 Electrical Performance

Input Current (either input)	150pA max.
Unity Gain Slew Rate	6V/µS
Input Resistance	10^{12} Ohms
Voltage Gain	120dB
Input Offset Current	30pA

The new linear has all the convenience of the µA741: internal frequency compensation for unity gain, input over-voltage protection to either supply, output short circuit protection to ground or either supply, and the absence of "latch-up."

Balanced offset null is easily obtained with a 10KΩ potentiometer and does not affect other parameters.

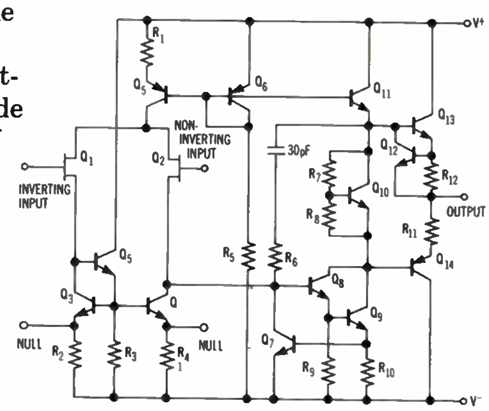
Other µA740 features include a wide common mode range of ± 12 volts, high differential voltage range of ± 30 volts, and wide operating supply range of ± 5V to ± 22V.

The µA740 is directly interchangeable with the µA741, µA748 or µA709.

The new Fairchild device provides circuit designers with superior performance in such applications as active filters, voltage followers, integrators, summing amplifiers, sample and holds, transducer amplifiers and other general-purpose feedback applications.

The µA740 is now available in TO-99 packages (both military and industrial temperature ranges) from any Fairchild Distributor.

Reader Service Number 511



µA740 FET INPUT OP AMP

The New µA796:

We Knew It Was Going To Be Versatile, But We Didn't Know How Versatile.

The new low-cost µA796 Doubly Balanced Modulator/Demodulator is finding its way into an amazing variety of systems.

Communications-gear engineers are taking advantage of its great versatility and high carrier suppression in modulators and demodulators for single sideband, suppressed carrier and phase shift key transceivers. It's also being used as a synchronous AM demodulator, a quadrature FM demodulator, and as a phase comparator for phase locked loop receivers.

Digital tape/disc memory designers are utilizing the µA796's unique properties in fast differentiators and phase correcting circuits for NRZ or phase encoding systems, while remote D.C. R-G-B gain controls, color shade and keystone corrections are practical for color TV broadcast equipment use. Other possibilities lie in signal chopping, frequency changing, linear mixing and more.

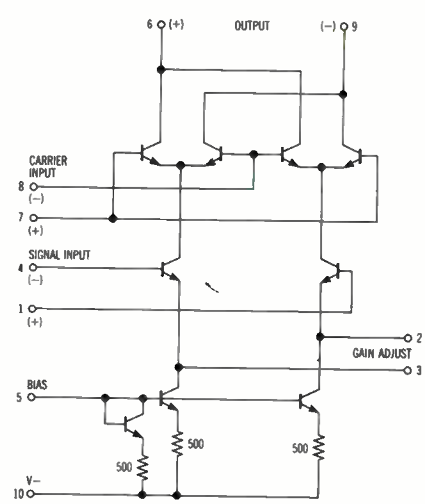
Here Are The Specs:

Carrier Suppression	65dB
Transadmittance Bandwidth	
Carrier Port	300MHz
Signal Port	80MHz
Signal Gain	3.5V/V
Input Impedance (signal port)	200KΩ
Input Offset Current	0.7µA
Differential Output Swing	8.0 volts p-p

Here Are The Prices:

U5F7796312 −55°C to +125°C	\$4.80 @ 100 pcs.
U5F7796393 0°C to 70°C	\$2.25 @ 100 pcs.

µA796 DOUBLY BALANCED MODULATOR/DEMODULATOR



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

FAIRCHILD SEMICONDUCTOR

New Op Amp has Gain of 3,000,000.

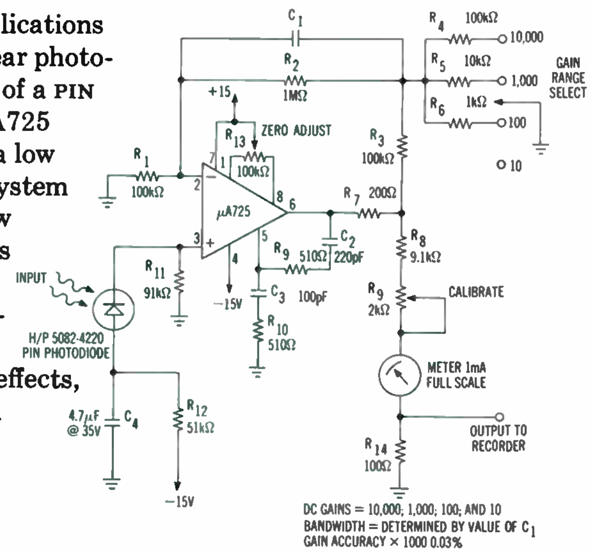
Fairchild's new µA725 Instrumentation Operational Amplifier can do the same jobs that used to require expensive chopper-stabilized or complex discrete component amplifiers. The µA725 is ideally suited for use in Low Level Signal Conditioners, Instrumentation Amplifiers, Precision Measuring Equipment, Process Control Systems and Data Acquisition Equipment.

Electrical Performance/Features

Low Input Noise Current . . . 0.6pA/Hz
High Open Loop Gain 3,000,000
Low Input Offset Current 3nA
Low Input Offset Voltage Drift . . . . 0.5µV/°C
High Common Mode Rejection . . 120dB

One of the many applications for the µA725 is in Linear photodetection systems. Use of a PIN Photodiode with the µA725 provides the user with a low noise linear detection system which operates from low voltage supplies and has none of the inherent disadvantages of photomultiplier tubes (high voltage supplies, aging effects, large physical size, high power dissipation).

Reader Service Number 509



µA725 PIN PHOTODIODE AMPLIFIER

Micropower Exists-µA735

Minimizing power drain, weight and space gives design engineers ulcers (how come the system power supply designer is the last one to know you've overrun the allotted system power consumption?).

Here's good news. Relief exists:

The µA735 micropower operational amplifier uses only 100µW at ± 3.0 volts.

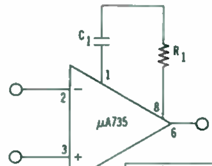
Systems such as space vehicles, aircraft, and portable medical equipment will benefit from the use of the µA735 by shrinking bulky batteries. It gives you low quiescent currents. It also gives you versatile, accurate and cool operation without the customary design tradeoffs.

In addition, the µA735 simplifies design of high impedance instrumentation circuits due to its extremely low input currents.

Here are some typical device specifications:

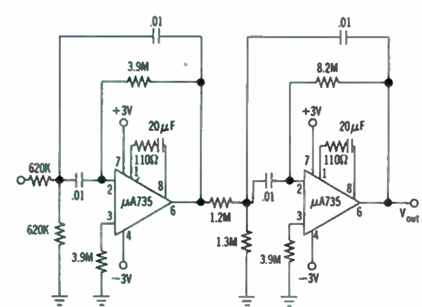
input offset current	500 pA
input bias current	5.0 nA
input offset voltage	1.0 mV
supply voltage range	± 3 volts to ± 18 volts
power consumption	100 µW
open loop voltage gain	20,000
input impedance	10 mΩ
noise	.5 pA / √ Hz

Smart engineers who like to minimize component count can now take advantage of a new simplified frequency compensation scheme that applies over the entire supply voltage range of the µA735.



Closed Loop Gain	C_1	R_1
1	20nF	110Ω
10	2nF	1.1kΩ
100	680pF	11kΩ

Most engineers like to eliminate those large, expensive, hard-to-find capacitors that hog space and dollars. Here's a nifty little application which will avoid large capacitors in low frequency, active filter design. And with very low supply current drain!



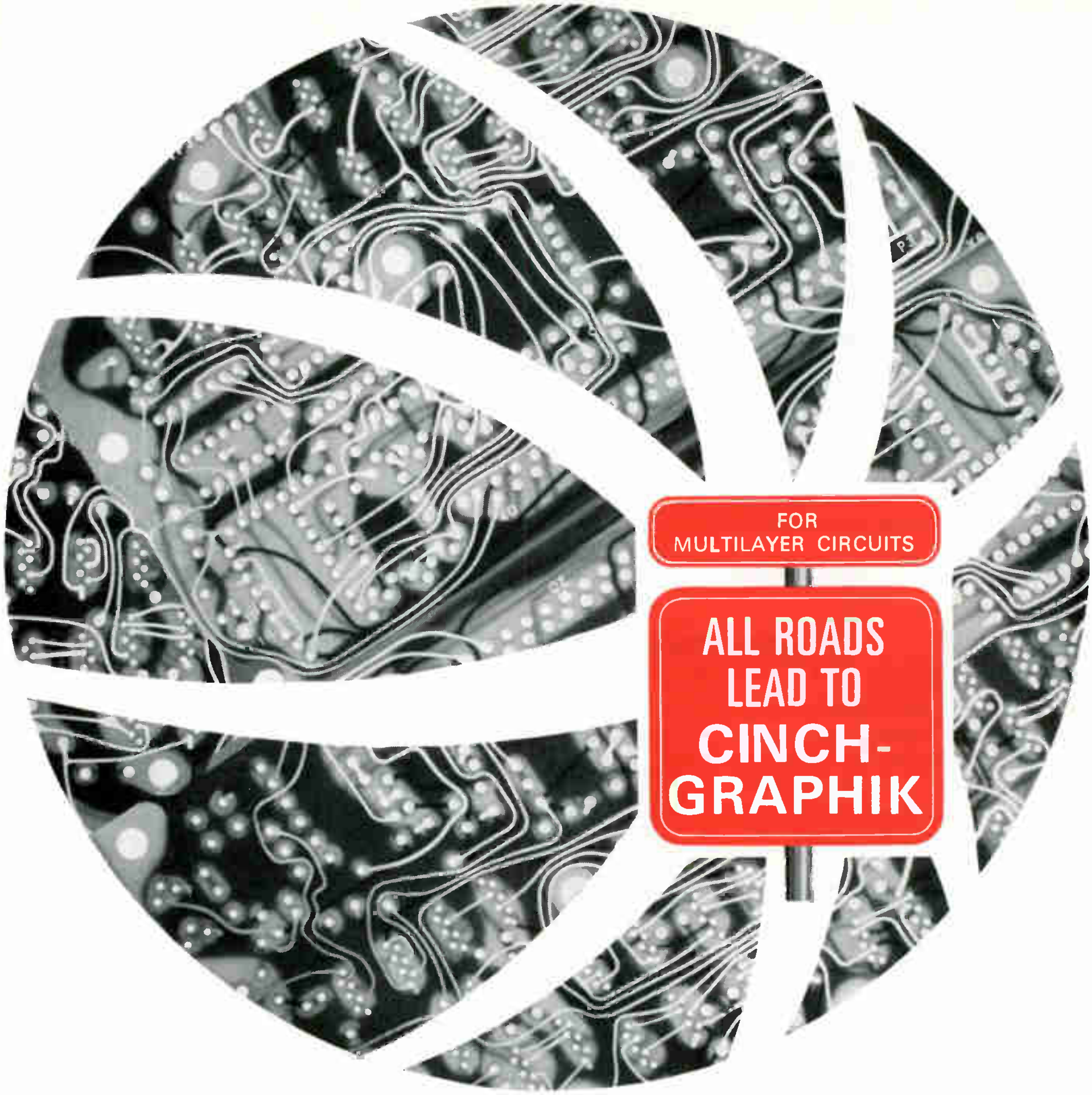
This circuit has a center frequency at 10 Hz, 12 dB rolloff with −3 dB points at 6.5 Hz and 14 Hz. The µA735 lets you use small capacitor values and large resistors for frequency shaping at a few Hz, due to the µA735's low input offset current.

The new price is low, too—

µA735	−55°C to +125°C	$37.50 @ 100
µA735B	−20°C to +85°C	$22.50 @ 100
µA735C	0°C to +70°C	$15.00 @ 100

See? Micropower does exist; alive and in quantity at your Fairchild distributor.

Reader Service Number 510



For multilayer or precision double sided boards with plated-thru holes,—in volume—the place to go is Cinch-Graphik—the world's largest independent producer of precision circuits.

For information on the capabilities and automated facilities of Cinch-Graphik, contact your local Cinch Electronics Group District office or Cinch-Graphik, 200 South Turnbull Canyon Road, City of Industry, California, 91744.
Phone (213) 333-1201.

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Circle 73 on reader service card →

The ultimate oscillator.

Now there's a true function generator that's priced like an oscillator.

The new Model 130 delivers sine, square, triangle and sync outputs from 0.2 Hz to 2 MHz with flat frequency response and low sine distortion.

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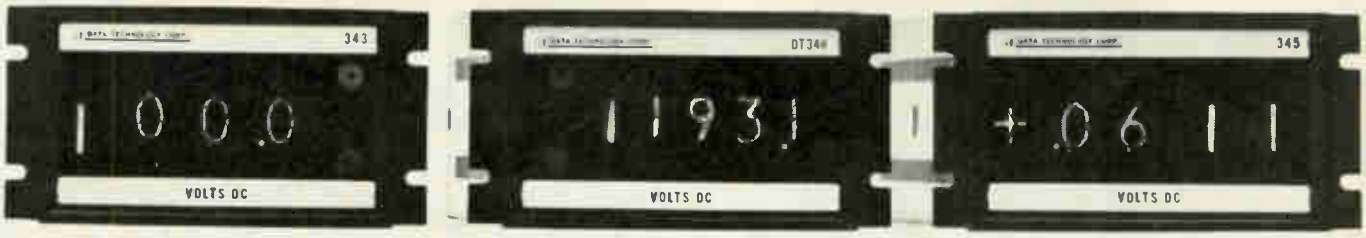
Safety in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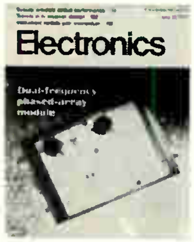
July 20, 1970

Article Highlights

Versatility's designed into dual-band module for phased arrays
page 78



A unique transmit-only solid state radar module promises great things for the future of phased array systems and could end the need for separate radar and communications antennas. The module, built with microstrip techniques, operates at both L and S bands and incorporates the phase shifting circuitry needed for phased-array operation. A dual-frequency radar system built with these compact modules in not much more space than that required by a single system could do the work of several at less cost than the units it replaces.

MOS memory travels in fast bipolar crowd
page 82

Silicon on sapphire, an up-and-coming technology, now is taking MOS into speed ranges that had been exclusively the preserve of bipolar IC's. One speedy device being developed is a 256-bit MOS random-access memory with access time of only 40 nanoseconds. And once mass production brings down the price of silicon substrates, considerable savings should be realized.

Modified CAD device models reduce circuit analysis costs
page 90

Computer-aided design programs are a fine circuit-analysis tool but sometimes suffer from overkill. For example, if the designer requires only a low-frequency analysis, few programs are designed to speed up the many small iterations made by the computer to solve for high-frequency transient responses. Now, by proper adjustment of an active device model's critical parameters, expensive computer time can be saved with no loss of accuracy.

IC's save power, boost efficiency of voltage regulators
page 94

Near-ideal power supply performance can be obtained by combining the best features of both series and shunt regulators without the usual disadvantages. Now it's easy with low-cost, commonly available IC operational amplifiers and regulators that yield a highly efficient, highly stable power supply.

Design pruning trims data modem costs
page 99

In a large digital data network requiring transmission from remote terminals, the ubiquitous data modem can be a costly item. Clever circuit economy and generous application of digital design techniques have yielded a 1,200-bit-per-second unit that's within the price range attractive to such cost-conscious computer users as educational institutions.

Coming

How safe are consumer products?

Recent alarming reports citing fire, shock, and radiation hazards in color tv's, radios, and microwave ovens have fanned continuing controversy over how safe consumer electronics products really are. A special report tells why hazardous designs sometimes reach the marketplace, and what's being done about it.

Versatility is designed into dual-band module for phased array systems

Built with microstrip techniques, L- and S-band transmitter is a step toward multifrequency and multifunction phased array networks

By Alfred Rosenblatt, *Electronics' staff*

● A two-for-one approach promises to be the trend of the future in reducing costs of phased array radar systems and easing up cramped space requirements on ships or in aircraft. The concept is a dual-frequency radar system that uses compact modules to operate at more than one frequency and operates with a single antenna. Such a system can do the job of several in not much more space than a single unit occupies. And it will cost less than the separate systems it replaces.

Lockheed Electronics, Plainfield, N.J., has developed the first module for an all-solid state phased-array system that operates at multiple frequencies. The transmit-only radar module produces 32 watts of peak power at 1.25 gigahertz, or 8 watts at 3.75 Ghz, its third harmonic. Cooled by forced air, the unit produces 100-microsecond pulses at a 10% duty cycle. The module was funded both by Lockheed and by the Naval Research Laboratory; the resulting dual-frequency techniques dovetail nicely with the Navy's Ships Integrated Electronics System (SIES).

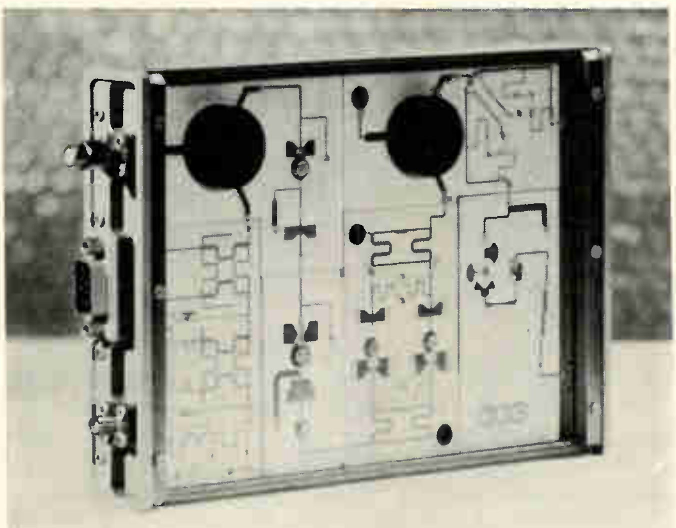
In SIES, the Navy is considering the total electromagnetic environment aboard a ship, determining how various electronic systems may be integrated within themselves and within the vessel to conserve physical and electromagnetic spectrum space. As such, the SIES effort furthers the trend started with the DD-963, [*Electronics*, July 6, p. 102] in which naval vessels are built as a single integrated system, with both the vessel and its electronics designed simultaneously.

In part the SIES effort resembles the Air Force's Unified Communications, Navigation, and Identification (UCNI) program [*Electronics*, May 11, p. 33]. Navy thinking goes beyond the CN and I functions to include such things as radar and command and control functions.

Right now, the exact goals of the SIES effort—it is not a firmly established program yet, points out one Navy source—are still being worked out in discussions among organizations like the Navy's Office of Naval Operations, Ships Systems Command, Electronics Command, and the Department of Defense Research and Engineering.

Along with integrating electronic "black boxes" aboard a ship, it's also possible to further save space and reduce costs, as well as end the need for separate radar and communications antennas, by combining various antennas in a common array of elements. The key is to get harmonically related frequencies. The half-wavelengths are then integral multiples of each other and the number of elements in each band is proportional to the square of the harmonic number.

Thus, for the Lockheed module, L- and S-band antenna elements could be nested within each other, with every third element in a row of the S-band array also serving as an L-band array element.



L and S. Lockheed Electronics' electronically steered, dual-frequency transmit module, fabricated in microstrip, measures roughly 7½ by 5 inches. Eight circuit functions, each on its own alumina substrate, make up the module.

It's feasible to design systems using multifrequency modules and sharing a common antenna array to operate at frequencies ranging anywhere from L through X band, points out Robert W. Easton, manager of Lockheed's dual-frequency module project. Such a system could be digitally controlled to shift from one frequency to the other. And it could perform multiple functions, including multi-target acquisition and track, communications and navigation, Easton says.

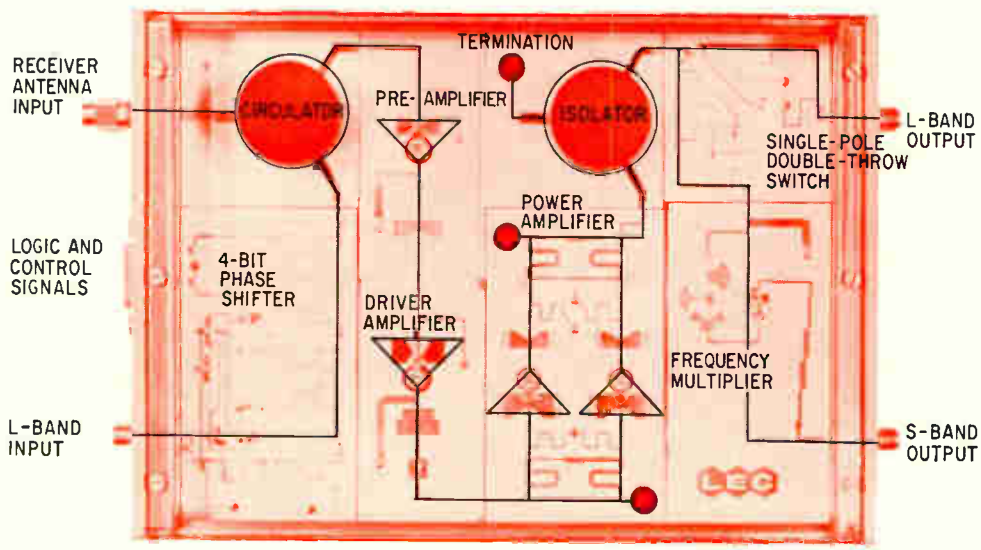
The Lockheed module accepts a pulsed, L-band input signal of 250 milliwatts. It's then digitally phase shifted, and is passed through a circulator and into an amplifier. Then the signal is either applied through an isolator to an L-band output connector, or is frequency multiplied by a factor of three and applied to an S-band output. Output frequency is selected by a logic-controlled switch circuit. Designed completely in microstrip, the module measures about 7½ by 5 inches, and is one inch deep. It weighs just 27 ounces.

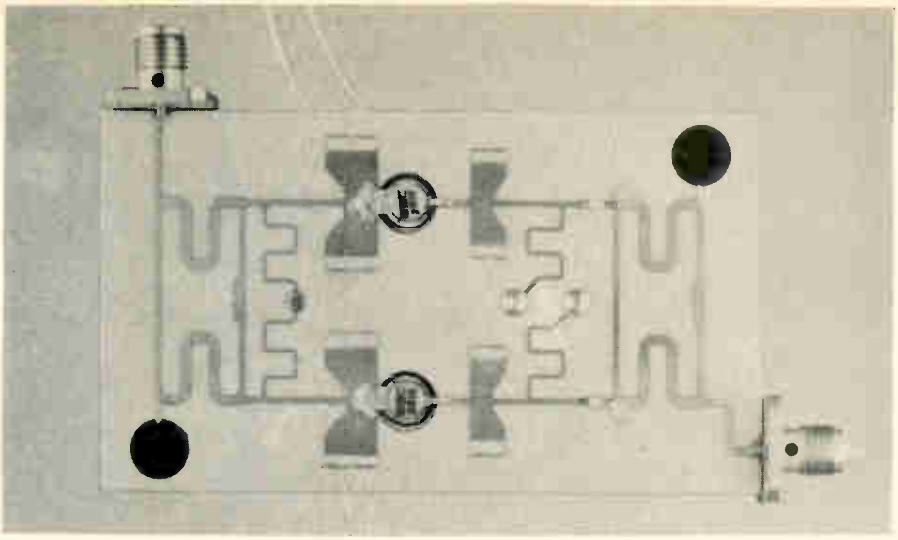
L-band power is provided over a 10%, 1-decibel bandwidth at 1.25 Ghz. (The 3-db bandwidth is about 15%.) At 3.75 Ghz, the bandwidth is reduced to 10% at 3 db. These percentage bandwidths are needed because such a module, although fixed tuned, also would have to operate at other than its center frequency.

The module contains eight separate circuits, as shown below. Each circuit is built on its own alumina substrate and performs a distinct function. At the module's input is a phase shifter circuit consisting of four digitally controlled phase bits. This circuit provides 337.5° of differential insertion phase in 22.5° steps. A circulator isolates and couples this output to a three-stage amplifier and can route received signals through its other port which, in the present module, is not used but was designed for possible use in future systems.

Each circuit's alumina substrate is 25 mils thick and is bonded with a heat-conducting silver-loaded epoxy to a ¼-inch-thick aluminum frame. (The epoxy also has other functions. For example, it acts as ground-return path for the varactor diode in the multiplier.) Miniature coaxial connectors then are bolted to the frame so the circuit may be tested and aligned. After testing, the connectors are removed and the substrate frames are bolted into an aluminum carrier frame that forms the complete module. End and side plates are added, with connectors passed through directly to the circuits.

Within the completed module, the circuits butt together at machined surfaces raised from the sides of the aluminum frames, as shown at the bottom of the next page. The frames are screwed together to form a continuous ground. The substrates actually are set slightly back from the frame edges so that they won't grind against





Powerful. L-band power amplifier delivers 40 watts of peak power—100 microsecond pulses at a 10% duty factor—with two r-f power transistors in a power divider/combiner circuit.

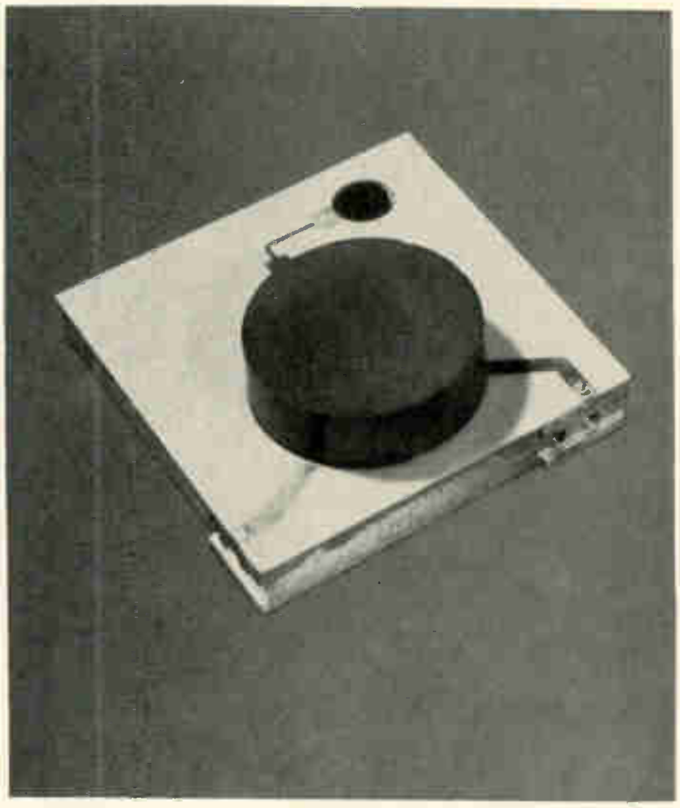
each other. The resulting 10-mil-wide gap between substrates is easy to bridge when the individual circuits are interconnected, Easton says.

In the future, however, Lockheed plans to integrate the now separate circuits on two substrates at most, says Easton, to cut fabrication costs. Alternate interconnecting paths and extra tabs might be added to help in testing the completed circuit. The entire module could even be fabricated on one large substrate. But Lockheed fears processing problems may be encountered in putting such a large piece of alumina through the photographic and plating steps. Moreover, says Easton, Lockheed is considering selling the individual circuits it has developed.

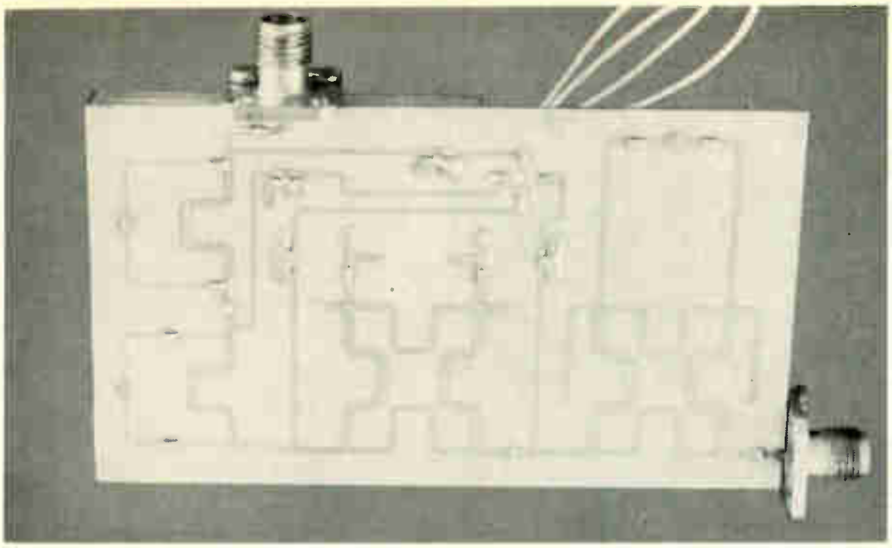
Lockheed's circulator is of its own design. It's a one-inch-diameter device fabricated in microstrip and operating in an above-resonance mode, says Lawrence H. Silverman, the engineer who designed much of the module's circuitry. Microstrip devices offered by outside suppliers all operate in a below-resonance mode and are about twice as large, he points out. Balanced stripline units, which would have been small enough, would have been difficult to integrate with the microstrip technology, Silverman says.

Circulators are generally designed so that the ferrite material is biased to operate in a below-resonance mode. This mode requires a smaller externally applied magnetic field than does ferrite material operating above resonance. In addition, the size of the circulator remains fairly small for S- through X-band operation.

But at L band, the size of a below-resonance circulator is just too large for Lockheed's requirements, Silverman says. This type of circulator also has a low characteristic impedance—one ohm—because its ferrite material cannot be thicker than the 25-mil height of its microstrip substrate. (The thicker the ferrite disk, the larger its impedance.) This makes for difficult matching in a 50-ohm system. On the other hand, the impedance of Lockheed's above-resonance unit is 18.8 ohms. And its operating characteristics—20 db isolation, 10% bandwidth, and insertion loss of 0.5 db—equal those of most stripline and below-resonance-microstrip designs, Silverman asserts. For his microstrip design, Silverman sliced a stripline circulator structure down the middle of its plane of symmetry. Thus, instead of using two ferrites separated by a conductor, he uses



Interface. Special machined surfaces on the aluminum frame to which the individual substrates are bonded are used to bolt together circuits in the completed module. Circuit shown here is the above-resonance mode circulator which has vswr of 1.35 maximum, 20 db isolation.



Phase shifter. Four-bit diode phase shifter uses p-i-n diodes in a loaded-line configuration to provide the 22.5° and 45° phase shifts, and in quadrature hybrids for the 90° and 180° shifts.

only one, with one magnet above and another below.

The circulator was fabricated by ultrasonically drilling a 0.9-inch-diameter hole in the alumina substrate. The ferrite disk, some 2 mils smaller in diameter, is fastened in the hole with nonconductive epoxy. Electrical connections to the disk are made with soldered 5-mil-thick copper strips. Quarter-wavelength transformers of about 30 ohms match the circulator's impedance at 1.25 Ghz to the 50-ohm microstrip line.

To operate in the above-resonance mode, the circulator requires an external magnetic field of 2,400 oersteds,—about 1,000 oersteds greater than in the below-resonance mode. The required field is large enough to require two cylindrical magnets, one on either side of the ferrite. However, in a below-resonance device, one magnet would have sufficed. Lockheed uses magnets made of a barium ferrite because its properties remain stable with age and temperature. The magnets are an inch in diameter and 0.40 inch high.

The three-stage solid state amplifier consists of preamplifier, driver and power amplifier stages. It boosts the input signal to 40 watts peak power at L band, at a gain of 26 decibels. (L-band output power actually is only 32 watts due to switching losses.) This signal then goes into an isolator which buffers the amplifier from the output p-i-n diode switching circuit. Digitally controlled, the switch routes power from the L-band amplifier either to the L-band output of the module or to the varactor multiplier. The 8-watt S-band output from the multiplier is applied to a separate connector.

The power output peak is supplied by two r-f power transistors in a power combiner/divider configuration, according to Easton. Such power is obtained with only two transistors using Microwave Semiconductor Corp. MSC 2010's, Easton says. These power transistors, rated 10 watts for continuous operation at 2 Ghz, can handle about 20 watts of peak power at the lower, 1.25-Ghz frquency. Over-all d-c-to-r-f conversion efficiency of the complete amplifier is 40%. Gain of the power stage, shown at the top of page 80, is 7 db.

The impedance of both driver and preamplifier transistors varies with input power level and frequency, due mainly to the parasitic reactances of the transistor's package. This is characteristic of large-signal r-f power transistors. Lockheed operates the transistors saturated to keep phase shift through the amplifier constant with drive level. Saturated operation also allows the amplifier to tolerate an input variation of ±1 db while maintaining constant output, Easton notes.

To match the driver to the power amplifier, Lockheed uses a quadrature coupler. This tends to isolate any impedance changes that occur in the power-amplifier stage. Since any reflected signals caused by the mismatch are absorbed in a terminated port, the mismatch doesn't upset the driver stage's balance. Also, if one of the power-stage transistors fails, only half of the input signal is reflected back and lost. The other transistor continues operating normally and the over-all module power drops but 3 db.

Lockheed also uses a quadrature coupler to match the power amplifier output to the switch. Terminations in the amplifier couplers are metal film resistors on a beryllia base. This allows the terminations to handle fairly high power—7 watts c-w—without overheating.

Transistor bias voltages are routed by feed-thru filters placed in holes drilled in the alumina substrate. Easton feels that using the filters is simpler than having to bypass each voltage-feed pin with a high quality r-f chip capacitor.

The four-bit phase shifter circuit used for beam steering, shown above, uses p-i-n diodes. It provides up to 337.5° of phase shift, with an insertion loss at any phase shift of 2 db ±½ db, using a combination of 22.5°, 45°, 90°, and 180° steps. The smaller shifts—22.5° and 45°—are obtained simply with shunt-loaded transmission lines; the larger shifts are achieved by placing p-i-n diodes in the output ports of two quadrature hybrid couplers. In each coupler, the phase shift depends on how the signal is reflected by the diodes at the output ports, or on whether the diodes are on or off. The coupler technique requires only two diodes per 90° or 180° phase shift, Easton points out. With a loaded line design, three diodes would be needed for a 90° shift and five diodes for a 180° shift.

The frequency multiplier uses a high-power varactor diode to provide 8 watts peak output at 3.75 Ghz. At the input is an elliptic low-pass filter chosen for its small size and sharp cutoff characteristics. The output filter is a quarter-wavelength, coupled-line bandpass filter.

There are two other circuits in the module. The switch is designed fairly conventionally, says Easton. And the isolator is a circulator with one port terminated. ●

MOS memory travels in fast bipolar crowd

Silicon-on-sapphire technology yields a 256-bit random-access memory with access time of only 40 nsec and potentially inexpensive fabrication

By Edward J. Boleky, Joseph R. Burns, John E. Meyer, and Joseph H. Scott,
David Sarnoff Research Laboratories, RCA Corp., Princeton, N.J.

● When you can build economical metal oxide semiconductor devices that operate at bipolar IC speeds, you know you've found a jewel of a technology. Silicon on sapphire is the name of this sparkling process, and some of its gems are a 50-stage dynamic shift register with a 90-megahertz clock rate, an associative memory with 10-nanosecond write and search time and a 50-megahertz digital correlator.

These and other high speed MOS-SOS circuits were built under Air Force sponsorship to demonstrate the potential of SOS technology. The results have been so encouraging that a larger pilot production line for a process evaluation is being established, with an eye to full-scale commercial manufacturing in a year or two. And there's good reason to believe that, in spite of the present high cost of the sapphire substrate material, SOS eventually will be price competitive with conventional MOS IC's made of bulk silicon [*Electronics*, June 8, p. 88].

Theoretical analyses have shown that MOS IC's could be faster than bipolar integrated circuits. [See panel on opposite page.] This might be surprising in view of the slow switching performance of available MOS circuits vis-a-vis bipolar IC's.

The reason for this discrepancy between the ideal and the real is parasitic capacitance. MOS IC's are slowed down by the parasitic capacitance that abounds on the chip between the gate and source or drain electrodes, and between metal interconnections on the surface of the oxide and the silicon substrate under the oxide.

Here silicon on sapphire offers a significant advantage. With SOS, sapphire, which is just a rhombohedral crystalline form of aluminum oxide, replaces bulk silicon as the structural base of the IC. Because sapphire is an insulator, parasitic interconnection capacitance is reduced to negligible levels, as is current leakage to the substrate. Moreover, since the active elements are contained in thin-film islands of silicon on the surface of the sapphire and therefore are electrically isolated from each other, parasitic interaction among these elements is eliminated. Most important, the thinness of the silicon film allows the source and drain to be diffused all the way to the silicon-sapphire interface. This results in a drastic decrease in the source and drain junction area and junction capacitance.

This is why RCA's random-access memory will exhibit such a short access time: computer simulations indicate that the time to address and read any bit in the memory, including the full address decode, is 40 nsec. The actual access time in an operating system, of course, will be somewhat longer because of delays in interface circuits and off-chip stray capacitance.

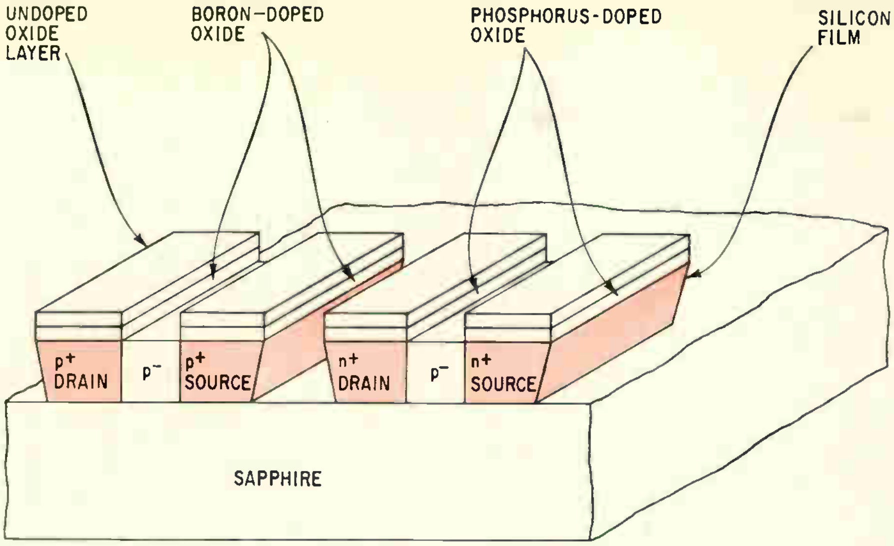
Both design and layout of the SOS RAM are quite conventional, although less chip area is required than for standard p-channel or complementary MOS. The basic cell for each bit is used in many commercially available static MOS memories. Cell transistors are designed with a conservative 0.4-mil-wide channel; no effort has been made yet to squeeze in the maximum number of cells per unit area. All in all, the performance potential of SOS has barely been tapped in the RAM.

The memory cell employs complementary MOS transistors. Complementary MOS inherently provides higher speed and lower power dissipation than p-channel MOS [*Electronics*, Jan. 5, p. 170]. Although C/MOS requires considerably more processing than P/MOS in bulk-silicon IC's, the extra work involved in RCA's SOS technique is only slight; one extra oxide deposition and one more etching step do it.

Efforts have been confined to memory-type circuits, rather than logic devices. Logic IC's use a variety of different-shaped cells, not just the single cell of memory circuits. Logic IC's also employ irregular metal interconnections, not the highly repetitive patterns encountered in memory circuits. Because these factors increase the area per function of logic IC's, they limit the number of gates that can be put on a chip of any given size, and make it necessary to transfer signals from chip to chip rather than process them completely on a single chip. Bipolar circuits have a clear edge here because they can drive the large capacitance that the printed-circuit wiring presents between chips. MOS circuits—even SOS MOS—cannot do it because of the high impedance of the MOS transistor.

But in memory circuits, where the complete function can be accomplished on a single chip, SOS MOS really shines. And the market for IC memories is extremely important—it could amount to several hundred million dollars per year by the end of the 1970's as computer manufacturers replace ferrite cores with semiconductors.

Typical conventional static MOS RAM's have access times measured in hundreds of nanoseconds. An



Solid diffusion. Dopants from boron- and phosphorus-doped oxides diffuse simultaneously into the silicon film to form p-channel transistor (left) and n-channel device (right). Complementary transistors thus are made in a single high-temperature operation.

approach to speeding up conventional bulk-silicon MOS RAM's is to perform address decoding functions externally with bipolar circuits. But there are two major problems: first, the access time is still about three times greater than that of the SOS RAM; second, packaging the MOS chip becomes extremely difficult because of the large number of leads required to connect to the external address and decode circuitry. For example, about 40 leads are needed for a 256-bit memory of this type—enough to place the economy and reliability of the traditional wire bonding method in doubt.

But the 256-bit fully decoded SOS RAM needs only 13 leads, so wire bonding still is practical. Moreover, with that number of leads the chip can be put in a standard dual-in-line package. And even if the capacity of the fully decoded SOS RAM is quadrupled to 1,024 bits, only two extra leads are required.

Moreover, as conventional P/MOS cells are made smaller to cram more bits on the chip, the sense current output gets smaller. The magnitude of the sense current from the memory chip determines the design of the external sense amplifier: the lower the sense current, the more complicated the external amplifier. A p-channel MOS memory chip with extremely small geometry may have a sense current as low as 80 microamperes. The designer has merely converted an internal problem to an external one: although the chip is smaller, the external circuitry is larger, so there's no net size reduction. In the 256-bit SOS RAM, however, sense current exceeds 300 microamperes, a level that's easy to amplify and thus benefits the total system.

Another major advantage of SOS sense current is minimal noise problems. Even if a low sense current can be discriminated by the sense amplifier, a noise problem remains because in a big system, noise spikes far exceed a sense current of 50 or even 100 microamperes. So, before sensing can be accomplished time must be wasted while the noise settles below the sense current level. No waiting is necessary with the SOS RAM, however—the current is well above the noise level.

The high-speed performance of SOS integrated circuits isn't limited to active-element memories. A 256-bit read-only memory, for example, has been made from vertical-junction SOS diodes by means of an extremely simple process that employs one diffusion and one oxidation step. Yields of perfect packaged diode arrays were

Faster than a speedy bipolar . . .

If parasitic capacitance is eliminated—as it is just about eradicated in silicon on sapphire—the switching speed of MOS integrated circuits should be equal to or be even less than that of bipolar integrated circuits. The reason lies in the mechanism of carrier transfer. In the bipolar transistor, charge carriers diffuse at a rate established by the thermal voltage within the silicon bulk. Thus in the expression for transit time in a bipolar transistor, the diffusion constant of minority carriers in the base, D, which depends on the thermal voltage, kT/q, is the controlling factor for a given base width W_B:

$$t_{bi} = \frac{W_B^2}{2.4D} = \frac{W_B^2}{2.4\mu\left(\frac{kT}{q}\right)}$$

where μ is the mobility of minority carriers in the base region, k is Boltzmann's constant, T is the absolute temperature, and q is the charge on an electron.

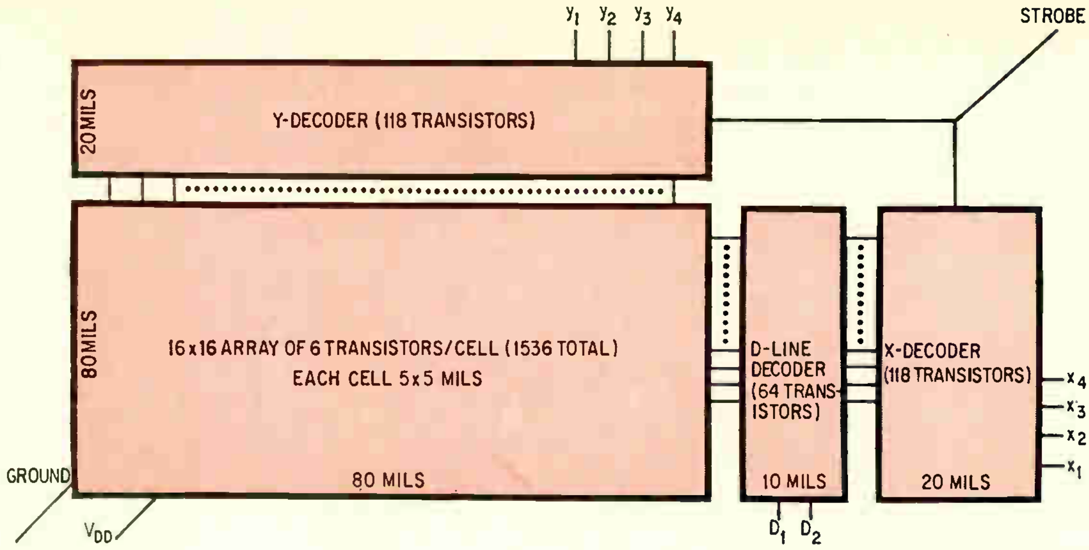
In an MOS transistor, on the other hand, majority carriers move at a drift velocity determined by the operating voltage, V_o, and the effective mobility $\bar{\mu}$ at the oxide-silicon interface:

$$t_{mos} = \frac{4}{3}\,\frac{L^2}{\bar{\mu}V_o}$$

where L is the channel length. In this transit-time equation, as in the one for the bipolar tansistor, parasitic capacitance terms have been dropped on the premise that their contribution is negligible.

Assume that the following values are typical for the terms in the equations: $L = 5$ microns, $\bar{\mu} = 250$ cm^2/volt-second, $V_o = 10$ volts for the MOS transistor; $W_B = 1$ micron, $\mu = 600$ cm^2/volt-second for an npn bipolar transistor with a base resistivity of 1 ohm-cm. For these values, t_{MOS} is 0.133 nanosecond and t_{bi} is 0.28 nsec.

Some argument could be offered about the precise values assumed for the terms, but the basic conclusion is unmistakable: without parasitic capacitance, MOS transit time is in the same ballpark as bipolar transit time.



75%. When the 256-bit ROM's were breadboarded as a 4,096-bit ROM with emitter-coupled-logic driver and sense amplifier, a system access time of 18 nsec was obtained. Larger, electrically alterable SOS diode arrays are under development.

It's a widely held view that because of the cost of the sapphire substrate, SOS is an expensive technology. While it's true that materials for SOS circuits cost about five times more than those for conventional bulk IC's, there's every reason to believe that this figure will drop and approach that of silicon as synthetic sapphire is mass produced. Moreover, recent advances in the production of spinel substrates have made this material available in quantity and at relatively low cost. [*Electronics*, July 6, p. 44]. Spinel is a crystalline material similar to sapphire, but more compatible physically and chemically with silicon. In any event, the substrate cost is only a fraction of the total processing cost of about $50 per wafer in volume production.

Actually the cost factor favors SOS—or silicon on spinel—over bulk silicon because the insulating substrate affords a far greater process yield. The insulating sapphire substrate eliminates the need for guard bands surrounding the transistors to provide p-n junction isolation, thereby cutting out the extra masking and diffusion steps required in bulk silicon in order to separate the components electrically. And this exposes the SOS IC's to fewer possibilities for introducing fabrication defects than either C/MOS or bipolar circuits.

Complementary MOS SOS circuits require no more diffusion steps than conventional P/MOS circuits, because the dopant for both n-channel and p-channel transistors is introduced simultaneously and the thick field oxide between devices is eliminated. In addition, the sapphire substrate gives C/MOS circuits an edge in yield over bulk P/MOS. This is because the silicon area of an SOS circuit is less than 5% of the area of a bulk silicon circuit, because of greater packing density and the small amount of silicon that's actually needed for the devices. There is a proportional reduction in the number of pinholes in the insulating oxide. Therefore, the SOS process should allow fabrication of bigger chips with greater memory capacity at higher yield and lower costs to the user.

One of the factors that has inhibited the emergence of the SOS technology is that the circuit's active parts are contained in an extremely thin film of silicon—about 10,000 angstroms—and built up on a material that has a quite different crystal structure. Success in SOS fabrication requires an adjustment of the photoetching and diffusion processes to minimize these limitations.

The difference between crystal structures—sapphire has a rhombohedral structure while silicon is cubic—means that some crystal distortion of the silicon is inevitable when it is grown on sapphire. This distortion becomes less significant as the silicon gets thicker. But since the difficulty of depositing metal interconnections over the silicon islands increases as the film gets thicker, the thickness can't be increased indefinitely; 10,000 angstroms is the practical limit. So the single-crystal silicon film will always suffer from some distortion.

The most obvious effect of this distortion is a reduction in carrier lifetime. But, with care, the lifetime can be as much as 90% of the bulk silicon lifetime, and the performance of the MOS transistors doesn't suffer.

Another more serious effect of the crystal distortion is the variation of the rates of both diffusion and etching. Etching proceeds more rapidly at the bottom of the silicon film than at the top, resulting in substantial undercutting of the silicon islands. The solution is to reduce the concentration of the etching solution and change the etching conditions as the etchant penetrates deeper into the film. Then, although some undercutting still occurs, it's far less serious.

In addition, dopant tends to diffuse far more rapidly as it gets near the silicon-sapphire interface where distortion is greatest. Therefore, it's easy for the source and drain of a transistor to meet and short out at the bottom of the silicon film.

The cure is to limit the circuit's exposure to high temperature to a single diffusion step. With tight control of temperature and time, diffusion of drain and source will occur vertically through the silicon film to the sapphire interface, but the drain and source will not spread appreciably toward each other. And they will not spread laterally during subsequent process steps; the temperature won't be high enough.

Getting down to one high temperature step is somewhat tricky, particularly in the case of complementary MOS IC's, where two distinct dopants—n-type and p-type—must be diffused into the silicon. RCA's solution is to use solid diffusion, so that both dopants can be diffused

Blocked out. Superfast 256-bit complementary MOS SOS random-access memory requires only 13 external connections. In this block diagram, which is not drawn to scale, dimensions on each functional block indicate the area the function occupies on the SOS chip. Expanding the RAM to 1,024 bits would require a larger chip but only two additional external connections—one more x decode pin, x_5, and another y decode pin, y_5.

simultaneously, as shown above, during thermal growth of the gate oxide at 1,100° C. Subsequent steps are done at much lower temperatures.

The dopants are deposited on the silicon surface in the form of oxides. To form the p-channel transistors, a layer of silicon dioxide containing boron is deposited on the silicon surface at 300° C. This boron-doped oxide is photolithographically etched away so that it remains only in those regions where drains and sources of the p-channel transistors are desired. Next, a layer of phosphorus-doped SiO_2 is deposited over the entire SOS wafer and likewise etched so that it remains only where n-channel transistor sources and drains are needed. Then the wafer is placed in an oxidation furnace, the gate oxide forms, and the drain and source regions of both n and p channel transistors are diffused into the silicon simultaneously.

This single-step method for SOS was developed out of necessity, but actually it offers significant advantages for bulk IC fabrication, too. One benefit, for example, is that the n and p channel have virtually identical lengths, and therefore identical threshold voltages of 0.5 volt. In bulk C/MOS processing, on the other hand, one type of device is diffused first, and tends to continue diffusing—and narrowing the channel—during the diffusion of the other type of device.

The p-channel transistor used in RCA's SOS circuits, a deep depletion device developed by F.P. Heimann, is unusual in that it is based on lightly doped p-type (p^-) silicon instead of n silicon. Because the silicon layer is so thin, and because the concentration of p dopant is so light, the channel can easily be depleted of carriers. In fact, at zero gate voltage, the channel is depleted and the transistor therefore is off. When the voltage is raised above about 0.5 volt, the transistor turns on and behaves just like a normal p-channel transistor. The deep depletion transistor, taking advantage of the fact that the silicon is a thin film, makes it possible to use the same p^- silicon for both n-channel and p-channel transistors without a counter-doping step to alter the polarity of the p-channel devices.

For the most part, however, the thinness of the silicon is a mixed blessing. It makes contamination more of a problem than in bulk IC fabrication. In bulk silicon, the 10-mil thickness of the wafer provides a fairly large capacity for absorbing and diluting contamination so the effect on device performance is negligible. But in the 1-micron film of silicon in SOS devices, there's no place for the contamination to go—the sapphire acts as an almost impenetrable barrier—so that the contamination remains in the device's active region. Even the oxide that's grown on the silicon as a functional part of the device can saturate the silicon film with oxygen. If the film is subjected to heat after oxide formation, these oxygen atoms can be activated, drastically altering device characteristics.

Even the sapphire substrate can be a source of contamination. Sapphire, after all, is just a crystalline form of aluminum oxide, and both aluminum and oxygen atoms can diffuse from the sapphire into the silicon film.

Again, the one-step high-temperature exposure of the fabrication process offers a solution. Because the wafer is subjected to high temperatures only during one diffusion step, the opportunity for unwanted diffusion is minimized.

One remaining production problem was metalization. Each silicon island on the sapphire substrate is about 10,000 Å high, and aluminum stripes must climb up to interconnect these islands. A similar problem is encountered in bulk MOS circuits, where the aluminum metalization must pass over oxide as high as 14,000 Å. The difference in SOS is that the islands are slightly undercut—because the dislocated crystal at the bottom of the silicon film etches faster—and the metalization must therefore climb an overhanging slope. The solution, it was found, is to use thicker metalization. When 1.5-micron-thick aluminum was substituted for the usual less-than-1-micron aluminum, the resulting metal path over the step was continuous and reliable.

The solution to these problems is really only the beginning. Now that the basic technology has been proven and large-scale integrated circuits have been constructed, it's possible to move on to advanced circuit designs and fabrication techniques such as ion implantation and self-aligning gates. ●

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Designer's casebook

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

Preset pulse train checks sequential logic

By Bruce M. Smith

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Testing clocked sequential logic circuits is easier with a pulse generator that can be set to produce a train of any number of pulses. The states of the logic circuits then can be checked after the preset number of input pulses are applied. With six integrated circuit packages and two 10-position, 4-pole rotary switches, the number of pulses can be set to any number between 1 and 99.

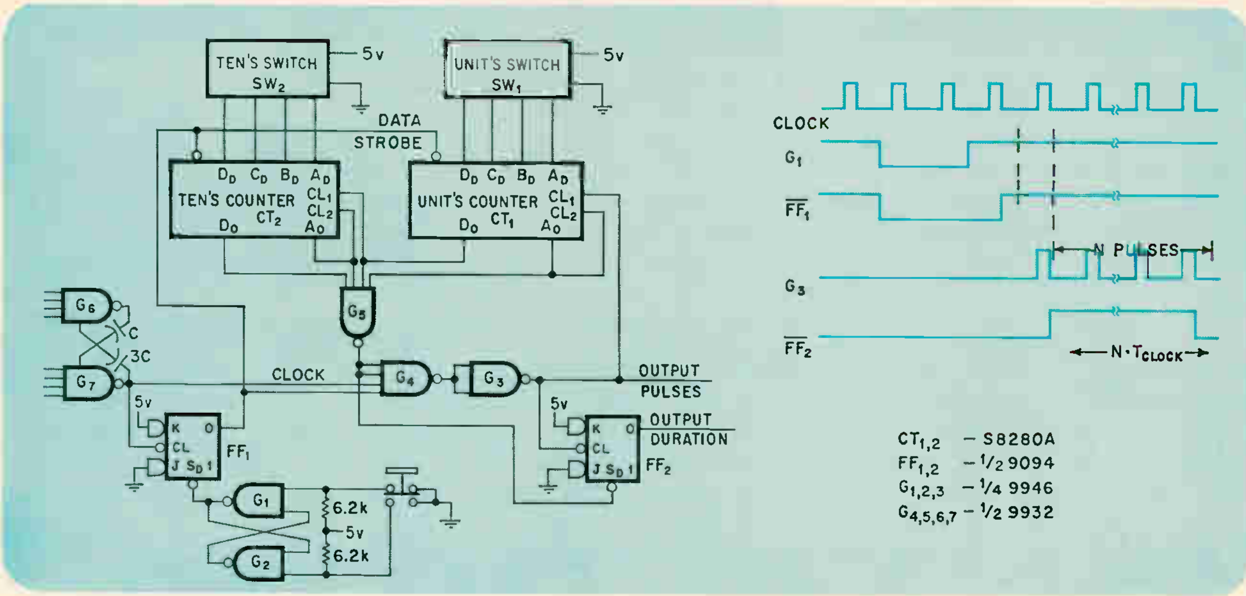
The rotary switches are wired to give the nine's complement, in binary-coded decimal format, of the selected number of output pulses. The clock can be obtained from gates wired as an astable multivibrator, as shown, or from an external source.

After the rotary switches are set, the pushbutton is depressed; the circuit generates pulses when it's released. Upon depression, the G_1-G_2 latch, used to prevent effects of contact bounce, sets FF_1. This causes FF_1's 0 output to go low, removing enabling input from G_4. The FF_1 0 output also acts as data strobe input to the counters and enters the switch information into the counters—the nine's complement of the desired number of pulses (the counter will actually count from this number to 99, thus producing the number of pulses as set on the switches).

The first clock pulse following the release of the pushbutton resets FF_1, which enables G_4 and the decade counters. Beginning with the next clock pulse, output pulses appear and are counted by the counters. The use of a clocked flip flop FF_1 guarantees that all output pulses will have the same width regardless of the timing of the asynchronous release of the pushbutton.

Output pulses continue until the counters reach 99. At this time, both D_0 and A_0 of each counter are 1's. This causes the output of G_5 to go low so that G_4 turns off and blocks the flow of clock pulses to the output. The circuit then stays in that state until the pushbutton is depressed again, either with or without changing the settings on the two rotary switches.

The extra flip-flop FF_2 yields an output pulse whose width equals the time taken by the preset number of clock pulses.



Pulse train. The number of pulses in the pulse train is set with the two rotary switches, which fix the starting point for the two counters. When the pushbutton is released, the clock pulses flow to the output through G_4 and G_3 and also are counted. When the counters reach 99, G_5 turns off, blocking the pulses.

Feedback triggers one-shot from both polarity edges

By P.B. Weil
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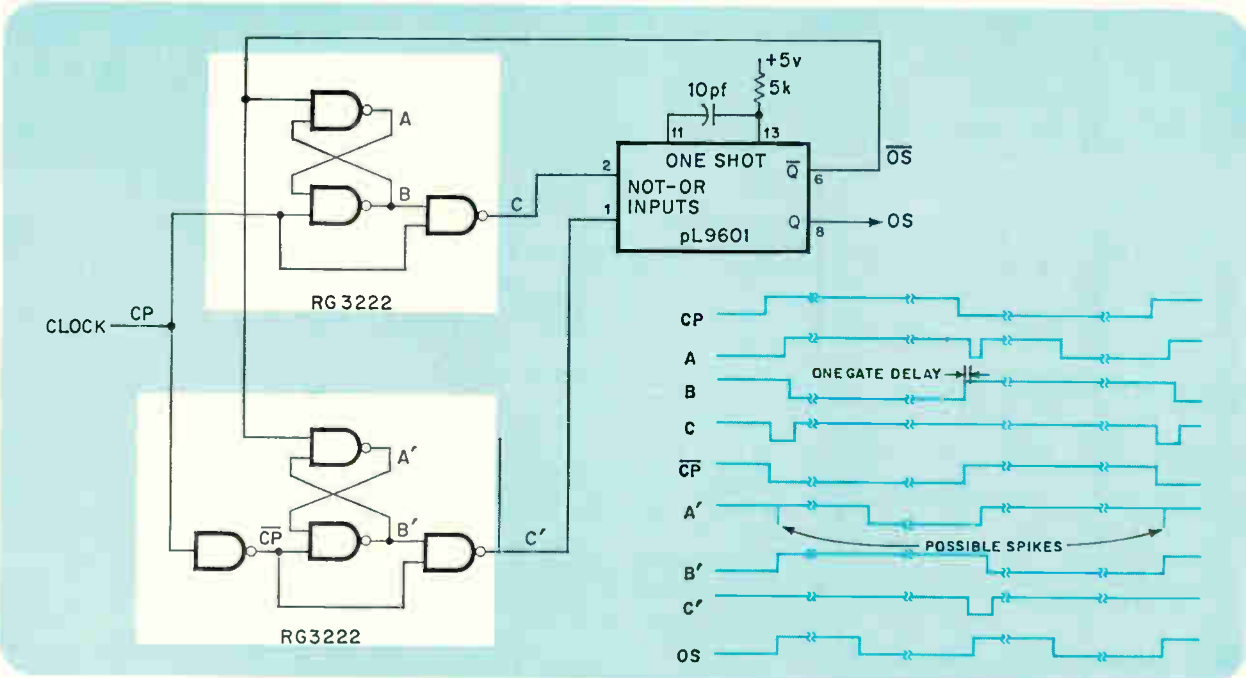
When it's necessary to trigger a one-shot on both edges of a clock signal, the schemes that come to mind first likely are simple differentiator circuits or two additional one-shots. But such devices use large components that may be incompatible with integrated circuit packaging methods and may introduce their own timing problems. And the differentiator may be susceptible to noise. A better method is to use a set of integrated gates connected as flip-flops and to take feedback from the one-shot back into the triggering circuit.

The circuit produces a trigger whenever the clock changes state. When the feedback shows that the trigger has done its job, the trigger pulse is turned off. The one-shot's pulse length is set at a quarter of the clock period. Thus, when triggered on both clock edges, it produces a signal at twice the clock frequency.

As the waveforms show, when the clock pulse is about to go high, flip-flop A-B has been set with B high. When CP does go high, output C goes low, firing the one-shot, within only two gate delays. When the one-shot output $\overline{OS}$ goes low, the flip-flop A-B is reset, putting B in the low state, and forcing trigger pulse C to return to the high state within three gate delays after firing.

When the clock goes from high to low, a similar action takes place in the A′-B′ flip-flop. Here, C′ acts as the trigger pulse.



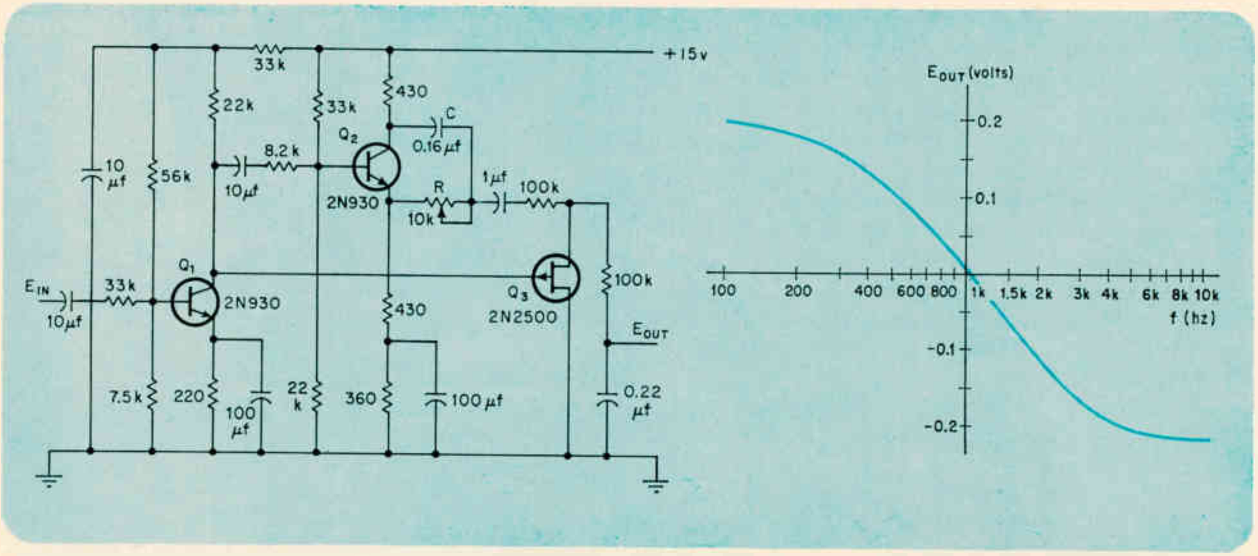
On edge. The one-shot is triggered on each edge of the clock signal—when the clock goes from low to high, the one-shot switches and one of its outputs is fed back to A-B to turn off the trigger pulse. When the opposite clock transition occurs, the lower flip-flop produces the trigger pulse.

FET phase detector can be frequency-voltage converter

By Jerzy Kalinski
Unipan Scientific Instruments, Warsaw, Poland

A field-effect transistor with phase-shifted inputs to its gate and source, when used as a phase-sensitive detector, can deliver an output voltage proportional to the input frequency. As a frequency-to-voltage converter, it is useful in frequency meters and in measuring carrier frequency drift of higher r-f signals after demodulation. The FET circuit is particularly valuable in the audio-frequency range, where other methods using simple capacitor-charge measurements may be inaccurate.

The amount of phase shift depends on frequency; for one particular frequency, adjustable with potentiometer R, phase shift will be 90°. At this frequency, the d-c output voltage of the phase sensitive detector is zero. Frequencies that are lower than this center value voltage produce a positive voltage, while higher frequencies produce a negative voltage at the output.



FET detector. The field-effect transistor produces maximum voltage when its gate and source voltages are in phase or 180° out of phase; 90° phase shift gives zero voltage. Phase shift through the RC network depends on frequency and can be zeroed with the variable resistance.

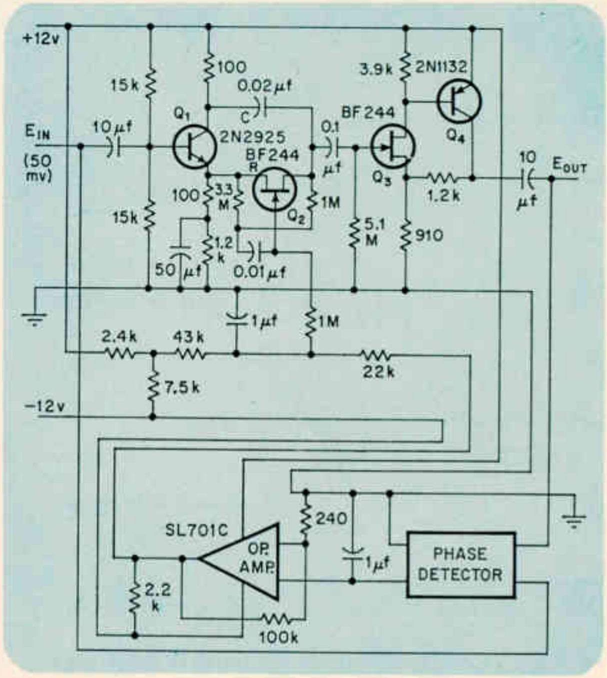
Variable FET resistance gives 90° phase shifts

By Jerzy Kalinski

Unipan Scientific Instruments, Warsaw, Poland

Frequency-independent phase shifters that produce 90° shifts in the audio-frequency range are useful for producing circular sweeps on a cathode-ray tube. They also can be employed in phase-measuring methods where a calibrated 0-to-90° phase shifter is formed by adding a signal to the quadrature component. A field-effect transistor can be used as the variable resistance in the RC phase shifter; FET resistance is controlled by feedback from a phase detector and operational amplifier.

In the circuit, the phase shift will be 90° when the reactance of capacitor C is equal to resistance R, the FET's source-drain resistance. When the phase shift tends to move off the 90° point due to a frequency shift, the phase detector produces an output of the proper polarity to bring the phase shift back to 90°.



FET setter. Field-effect transistor resistance sets the RC phase shift to 90°. FET resistance is controlled by the phase detector-amplifier combination.

Modified CAD device models can cut down circuit analysis costs

Proper adjustment of an active device model's critical parameters cuts expensive computer time with no loss in accuracy

By J. R. Greenbaum,
Electronic Systems division, General Electric Co., Syracuse, N.Y.

● Computer-aided design programs, like Sceptre and Circus have proven a powerful tool for circuit analysis. However, there's a drawback: if only a low-frequency analysis—less than 10 kilohertz—of a circuit were required, the user had no way to change the original computer program to stop the computer from making the very small iterations necessary to solve for the high-frequency transient responses. Since it usually takes considerable computation time to run the short step size analysis, the user can run up heavy costs.

In most computer systems, nonlinear circuit analysis is performed with a semiconductor charge-control model, usually found in the CAD program library. The model comprises resistors, capacitors, and equivalent current generators, and is evaluated by an iterative process under which the size of each step depends on the smallest resistor-capacitor product—the device time constant—used in the model. Since the program routines are not accessible, the step size can't be changed by manipulating them but, the value of the component most responsible for the short time constant—usually the capacitor—can be adjusted to force the computer to take longer steps.

Now the question is to determine how much to increase the model capacitance to minimize analysis time and still achieve accurate results. Although there are no ironclad rules that apply, usually the approach calls for gradually increasing the capacitance, and, after each increase, measuring the low-frequency response of the actual circuit and checking the results against the computer analysis to determine how large a change can be tolerated. Here a rule of thumb might be useful: if the critical capacitance is about 1 picofarad, an initial increase to 1,000 pf should be attempted. If, however, the circuit's response above 1 kilohertz isn't required, the initial increase could be as much as 1 microfarad. Although bothersome, this process is done only once for each different device. The modified device model then is recorded for future use.

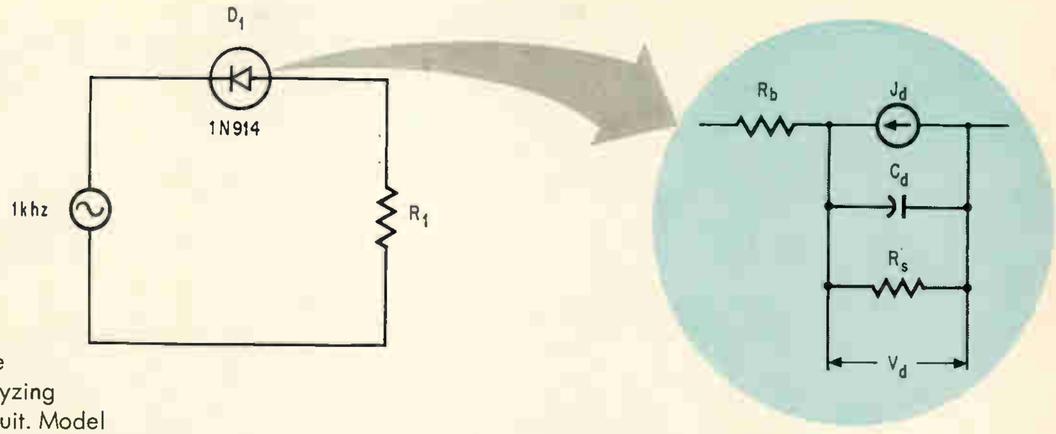
In the charge-control model of diodes and transistors the junction capacitance—particularly in the reverse biased case—determines the high-frequency operating limit. The junction capacitance of a diode can be expressed as

$$C_d = \frac{A}{(\Phi - V_d)^n} + K_d I_s e^{\theta V_d}$$

where ϕ = built-in potential across junction
V_d = voltage drop across current source
A = constant capacitance which depends on device
n = constant which depends on type junction
K_d = equivalent capacitance which is a function of stored charge
I_s = junction current
$\theta = q/(KT)$
where q = charge on an electron
K = Boltzmann's constant
T = absolute temperature in °K

The transistor charge-control model is represented as two diodes back to back. In this configuration, one diode serves as the base-to-emitter structure and the other as the base-to-collector. The model has two sets of equations, C_{d1} and C_{d2}, each similar to that of the diode model.

When the device is reverse biased, the capacitance of the junction can vary appreciably—as V_d becomes more negative, the capacitance becomes smaller. In this condition, the junction current is very small and the terms of interest are A and n. When the device is forward biased—V_d is positive—capacitance increases



Circus. Charge-control diode model (color) is used in analyzing the simple diode-resistor circuit. Model parameters for the 1N914 diode stored in the Circus library are tabulated. The dominant junction capacitance parameters for the reverse-bias case are A and n. For forward bias, the dominant term is the junction current, I_s, produced by the voltage-controlled current source, J_d: Diode time constant is determined by C_d and R_s, V_d is the voltage across the parallel combination.

PARAMETER VALUES FOR D_1

R_b = 2.0 OHMS	n = 0.5
Φ = 0.9 VOLTS	K_d = 18.1 μf
$\otimes$ = 21.5	A = 24 pf
R_s = 1.1 MEGOHMS	I_s = 2.9 na

with voltage. Junction current goes up from picoamperes to milliamperes and the equation becomes current dependent, hinging on I_s, since K_d is a constant.

For low-frequency analysis, the greatest control of the junction capacitance is obtained by adjusting the value of A. This can be done through establishment of tolerable levels of reverse signal (leakage) by changing the value of the junction's capacitive reactance. The user must determine how much leakage current he can tolerate and then establish a value for A that will meet this requirement. Although A is the value that offers the greatest control, some change can be effected by adjusting n. This value, however, is usually set equal to zero making A the only effective variable.

It's easy to modify A and n in both the Circus and Sceptre programs when describing the circuit to the computer. Change statements indicating the new values are typed into the program as part of the circuit description, and are used only for a particular solution since the original values are permanently stored.

To illustrate the effect on the analysis of modifying the junction capacitance, four different sets of values were used for A and n in the diode model in a simple diode-resistor circuit: n was set at zero; A was increased to 160 pf; n was made zero and n set at 160 pf; and finally the analysis was run using the original parameter values—n = 0.5 and A = 24 pf—stored in the CAD program library.

The analysis used Circus with the provision that the computation would be terminated either after one minute of computer time, or when 20 milliseconds of applied signal time had elapsed, that is, after 20 cycles of a 1-khz signal had been evaluated.

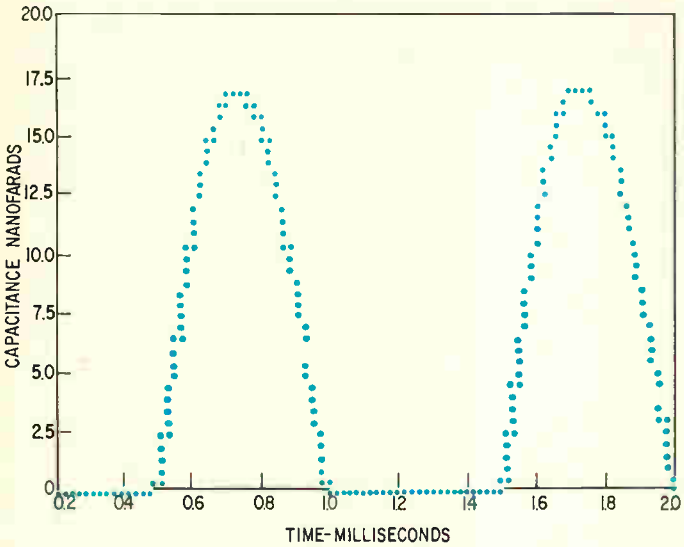
The results: the unmodified diode model required the full minute of computer time and evaluated less than 10 msec of applied signal. All three modified models required less than the allotted minute of computer time to complete the analysis of 20 msec of applied signal. Of these, the fastest analysis—only 30 seconds of computer time—was achieved when both parameters, A and n were modified; whereas it would have required two minutes for the unmodified case to run through the full 20 msec of signal.

The same four diode models then were analyzed using both Circus and Sceptre, but the analysis limit was set to 2 msec of applied signal. Economic reasons dictated the selection of the new limit. It was short enough to eliminate the possibility of minor transients and long enough to give accurate results. Each program required approximately the same amount of time to complete a comparable analysis.

The computer analysis was examined with an expanded time scale to determine short-term effects. The voltage across the load resistor in the diode-resistor circuit was presented on an expanded scale—500 microseconds—with the following results: only the modified model, where A and n were changed, was affected. There was a marked increase in the relative voltage across the load resistor, and as the value of capacitance was increased, the phase of the output voltage shifted with respect to that of the applied signal. If either effect can't be tolerated in a particular circuit application, device modification must be re-evaluated.

The applied signal amplitude affected the junction capacitance of a reverse-biased diode, and the magnitude of change depended on the particular model used. For the case where n = 0 for reverse-bias voltages of 10 millivolts and 10 volts, capacitance was 24 pf for A unmodified and 160 pf for the modified A.

The reverse-biased case, where n wasn't zero, illus-



CAPACITANCE VALUES		
MODEL	APPLIED VOLTAGE	CAPACITANCE pf
Library A=24 pf, N=0.5	−10 v − 1 mv +10 v	7.3 24 17,000
Modification 1 A=24 pf, N=0	−10 v − 1 mv +10 v	24 24 17,000
Modification 2 A=160 pf, N=0.5	−10 v − 1 mv +10 v	48 24 17,000
Modification 3 A=160 pf, N=0	−10 v − 1 mv +10 v	160 160 17,000

Changing. Junction capacitance variations of a 1N914 are plotted for 2 milliseconds using the Sceptre library model. Vertical scaling of the computer plot was insufficient to permit accurate determination of values; they were calculated and printed out as a function of the amplitude of the applied voltage. The tabulation checked the junction capacitance of the three modified diode models for 10 volts and 1 mv of reverse bias and 10 volts of forward bias.

trated the effect of the voltage across the junction: for the unmodified model the capacitance was 24 pf at 1 mv and 7.3 pf at 10 volts; when A was the only modified value, the capacitance was 24 pf at 1 mv and 48 pf at 10 volts. For 10 volts of forward bias the capacitance, which is established by the large junction current, was 17,000 pf for all four models.

Then a dual-peak detector using four diodes was selected for analysis by Circus. The analysis was performed with three models: the first used A = 24 pf and n = 0.5, the values initially stored in the program library; the second increased the value of A to 160 pf and kept n equal to 0.5; the third increased A to 24 μf and reduced n to zero. In addition, two limits were imposed: the computer analysis was to terminate either after 24 μsec of the applied 10-khz signal or after one minute of computer time had elapsed.

The computer analysis was completed in 26 seconds for the model where n = 0 and A = 24 μf, and evaluated the entire 24 μsec of applied signal. With the original library model, only 0.425 μsec of applied signal was analyzed, while the model where n = 0.5 and A = 160 pf looked at 0.625 μsec of applied signal.

A special analysis was conducted to illustrate the potential cost reduction. The one-minute time limit was removed. In one case, the simple diode model was modified by setting A equal to 24 μf and n to zero. The other case used the unmodified library model, but its step size interval was changed from 1.17 nanoseconds to 1 nsec because the computer had advised that it ran out of computation time using the former increment.

The special analysis indicated that even when analyzing simple circuits, a considerable cost reduction is achieved by properly modifying the modeled active device. Using the modified model, the computer analyzed 59.3 μsec of applied signal during its alloted one minute at a cost of $17.97 in computer time. With the library model only 0.425 μsec of signal using the 1-nsec steps was evaluated and cost $7.38. However, the computer costs would soar to about $102.50 if the signal were applied for a full 59.3 μsec.

Next, a more complicated circuit was selected to further determine modification effects. The circuit, an amplitude/phase discriminator, comprises three μA709 operational amplifiers and four 1N914 diodes.

Three analyses were performed using different values for the diode model capacitance, A, and the input capacitance, C, of the operational amplifier model. For the first analysis, A = 2.4 pf and C = 25 pf.

The computer used 4,870 steps, the majority of which were less than 1.6 nsec, and analyzed only 0.216% of the signal. In the second analysis A was increased to 24 pf and C remained at 25 pf. The result was that 4,850 steps, most of which were 2.6 nsec, were used and 0.41% of the signal was analyzed. The final analysis provided the best results from the point of view of the 400-hertz signal analyzed. Here the diode capacitance was greatly increased to 24 μf and the op amp capacitance to 250 pf. This analysis was performed in 4,780 steps lasting from 50 to 200 nsec, while 13.5% of the applied signal was computed.

The results of the previous three computer runs on the diode-op amp circuit indicate that the increase in percentage of computed signal in the model where A = 24 μf and C = 250 pf was due to the great increase in step size. Larger capacitance values produced approximately 60 times more information with no loss in accuracy for the same dollar investment—the computer ran for three minutes for all three analyses.

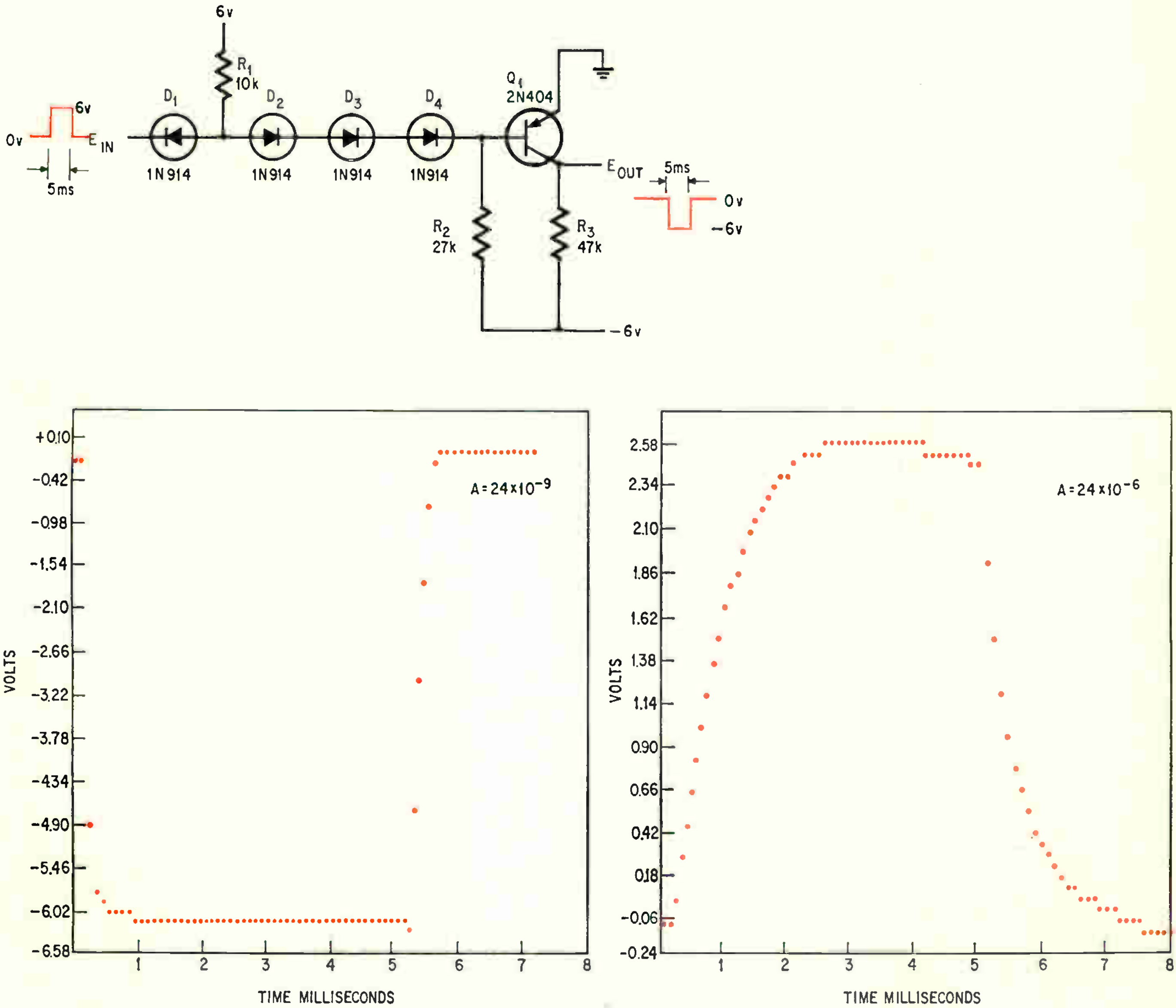
The dangers of exceeding a reasonable increase in capacitance reductions are illustrated by another circuit, this one performing a simultaneous switching and voltage level shift function. It consists of four 1N914 diodes in series connected to the base of a common-emitter 2N404 transistor. The circuit is designed to provide zero volts output for a zero volts input signal, and —6 volts when the input rises to +6 volts.

Initially the value of A for the diodes and the transistor was increased from the 24 pf of the unmodified model to 24 nf. The computer analysis time was set for three minutes. Analysis showed that the transistor's output voltage responded to the input signals changes with 100 μsec delay for either negative- or positive-going signals.

However, the results changed drastically when A was further increased to 24 μf and the analysis was repeated. When the input signal increased, the output voltage also increased, instead of decreasing to —6 volts. Because the semiconductors behaved as coupling capacitors, the output didn't reach —6 volts until the input signal switched back to zero in about 5 msec.

The unmodified library model also was analyzed to determine the cost effectiveness of the modified version. The library model, using an A of 24 pf and a step size of 1 nsec, imposed by the program to insure complete analysis, cost $8.50 to analyze 800 nsec of applied signal. The modified model, where A was 1 nf, cost $8.29 to analyze 7 msec of input signal—about 9,000 times as much information as the unmodified case. The cost of analysis for the model using A = 24 μf was $2.14; the results were invalid, and the case too costly to consider. ●

Tilt. If the value of junction capacitance used in the semiconductor's charge-control model is increased too much, the response will be erroneous. The diode-transistor circuit's voltage-level shift is accurately depicted (left) when the value of A is 24 nanofarads, an increase of 10^3 from the Circus library value. But when A is increased to 24 microfarads, the circuit's output response (right) is erroneous.



IC's save power, boost efficiency of regulated power supplies

By William L. Brown,
Electrical Engineering Department, San Diego State College

● Near-ideal power supply performance isn't something that's confined to designers' dreams. With proper use of low-cost, high-gain monolithic operational amplifiers and low-power voltage regulators, designers can avoid the disadvantages of conventional power-supply regulators while retaining all the benefits of both series and shunt types.

Though both series and shunt regulators feature constant voltage output, the high output impedance of series units prevents rapid response to changes in load demand. And efficiency is poor if the series-regulated voltage is much lower than the source voltage. The low impedance of shunt regulators allows fast response to load variations, but low-current efficiency is poor.

The advantages of both series and shunt elements can be combined in a single regulator circuit. But this approach doesn't improve the low efficiency of the conventional shunt regulator. Here's where inexpensive, high gain operational amplifiers can be used to obtain the best possible performance. The class B output stage of these devices provides the low-impedance shunt path across the load terminals and the high-gain differential amplifiers sense the load changes and control the series-pass transistor. Thus, the low efficiency of the shunt regulator is overcome, while still providing the necessary low impedance. The reason: the series pass transistor is continuously readjusted to deliver only the load and operational amplifier demand; the shunt element no longer must absorb any excess current under reduced-load conditions.

Depending on requirements, the series-shunt regulator can be linear, or, if even greater efficiency—almost independent of the load voltage—is required, a switching type can be used. In one application, a switching series shunt-regulator made from about $15 in parts delivers a regulated 15 volts from a 25-volt source with less than 1 millivolt peak-to-peak ripple at a load current of 5 amperes. It also provides output regulation within 1 mv from no load to full load. The efficiency is about 90% under load currents from 0.5 to 5 amperes and remains greater than 50% down to 20 milliamperes.

A typical series shunt-regulator is shown on page 95. At 15 volts, the operational amplifier can provide up to 18 ma; R_6 is chosen to keep the actual output current at 8 ma, about at the center of the available range. This resistor also provides surge protection for diode D_3, which compensates for the change with temperature variation of Q_3's base-to-emitter voltage. This insures that the average shunt current remains approximately constant. A germanium diode is used; its forward voltage drop is about 0.5 volt lower than that of a silicon transistor. R_6 can thus be included to protect D_3 as well as to provide a load resistor across which the operational amplifier can develop a control signal for Q_3.

Operational amplifier ≈ short circuit

An operational-amplifier shunt regulator is usually used only to augment the current control effected by a higher-power series regulator. Its own modest current capability cannot, by itself, provide regulation for load currents above a few milliamps. But combined with a series regulator to handle the bulk of the load change requirements, an operational amplifier can present the equivalent of a low-impedance source for loads of several amperes.

How good a shunt regulator an operational amplifier makes depends on how well it can respond to small changes in load voltages. The better the regulator the more its output current must change for a given change of input voltage. A good regulator thus resembles a short circuit.

The amplifier's current-signal voltage characteristic could be conveniently defined by its transconductance, g_m, but this parameter is seldom specified for an operational amplifier. However, it is closely related to the large-signal gain, A_v, and can be easily derived.

$$g_m = \frac{\Delta I_{out}}{\Delta V_{in}} \cong \frac{I_{L(max)}}{V_{(diff)}} = \frac{\dfrac{V_{L(max)}}{R_{L(min)}}}{\dfrac{V_{cc}}{2A_v}}$$

The maximum specified output current, $I_{L(max)}$, occurs at the maximum output voltage swing, $V_{L(max)}$, which is approximately half the total power supply voltage, V_{cc}, in order to maximize the amplifier's region of linear control. A typical operational amplifier will have a voltage gain of 50,000, and its load resistance will be at least 1,000 ohms (2,000 ohms is a commonly used value; with 2,000 ohms a 15 ma output current develops 30 volts). Therefore g_m will be on the order of 50 mhos, and the dynamic shunt resistance ($\approx 1/g_m$) will be about 20 milliohms—an excellent approximation to a short circuit.

R_5 limits the base current of Q_3; while it has some effect on Q_3's frequency response and phase shift, its value is not critical.

The μA741 and LM107 have built-in output current limiting as protection against burning out. However, at high output voltages, Z_2 must be chosen so that the current it can draw is held to within the maximum rating of the selected operational amplifier. Both of these devices also have built-in frequency compensation, which is designed to ensure that at the unity-gain frequency of about 1 megahertz, phase lag is held to about 90°. A Bode plot of the circuit shows a 6 decibel/octave slope from about 10 hertz to 1 Mhz. By providing almost a 90° phase margin at unity gain, overshoot is suppressed. For a typical loop gain of 100,000 the gain starts to roll off at around 10 hz and, at —6db/octave, is unity at 1 Mhz. Despite this seemingly slow response the circuit can supply current to rapidly varying loads. Both the series and shunt elements are merely intended to act as low-pass filters; the load-shunt capacitor, C_4, typically rated in tens of microfarads, will supply the high-frequency components of load demand from its stored energy.

Q_1 and Q_2 are connected in the conventional Darlington configuration to increase the series voltage regulator's current gain. The pair acts as an emitter follower feeding the load.

A low-frequency power transistor is chosen as Q_1, using the manufacturer's "safe area" specification curves to match the regulator's maximum current, voltage and wattage needs. By choosing a transistor with f_t above 100 Mhz for Q_2 the total phase shift contribution of the Darlington pair is minimized at gain crossover, thereby lessening the closed-loop stability problem. Also, since emitter followers may oscillate due to the effects of inductance in the base circuit, the base lead lengths should be kept short and, if necessary, a small powdered-magnetic bead or toroid can be added to the emitter circuit.

The type of transistor chosen for Q_3 is noncritical, but since it does affect the closed loop gain, its phase shift near unity loop gain must be considered. A lag-ramp compensation network comprising R_3 and C_3 in series should provide a phase lag that goes back to zero at frequencies above $f = 1/2\pi R_3C_3$. The phase lag encountered in the operational amplifier considered here begins to exceed 90° rapidly above 1 Mhz. Thus, to maintain loop stability and attain reasonable closed-loop transient overshoot (phase and gain margin), the values of R_3C_3 are chosen to reduce Q_3's gain below unity at a frequency below where the emitter-follower pass stage is producing 30° to 45° of phase lag. Added to the 90° lag from the operational amplifier, this results in a 45°–60° phase margin against oscillation.

For the network in the collector-to-emitter position of Q_3, R_3 is determined by

$$g_{m3}R_3 \leqq 0.5 \quad \left\{ \begin{array}{l} \text{a gain arbitrarily less} \\ \text{than 1, by a 2:1 safety} \\ \text{margin} \end{array} \right.$$

where g_{m3} is the transconductance of Q_3 and is equal to the ratio of output current change to input voltage change.

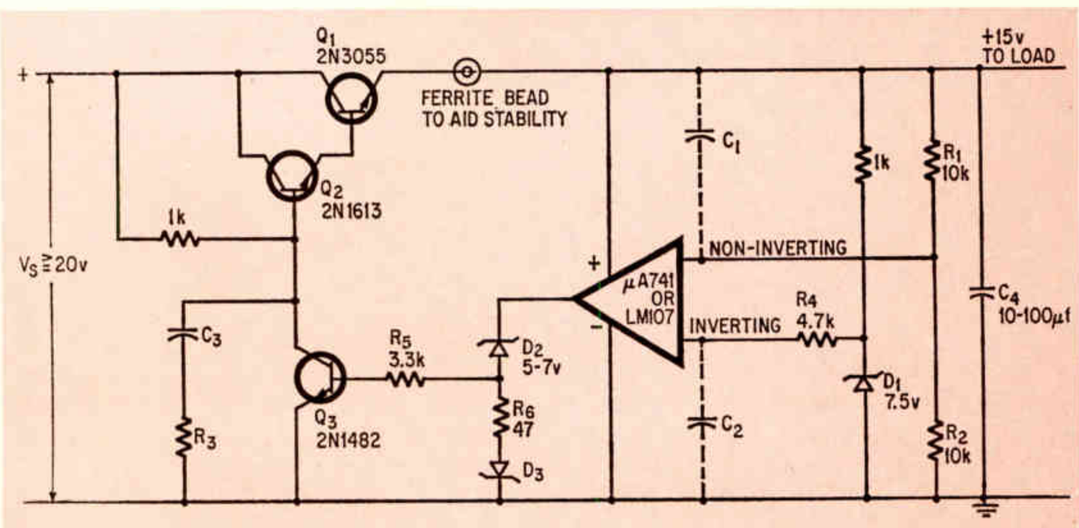
C_3 is determined by

$$\frac{1}{2\pi R_3C_3} < \frac{1}{2\pi h_{ib}C_4}$$

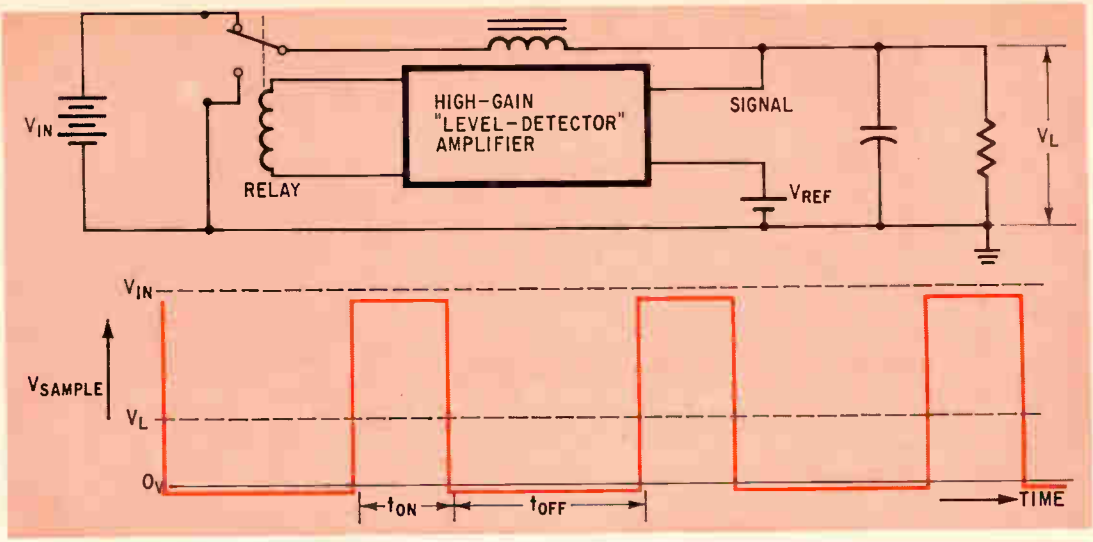
where h_{ib} is the resistance looking into the emitter of the emitter follower, Q_1.

Typical values are tens of ohms for R_3, and tenths of microfarads for C_3, placing the upper ramp corner (zero) below 100 kilohertz and the lower ramp corner (pole) between 1 khz and 10 khz.

Voltage dividers R_1 and R_2 form a sampling network



Choice. The linear series-shunt regulator is a good choice when the desired output is a large fraction of the source voltage. The dashed lines indicate optional circuitry; C_2 for noise suppression and C_1 to aid in loop stabilization. C_1, R_3 and C_3 are selected to minimize load voltage overshoot when driving a fast-switching load.



Replacement. This simplified block diagram shows how a switching regulator replaces the continuous energy flow of a linear regulator with energy surges as pulsed samples of the source voltage. The filter network passes the d-c component of the wave-shape—the waveform's average voltage, V_L.

by selecting a fraction of the output voltage for comparison with the reference voltage. This fractional load voltage sample can be adjusted by a trimmer; the sample appears at the non-inverting operational amplifier terminal. Stable resistors must be used in the divider—the temperature coefficient of the voltage divider is as important as that of the zener diode, D_1.

At its input terminals, the operational amplifier is a differential amplifier operated at an emitter current of about 15 microamperes, to minimize noise and base current, and insure high input impedance. The impedance of the sampling network is a compromise: the current drawn must not be excessive—1 ma of "bleeder" current is typically acceptable. But at the same time it must be large enough to swamp out any rise in operational amplifier input current with a rise in temperature, thus limiting the regulator's temperature sensitivity. The inverting terminal has a resistance, $R_4 \approx R_1 \parallel R_2$, inserted in series for the same purpose.

C_2 is a noise filter capacitor, typically 0.01 μf, and C_1 is a phase lead compensating capacitor, usually between 5-20 picofarads.

Short-circuit load protection for the series regulating element can be added as fold-back current limiting; a technique in which load voltage is sampled to sense overcurrent, and the series pass transistor is turned off.

Measured performance for the circuit on page 95 is about 10 times better than commercial power supplies costing $100 that would have had a parts cost for the regulator section similar to this unit's. The measured output ripple and noise are below 100 microvolts, as is the d-c output voltage change over a load range from 0 to 5 amps. But efficiency of the linear series shunt regulator can be very low. Since efficiency is approximately equal to the ratio of output and source voltage, it's not a good choice when required output is much less than the source voltage. A switching regulator serves best in this application because its efficiency is essentially independent of this ratio. Efficiency is related to the ratio of load current to regulator shunt current, making it ideal for low-voltage, high-current applications.

While a switching regulator may have 10 times the load ripple of a linear regulator, it never exceeds 1 mv peak to peak and is more than offset by the substantial increase in efficiency: 90% compared to 70% or less for a similar linear regulator.

The circuit on this page illustrates the basics of a switching regulator. The switching is accomplished by a mechanical relay, controlled by a high-gain amplifier. The inductive input filter produces a d-c output voltage equal to the average value of the input waveshape. The load voltage, assuming a lossless inductor is:

$$V_L = V_{in} \frac{t_{ON}}{t_{ON} + t_{OFF}}$$

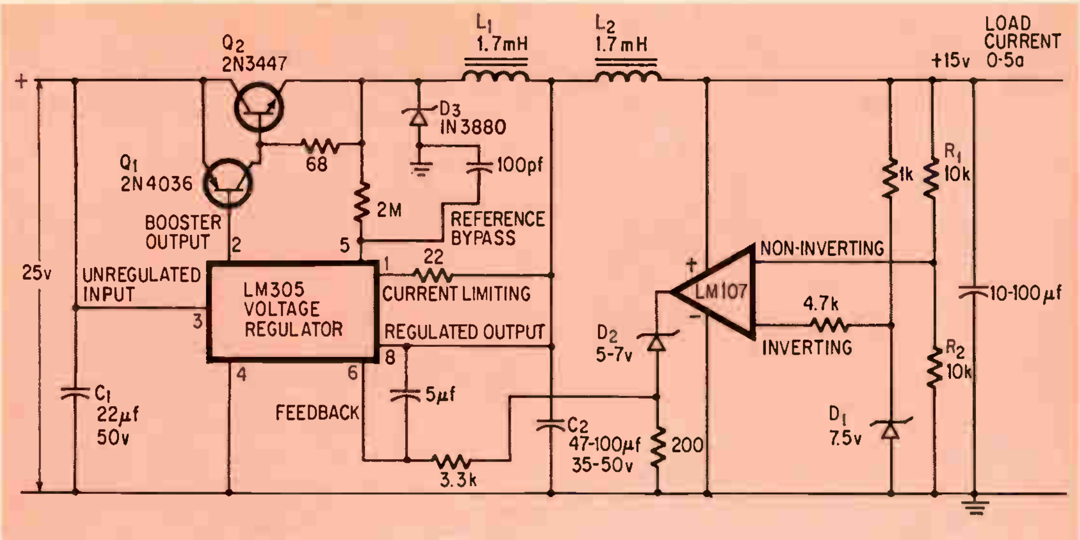
A series pass transistor can replace the relay; to minimize the power dissipated within it and insure high efficiency, the transistor should have low collector-to-emitter saturation voltage and good switching speed.

A typical switching series-shunt regulator, shown on page 97, is made up of two monolithic IC's. These are a high-gain operational amplifier and a low-power voltage regulator. Their function is to drive the higher-powered series-pass transistors.

The operational amplifier, either an LM107 or μA741 has two differential amplifier stages and a class B output stage. The first differential stage senses any load changes; the second amplifies any error signal that exists. The class B stage provides the low-impedance path across the load; its output then drives the voltage regulator. The LM305 is used in this circuit, but several firms make this type of monolithic linear voltage regulator. It's actually cheaper to use than a switch made of discrete components and includes circuitry and an input pin for either linear or foldback current limiting. To set it up for switching, add regeneration with an external positive feedback-path to pin 5.

In addition, the IC's always contain a built-in reference voltage that can be used to maintain the amplifier's input accurately at the switching level. While IC voltage regulators have been used at switching rates up to about 100 khz, losses in the higher-power switching transistors usually limit the rate to between 10 khz and 80 khz.

The fast-switching diode, D_3, provides a path to maintain current in the filter inductor, L_1, when the series-pass transistor is turned off. It also clips the negative inductive-switching spikes, which could cause collector-to-emitter breakdown of Q_1 and Q_2. The combination of L_1 and C_2 performs a dual function: primarily it determines the switching speed, and it smoothes the switching waveform by filtering the switching frequency



Versatile. This versatile switching regulator operates at a 20-khz rate, is efficient from output voltages of a few volts up to about 40 volts, and at currents ranging from 20ma to 5 amperes. Best of all, its parts list totals only about $15.

and its harmonics. Although switching actually is triggered by the load-voltage ripple, this ripple, as well as recovery time from load changes, and transient overshoot all are affected by this filter.

L_1 typically is a molybdenum-permalloy toroidal core with an inner diameter about the same size as a power transistor. It's wound with about 100 turns of #20-22 wire, for currents up to a few amperes and switching rates from 10 khz to 80 khz. The precise value will vary with load current between about 1 and 2 millihenries.

C_2 and C_1, the capacitor on the input side, will have to handle fairly large switching currents. C_2 for example, handles about 200 ma peak to peak at a switching frequency that's typically 20 khz. These currents may quickly overheat electrolytic capacitors designed for lower-frequency filtering. So far solid tantalum capacitors have proved best for this application. However, they should have a voltage rating two to three times the nominal d-c voltage placed across them and should be selected on the basis of internal heating losses and ripple ratings at high-frequency currents.

Although using the higher switching rate of 80 khz would minimize the filter's size and cost, higher frequency series-pass transistors would be required. This would more than offset the decrease in filter cost.

The ripple voltage attenuation provided by typical L_1C_2 filters is about 1000:1. For example, with a source voltage of 30 volts peak to peak the ripple out of the first L-C filter section may be as low as 30 mv peak to peak. The a-c current flowing through L_2 in the second filter section would be less than 1 ma. While an operational amplifier could provide a low-impedance shunt path for that low a current, an electrolytic capacitor does the job simpler and as cheaply. Moreover, some load shunt capacitance is needed to maintain low power-supply source impedance at higher frequencies and smooth out spike load transients.

The shunt operational amplifier provides the additional d-c loop voltage gain, (10,000 to 100,000 times) required to maintain the d-c load voltage within a few microvolts for load currents of from 0-to 5 amps. In addition, it acts as an active low-frequency ripple filter by presenting a very low impedance to the remnants of 60- and 120-hz line ripple from the rectifier.

This circuit presents no spurious oscillation or loop stabilization problems, and the layout isn't critical. Measured efficiency is in the 85%-90% range for currents from 0.5 to 5 amps, and remains above 50% down to about 20 ma. D-c and temperature stability depend almost wholly on the zener reference. Shunt regulator operation is identical to the one used in the linear case. Capacitors may be added as they were in the linear regulator to reduce circuit noise. The output voltage is easily set; it's simply equal to the zener reference voltage V_Z multiplied by the quotient R_1 plus R_2 divided by R_2.

The minimum output voltage that can be handled by the switching regulator depends on the lowest voltage the operational amplifier requires to adequately drive the IC voltage regulator; whereas the maximum output voltage depends on its maximum voltage ratings. The LM107 for example, needs about 3 volts, to supply 2 volts of drive, and it will withstand up to 40 volts. ●

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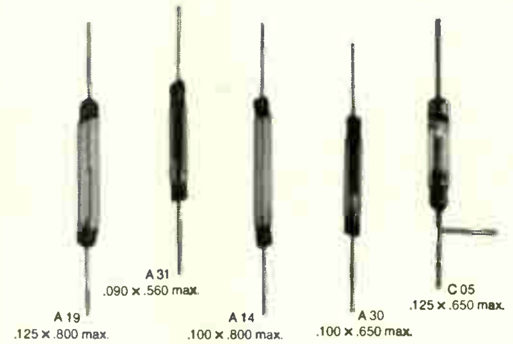

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Design pruning trims costs of data modem

Device for communicating with a computer at 1,200 bits per second features digital techniques and circuit paring that keep costs to a minimum

By Jack Stifle and Mike Johnson,
Coordinated Science Laboratory, University of Illinois at Urbana-Champaign

● Half the battle for economical computer-aided instruction systems was won with development of a suitable central computer. But the other half—low-cost, reliable modulator-demodulator units needed at each desk for communicating with the computer—is still being fought. To solve its own modem needs, the Computer-Based Education Research Laboratory at the University of Illinois developed a 1,200-bit per second transmit-receive modem for its Plato (programed logic for automatic teaching operations) system. Although the modem was designed for use in a specific system, this approach may strongly affect the design of future modems destined for similar applications.

The modem can handle all of Plato's data transmission, and for less than one-quarter to one-seventh the cost of most commercially available modems. Both the modulator and demodulator fit on a two-sided 3" x 4½" printed circuit board. Significantly, the total parts cost for the entire unit is less than $70. It is designed for full-duplex operation, which means it is ready to transmit or receive data at all times.

To achieve this operational flexibility without prohibitive expense, three basic factors guided the design:

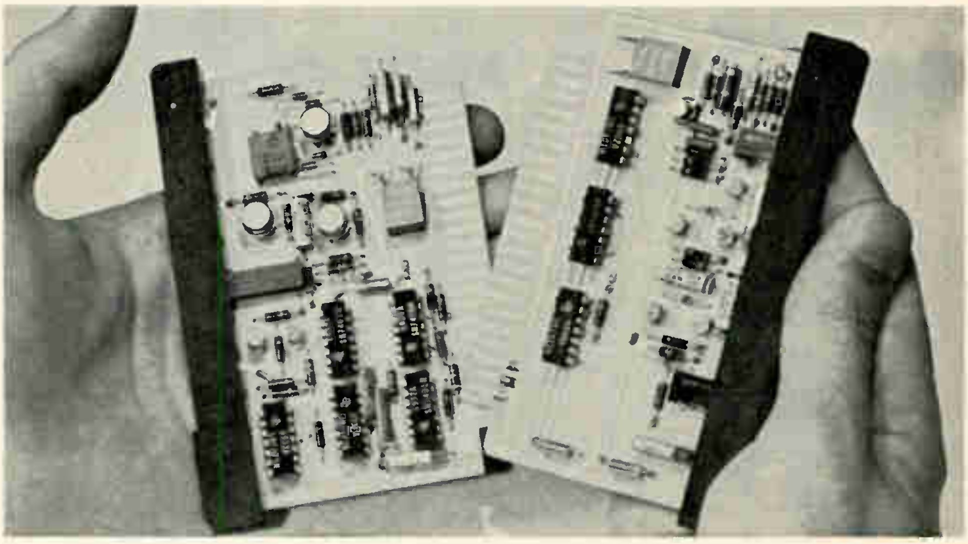
▸ Use of digital, instead of analog, techniques whenever possible. Digital techniques are inherently more reliable and can be effected through use of low-cost integrated circuits.

▸ Elimination of all unnecessary circuits usually provided in commercially-available modems. These include data-set-ready, request-to-send, clear-to-send, and timing circuits for line turnaround. Another feature is a frequency shift keying technique, wherein the carrier signal is always present; this eliminates a carrier detection circuit.

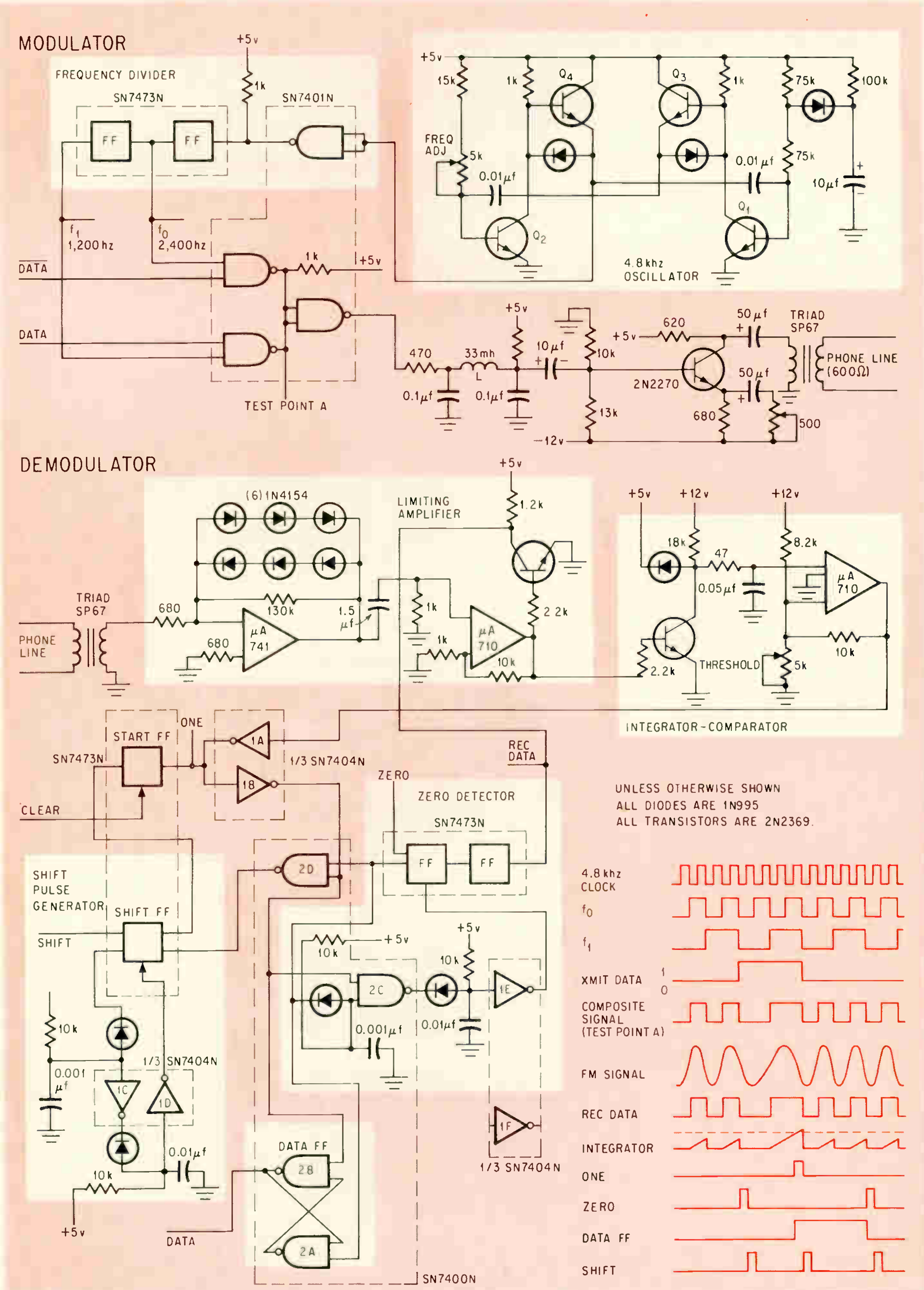
▸ Direct interfacing with transistor-transistor logic. This eliminates all voltage-level shifting circuits.

Further economies are achieved by using just one oscillator—usually several are required. But since the frequencies are harmonically related, a simple standard counter IC, which divides the oscillator's output, provides the additional frequencies. Also, with no circuit requirement for processing fractions of cycles, the demodulator circuits can be made simple. In addition, the low data rate of 1,200 bits/sec allows rental of the most inexpensive telephone data lines. What's more, the demodulator's output contains both the data stream and the shift pulses, so that data can be stored in the central computer's shift register without the additional circuits usually required by many commercially available modems.

To further reduce costs, no delay-equalizing circuits are used in the demodulator to minimize the delay distortion on the telephones between widely separated points. This limits the modem to relatively short-haul



Handy. Fabricated on two 3-inch by 4½-inch printed circuit boards, the entire modem for Plato's computer-aided instruction system can be built for about $70, a cost reduction factor of at least four over commercially available modems.



MODULATOR
FREQUENCY DIVIDER
SN7473N
SN7401N
FF
FF
+5v
1k
f_1 1,200 hz
f_0 2,400 hz
DATA
DATA
1k
+5v
TEST POINT A
+5v
15k
1k
Q_4
Q_3
1k
75k
100k
FREQ ADJ
5k
0.01μf
0.01μf
75k
10μf
Q_1
Q_2
4.8 khz OSCILLATOR
+5v
620
50μf
TRIAD SP67
+5v
10k
PHONE LINE (600Ω)
470
33mh
L
10μf
2N2270
50μf
0.1μf
0.1μf
13k
680
500
−12v
DEMODULATOR
+5v
(6) 1N4154
LIMITING AMPLIFIER
1.2k
+5v
+12v
+12v
18k
8.2k
47
μA 710
0.05μf
TRIAD SP67
680
130k
1.5 μf
1k
2.2k
PHONE LINE
680
μA 741
1k
μA 710
10k
10k
2.2k
THRESHOLD
5k
INTEGRATOR-COMPARATOR
START FF
ONE
SN7473N
1A
1B
1/3 SN7404N
REC DATA
CLEAR
ZERO
ZERO DETECTOR
SN7473N
UNLESS OTHERWISE SHOWN
ALL DIODES ARE 1N995
ALL TRANSISTORS ARE 2N2369.
SHIFT PULSE GENERATOR
2D
FF
FF
SHIFT FF
SHIFT
10k
+5v
+5v
10k
2C
1E
10k
0.001μf
0.01μf
0.001 μf
1C
1D
1/3 SN7404N
1F
1/3 SN7404N
0.01μf
DATA FF
2B
10k
+5v
DATA
2A
SN7400N
4.8 khz CLOCK
f_0
f_1
XMIT DATA
1
0
COMPOSITE SIGNAL (TEST POINT A)
FM SIGNAL
REC DATA
INTEGRATOR
ONE
ZERO
DATA FF
SHIFT

Quietly flows the data. A 1,200-hertz signal is used as a transmit clock to control the flow of data into the modulator. A binary 1 selects one cycle of f_1 while a 0 selects two cycles of f_0. The composite signal goes through a low-pass filter which transforms it into a sine wave. Filter output is amplified and delivered to the phone line. In the demodulator the incoming signal is passed through a limiting amplifier and digital-comparator which converts the sine wave back to a digital signal. The signal then is delivered to a 2-stage counter and an integrator-comparator; the latter provides an output for the 1 pulses while the former provides an output for each pair of 0's. The outputs of the integrator-comparator and the counter set the data flip-flop to the appropriate state and trigger the shift pulse circuit, which is composed of the shift flip-flop and 2 gates. The data flip-flop is set on the leading edge of the data signals while the shift pulse is generated on the trailing edge; thus the state of the data line is established in advance of the shift pulse. The shift pulse and the data line may be used by a shift register to input the data.

operation—less than 100 miles. However, if longer distances are required, standard equalizing networks could be added to the modulator at the front end of the amplifier-limiter.

In the modulator, the 4.8-kilohertz oscillator drives a two stage counter. The signal from the 4.8-kilohertz oscillator is fed into the counter's first flip-flop to produce the 2.4-khz signal. This output then is fed into the second stage to provide the 1.2-khz signal.

Using this technique to obtain an exact 2:1 ratio between frequencies f_0 and f_1 provides an additional bonus: it also eliminates any problems that may arise from asymmetry in the oscillator's waveform. Since the flip-flops in the counter are controlled only by the trailing edge of each pulse, only the oscillator's frequency and its pulse rise times must be maintained.

Digital data is stored in a shift register in the central computer. Loading and emptying of the shift register is controlled by the 1.2-khz transmit clock. For transmission through telephone lines, this data must be transformed into an f-m signal containing both f_0 and f_1 pulses.

The data in the f-m waveform is represented by a string of binary 1's and 0's. A binary 0 consists of two cycles of the 2.4-khz signal, f_0, and a binary 1 is one cycle of 1.2-khz, f_1. Thus when a binary 0 is present two cycles of the 2.4-khz signal are transmitted; when a binary 1 appears, one cycle of the 1.2-khz signal is transmitted.

The distinction between appearance of one's and zero's allows simple recovery in the demodulator: the high-frequency portion of the signal—two cycles for each 0 is simply integrated out, while the low frequency—one cycle for each data bit—is recovered. Furthermore, the data signals change only on the negative-going edge of the transmit clock, insuring that the composite signal contains an integral number of cycles of f_0 and f_1.

Now all that remains for modulation is to transform the composite digital signal into an approximation of a sine wave for transmission through the telephone lines. This is done by routing the digital signal through a low-pass pi filter to remove most of the high-frequency components of the pulses. What remains is a fair sine-wave modulated f-m signal that's amplified and transformer-coupled to the telephone lines. The gain control in the amplifier limits the power delivered to the telephone lines to +6dbm—approximately 4 milliwatts into a 600 ohm load.

In the demodulator, the incoming signal is transformer-coupled to a limiting amplifier and a digital comparator. These convert the sine wave back into a digital signal. This signal then simultaneously drives a two-stage counter and an integrator-comparator, whose threshold is set so that only the 1 pulses, twice as wide as the 0 pulses, rise above threshold. The higher-frequency 0 pulses therefore are removed and an integrator-comparator output occurs only for the lower-frequency 1 pulses.

The two-stage counter normally provides an output for any pair of pulses regardless of width. But the integrator-comparator's 1 output also is fed into the counter via a gate; this pulse resets the counter whenever a 1 is present in the incoming data, assuring that the counter provides an output only for the shorter pulses that represent 0's. Thus, the counter functions as a 0 detector; the integrator-comparator works as a 1 detector.

Now the composite signal data can be reconstructed. A 1 pulse from the integrator-comparator turns on a data flip-flop, and the 0 pulse of the counter turns it off. Since the data flip-flop's on duration equals the width of the data pulse, and off all other times, its output is the digital equivalent of the transmitted data. An external shift register temporarily stores recovered serial data until it can be read out in parallel. The output of the integrator-comparator and the counter are also used to trigger a shift-pulse circuit comprising a shift flip-flop and two gates.

Since the data flip-flop is set by the leading edge of the data signals, and the shift flip-flop by the trailing edge, the state of the data flip-flop is established in advance of the shift pulse.

A binary 1 is used to indicate the start of the message. It sets the start flip-flop that allows the remaining bits in the message to trigger the shift flip-flop and generate shift pulses. A counter that's external to the modem counts the shift pulses. Following receipt of the last message bit—the number of bits in a message must be known—the counter issues a CLEAR signal which resets the start flip-flop. This inhibits generation of shift pulses until the next message arrives. ●

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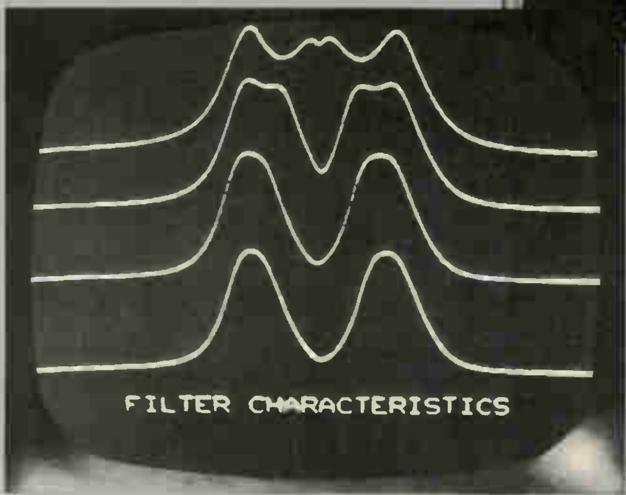

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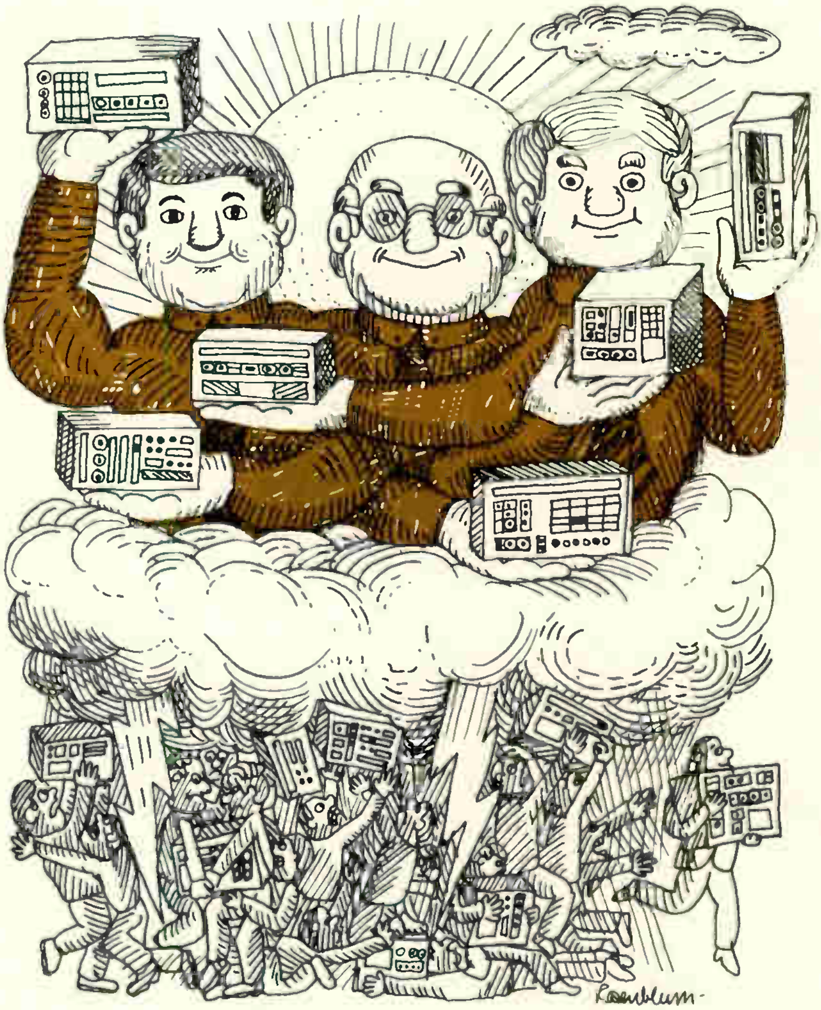
Shakeout due in minicomputers

Recession, dominance of a few companies put the squeeze on a host of makers

By James Brinton,
Boston bureau manager



By the year-end, a third of the 75 or more minicomputer makers now in business may be out. In a year the number may be down to 10 or 15. Though grim, these are the predictions of the industry's best informed marketing men facing tight money and a changing market. Even conservative Arthur D. Little Inc. is predicting a "consolidation," pegging it for 1971-1972.

Typical is the opinion of David H. Methvin, president of Computer Automation Inc., Newport Beach, Calif. "I've long expected a shakeout, but it's happening 15 to 18 months earlier than I thought it would." Lawrence Goshorn, president of General Automation Inc., Orange, Calif., predicts firms will be selling their inventories in bulk within the next six months and letting out rights in their operations soon after, just to keep cash flowing. By next spring, he feels, the weakest companies will be ready to sell out entirely.

In doing so, they'll be leaving a rapidly growing minicomputer market—usually meaning all eight-to-16 bit-word processors—that could reach half a billion dollars by the mid seventies. Since it became apparent three or four years ago that the PDP-8 series manufactured by the Digital Equipment Corp. of Maynard, Mass. was a resounding success, the minicomputer firms have multiplied much as did semiconductor companies in the early 1960's; now it appears they'll shake out just as drastically.

Except for perhaps seven to 10 companies which dominate the market, (not including IBM, though some consider its System 3 to be a minicomputer) most firms hold only a tiny share of the market. Nearly all were founded when cash flowed freely, but now interest rates are high, investors are scarce, and the stock market is bearish, making access to the capital markets very difficult. Also, now-cautious original equipment makers, who were to have bought vast quantities of minicomputers for use in systems, are tending to stick with one of the big mini makers or in a few cases are bent on developing an in-house computer capability.

Just the idea of trying to compete with the big firms is enough to frighten many. The market still is relatively small, though growing, but share-of-market figures show it already has become "IBM-ized."

According to Little, the 1969 market for mini's was about 6,000 mainframes—and it's growing at 35% to 50% per year. This means a 1970 market of 8,100 to 9,000 machines, Little predicts. Industry officials are more optimistic—despite the slumping economy, they predict 8,500 to 12,000 mainframes for 1970.

Share unlike. Depending on whom you talk to, DEC sells from 50% to 70% of all minicomputers. Little says DEC had 55% in 1969 but factors IBM's System 3 into its figures. The other major manufacturers are Hewlett-Packard, Honeywell's Computer Control Division, and Varian's Data Machines division; each is said to have from 7%

.... few today want to risk buying from little-known firms ....

to 10% of the market. The Data General Corp. also claims a 7% to 10% share, which it says is growing. And others credit General Automation with 4% to 5%. Adding up the lowest of these figures, the rest of the mini makers must subsist on only 18% of the market —at most, 1,500 to 2,000 machines.

Thus, at a time when cash flow is essential, only a little business is free to circulate among many firms. That's why industry observers expect the kind of shakeout that hit semiconductor makers. And some claim to have seen early signs already. "First come price cuts," says one. "Varian already has cut price several times without major redesigns, and so has General Automation."

Unkindest cut. "Price cuts hurt. They bite into near-term profits in the hope that quantity sales and the resulting parts-cost leverage will raise profit," continues this source. "But it almost never comes out that way."

Such slashes sometimes are thought to be effective in the OEM market—the target of nearly all minicomputer makers' sales efforts. But the OEM market is toughening.

Allen Z. Kluchman, marketing director of Data General, says his firm had expected to be selling 70% of its output to OEM's today. Instead, "it's already 50-50, and we've begun accelerating our push into end user fields." Apparently looking ahead, Data General over six months ago began adding peripheral equipment and complex software packages to its line; its latest introduction is a bus allowing minicomputers to be connected to form a multiprocessor [*Electronics*, July 6, p. 34].

OEM's ossify. "There are as many orders out there as ever," says Kluchman, "but OEM's have cash problems too. And they are going to buy only from firms with established reputations." Thus, the OEM market may not save many small firms. "Buyers are so scared," says an official of another firm, "that they even call our ad agency to see if our bill is paid."

Robert Lowry, president of Technology Marketing Inc., Santa Ana, Calif., also notes that it takes about "a year to bring an OEM aboard, and that's a long time to wait." He adds, "Lack of liquidity penalizes fast growing firms, but it's death to companies not growing."

Kluchman's axiom is that only the toughest most persistent sales effort will penetrate the OEM's. He could add, only the best backed.

Stacked DEC. DEC is regarded as the IBM of the minicomputer field and, in fact, claims to have sold more mainframes than IBM. It's position is such, that despite DEC's standing offer to overprint an OEM's logotype on any computer front panel, fewer than 10% of OEM's ask it.

Few today want to risk buying from little-known firms that have limited software or service support. DEC maintains 65 outlets worldwide employing about 650 service men, 400 sales engineers, and 400 hardware-software support specialists. No other minicomputer maker, except perhaps Honeywell-CCD, can come close to this figure, although Hewlett-Packard is said to have about 500 people in equivalent jobs.

Moreover, PDP-8 computer programs number from 500 to 600, some developed by DEC (more than 300) and others (250 or more) developed and shared by PDP-8 users. These figures are unmatched by other mini makers and are a strong sales weapon.

Also, DEC has dropped the bottom out of the 12-bit computer price structure with introduction of the PDP-8/E, selling in one version at a discounted price of about $2,500 [*Electronics*, July 6, p. 105].

Finally, with a plant larger than some auto assembly factories, DEC is in a position to deliver on time. And to quote Computer Automation's Methvin, when an order comes in, the maker had better be able to ship; "customers apparently wait till the last minute to order, then stand on us for delivery." Methvin's customers apparently want to keep cash in house as long as possible. But it could be worse; accounts receivable are now running 120-days, and some buyers even post date invoices according to one firm.

Clouds. Just as the end-user market is becoming the target of the more aware mini computer makers, cash-rich Texas Instruments and IBM enter the scene. IBM's System 3 already has proven its ability to take sales away from mini's in pure business applications. TI 980's are used at more than 90 stations in house as process controllers, and up to 10 may be in field test by potential customers.

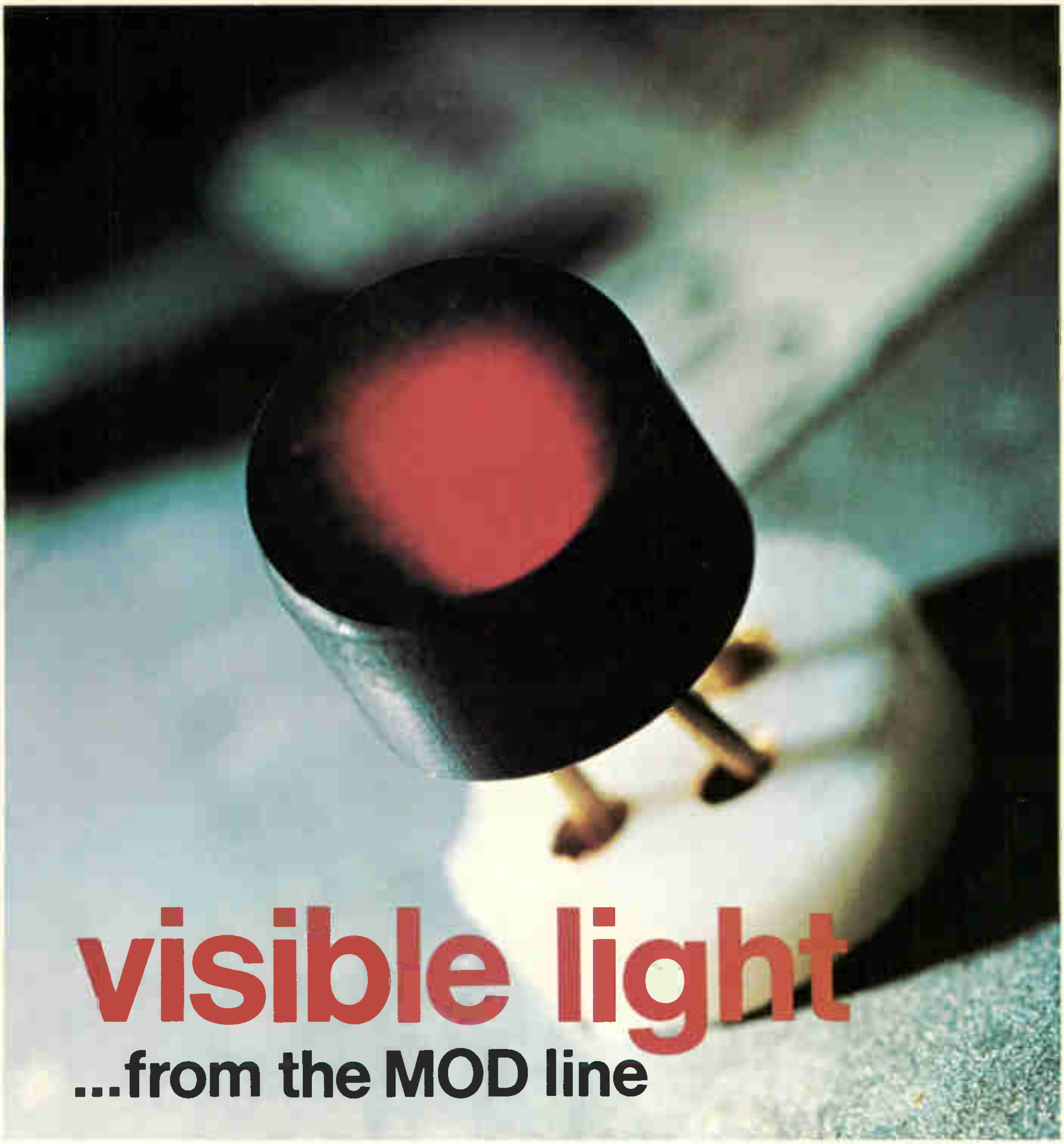
TI's other machine, the 9605, is said to be unique in architecture. It's a bit-oriented machine, aimed at "controlling discrete events," say TI sources, and appears to be aimed at complex process control.

What scares competitors isn't TI's process control goal or the 960's architecture, but the fact that TI makes it's own semiconductors, "and it knows how to run a price war," according to one mini maker spokesman; "they know the value of a loss leader, and are literally capable of freezing out 95% of their competition."

Gerald L. Seelig, president of the Lockheed Electronics Co., Plainfield, N.J., feels his venture would survive, but then no one is predicting his own failure. Seelig says that he personally has been approached by several firms seeking to be acquired and feels the shakeout has already begun.

Survival. In the face of this, firms are taking various routes to survival. Computer Controls Inc., Fairfield, N.J., is second sourcing the PDP-8 family of computers. Its version is similar in architecture and uses the same programs. Company president John Ackley says, "We looked at DEC with about 70% of minicomputer installations, then built a machine interchangeable with the PDP-8/I and with a lower price." Computer Controls sells only to OEM's and has given service duties to a representative organization. Ackley is confident of success, but DEC says it isn't worried.

Compiler Systems Inc.'s president, John Hayne, says that he expects the firm's two upcoming machines, the CSI-16 and CSI-24, to succeed because they can translate and execute compiler language programing and do multiprograming, too.



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New IBM series comes on soft

'Evolutionary' 370 line shares architecture with 360 machines; software man calls it 'just a 360 with some new bells and whistles'

By Wallace B. Riley,
Computers editor

Something big has been in the works at IBM for months. A few knowledgeable sources were predicting a whole new series of superfast computers with huge memories and radical design departures —machines whose impact would rival that of the 360 series [*Electronics*, June 22, p. 33]. Then came the eagerly awaited announcement —and the letdown: IBM will introduce only two models of its "evolutionary" new 370 line—the 165 and 155—and they would not obsolete, but instead offer a step up from, some of the 360 models.

Both machines, which will start going out early next year, share their architecture with the 360 line. Each one uses semiconductor "caches," high-speed buffer memories, as do the 360 models 85 and 195, and each employs faster versions of the monolithic circuits, MST, first introduced last year in IBM's System 3 computer. The new machines can work with many second-generation programs and will accept any of the 360's input-output devices. And each of the new computers uses error correction circuits for the main storage to increase reliability.

IBM says the new 370/165 and 155 offer a three- to fivefold improvement over their 360 counterparts—the 360/65 and 75, and the 360/40 and 50, respectively (see table).

Most computer houses are cautious in commenting on the 370's, preferring to wait until other models are introduced. But one source notes, "By sticking to the 360 architecture, IBM has just made an inefficient machine more efficient. But it still can't do real multiprograming efficiently—for example, running several cobal programs simultaneously."

Martin Goetz, vice president and director of proprietary software at Applied Data Research Inc., Princeton, N.J., feels IBM should have directed its efforts toward improving the 360 series' software, where there are "too many unsolved problems." At any rate, he notes, "The 370 isn't really all that new; it's just a 360 with some new bells and whistles." What's more, it doesn't seem likely that IBM's announcement will force many other computer firms to alter their plans. RCA Corp., for example, is expected to announce a new line of its own this summer.

Others feel IBM will be bringing other 370's out in the near future, especially since the new machines are relying heavily on proven technology. George Lowry, group vice president, Brandon Applied Systems, a New York consulting firm, feels that next 370 models will be in the slow speed range and will be designed to take over the market slots currently filled by the 360/30 and 40.

One factor that will bear heavily on computer makers' response to the 370 series is its cache memory. While very fast and economical for a single processor system, the memory still isn't cheap enough to pay off in multiprocessor computers, on which many computer houses, unlike IBM, are pinning their hopes.

The two new input-output devices IBM introduced at the 370 announcement may well be an immediate hit. One, a 2,000 lines per minute printer, is almost twice as fast as existing IBM units. The other, a disk storage device, halves available access time and triples storage capacity. Brandon's Lowry feels other companies probably will follow IBM's lead with similar units.

The cache makes the cumber-

Ups and downs. The new 370's are a step up from 360 models 50 and 65 and a shade below the 360/85, one of IBM's fastest machines.

Old vs New		360/50	370/155	360/65	370/165	360/85
Main memory cycle, μsec		2.0	2.1	0.75	2.0	1.0
Capacity*	min	65	262	131	512	512
	max	524	2,097	1,048	3,145	4,096
Machine cycle, nsec		500	115	200	80	80
Channels		4	6	7	12	6
Transfer rate**		1.2	1.5	1.2	3.0	1.2
Price range***		14-55	37-79	34-100	71-143	84-200

*In thousands of bytes
**In millions of bytes per second
***In thousands of dollars per month

some main memory seem to run as fast as the processor; perhaps 95% of all memory accesses retrieve data already in the cache, so it's not necessary to wait for a main-memory cycle. The cache concept succeeds because in normal operation accesses aren't truly random and tend to occur in nearby locations within periods of a few cycles.

In actual operation, the cache memory exchanges data and instructions directly with the processor, matching its fast cycle time. The slower ferrite-core main memory dumps large batches of data into the cache in a single cycle, thereby assuring that successive words needed by the program are almost always at hand.

Catchy cache. In general, cache memories are economical only when there's one central processor and one main memory, with the cache between them. Caches are ineffective in multiprocessing systems because several processors, all dipping into the main memory independently, change the essential nonrandom access pattern. A cache in each processor could overcome this, but then the ratio of cache capacity to main memory capacity would tend to be too high for maximum cache efficiency—unless the main memory were much larger than usual. Since most large computer makers—in particular, Burroughs, General Electric, and Univac—all design around the basic frame of a multiprocessor, they've decided against the cache memory.

But it's not even certain that IBM will stick with cache in the anticipated smaller 370 models, unless they feature unusually large memories.

Another trouble spot for the cache memory is in a multiprogramed machine—a single processor-single memory combination running several programs at once. In a non-cache computer, programs must switch back and forth between the main memory and a high-speed drum unit. But the cache itself requires a form of switching in and out of the main memory, so that the extra overhead may be too heavy in many cases.

Then and now

The differences between IBM's announcement of the 370 and its 1964 heralding of the 360 are more marked then the differences between the two machines. Six years ago, Thomas J. Watson Jr., IBM's chairman said, "This is the most important product announcement we have ever made." He called the System 360 a "new generation," which effectively condemned all older IBM computers to a lingering obsolescence. The 360 required a whole new manufacturing line, new software, new servicing techniques—hardly anything was salvaged from the company's eight or 10 predecessor lines. This time, Watson was more subdued—and for good reason.

IBM's troubles with the 360 software are legendary [*Electronics*, July 11, 1966, p. 129; Aug. 22, 1966, p. 149]. Some of the compilers were either too big to fit the memory, or, if they did fit, they didn't work right. The operating system, which keeps the computer going by feeding jobs into it, one right after another, while doing bookkeeping chores, wasn't available at all when the first machines were delivered. And when it finally was offered, it was only as specialized versions working with tape- or disk-oriented installations, but not both. The generalized operating system eventually was finished, but it is already in about its 18th version, and some observers feel it is still rather inefficient. At one time, over 2,000 IBM people were working on the problem.

In the manufacturing area, the 360's hybrid integrated circuit building blocks presented some rather serious difficulties, slipping delivery schedules over the first few months. Because of temporary shortages, IBM started a crash program to redesign its 360 magnetic tape systems so that they could use discrete-component circuits from earlier second-generation computers. Since almost every computer installation involves from four to 20 tape drives, this redesign freed large volumes of the hard-to-get hybrid IC's, which IBM calls solid logic technology, SLT, for central processors.

Nevertheless, IBM is touting the multiprograming capabilities of the 370, which it says are superior to those in the 360 line. The new machines can be set up to emulate one of several older machines, and can switch between a program for that machine and one for the 370 under control of the operating system. IBM calls the technique "integrated emulation." This means the computers can simultaneously process programs written for the 370 plus one older machine. However, equipping a particular machine to emulate a different machine isn't easy—a user can't decide on the spur of the moment what machines he will emulate.

Copy chart. In the 370/155, a systems engineer can emulate one of IBM's 1400 series in somewhat the same way as was done in the 360—by replacing the read-only memory. But the process is much less time consuming in the new machine. In the 165, the data necessary to emulate one of the IBM 7000 series machines is stored in a writeable control store loaded by a supervisory program that's not controlled by the user. The store, a small semiconductor array physically similar to the cache but functionally an extension of the ROM, is essentially the same as the writeable control store in the 360/85, which is used primarily for diagnostic programs.

Other computer manufacturers also part company with IBM over including error correction circuitry for the main memory. This drastically cuts speed, they maintain. But IBM cache speed circumvents this problem. Thus, the 370's circuits, which correct all single bit errors and detect all double-bit and most multiple-bit errors, hardly affect overall system speed. This was true of the 360/85, which marked the initial use of error correction in main memories. It's even truer of the 370's, whose main memories are considerably slower and less impacted by the delay.

Two console printer/keyboard units will also be available with the 155. One is another version of the familiar Selectric mechanism, a feature of most IBM console printers for perhaps the last decade. The other has a new wire-matrix printing mechanism that stutters along at 85 characters per second.

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Circle 112 on reader service card

Air traffic control socked in

Lack of funds, ineffective leadership, and political problems are holding up implementation of fourth-generation system studies

By Ray Connolly,
Washington bureau manager

Ten months have elapsed since the Air Traffic Control Advisory Committee delivered its two-volume study calling for an immediate start on a "fourth generation" ATC system. Yet the report is gathering dust on the shelves of the Department of Transportation, which commissioned the two-year study.

The Alexander report—named for General Research Corp.'s Ben Alexander, ATCAC's chairman—was applauded for its comprehensiveness and technical detail when it was first presented [*Electronics*, Oct. 27, 1969, p. 127]. Yet DOT still hasn't acted on any of the recommendations. According to those involved, the reasons—some call them excuses—boil down to three, all interrelated: lack of funds, lack of leadership, and politics.

Though DOT's Federal Aviation Administration is scheduled to receive $4 million more for fiscal 1971 research and development than it did a year ago, its $45 million total allotment is minimal by almost any measure—$15 million less than the FAA wanted, and $2.5 million less than the Budget Bureau allowed.

For fiscal 1971, FAA plans to spend $34.2 million on air traffic control R&D, nearly $5 million more than the previous year. But some $6.4 million of the total will go to increasing system capacities. No funds are proposed for FAA long-range R&D, which received $1.2 million a year ago. Yet industry sources see an annual outlay of about $120 million required to implement the major improvements in air traffic control suggested in the Alexander report, and that's about twice the amount the Transportation Department expects to get from user charges authorized by the recently passed airways and airport development legislation.

Charges of lack of leadership—

What's "automation"?

Semantics often is a root cause of technological disputes. Example: what does "automation" mean in terms of air traffic control systems? FAA officials use it freely in their National Airspace System now entering Stage A, as well as for en-route air traffic control and the Automated Radar Tracking System, ARTS III. Though these represent advances, they are only semi-automated, say ATC engineers, because human controllers are needed.

Gustav Lundquist, FAA's development chief, concedes NAS Stage A costs, when completed in 1974, will rise "20% to 30%" from the original $500 million estimate. DOT's air traffic control advisory committee chairman, Ben Alexander, asserts that the agency has been "frittering away its money on NAS while it hasn't spent one penny studying fully automated air traffic control." Systems engineers, he charges, have "no knowledge of the subject; no idea of what may be needed by way of equipment or procedures." Alexander asserts the section of his committee's report co-authored by FAA's Neal A. Blake and Univac's James C. Nelson is one of the first attempts to examine the technology required for full automation and, it is "a bare, halting first effort," he adds.

To begin true ATC automation, Neal and Blake believe the 1975 computers which would be used in a 1980 system will have to contend with these technological considerations:

- A basic component reliability at least one order of magnitude greater than today's, or between 1,000 and 1,500 hours for a complete system, including input output devices, memory, central processor, and related black boxes.
- Component speeds of about 2 nanoseconds, resulting in 50-nsec add times, equivalent to a maximum throughput of 20 million instructions per second per computation processor. Also required will be loaded logic costs from 60 cents to $1 per logic node, including packaging, cooling, wiring, and cabinetry.
- First-level main memory with a 150-500 nsec cycle time using either film, wire or logic technologies with five-cent-per-bit cost. Also needed will be second-level random access, non-rotating memories of film, wire, or MOS logic with cycle times on the order of 2 to 5 microseconds with costs running to about 1/10th cent per bit. Data banks on the order of 10^7 to 10^8 bytes can be achieved with this technology.
- Input-out data rates will hold at a maximum rate of 1 megaword per channel, but will commonly be used at a much lower rate. Several peripheral devices will be multiplexed on a single, 1-megaword data channel, and several such channels will be controlled by a satellite I/O processor.

the second ATC stumbling block—are leveled mostly at the Department of Transportation, though some industry and government sources hang it on the Congress, too. The FAA is sympathetic to the Alexander report, "but there is a great suspicion of FAA at the top of the Transportation Department," says one of the committee's members. While not conceding that DOT doesn't have a full appreciation of air traffic control problems, one department official says, "The way government works, it's premature to expect firm decisions from a report that's still drawing comment from a lot of places."

Politics. Two politically oriented moves bear on the inaction, according to several Washington sources. First is the DOT move to aggregate power in the Office of the Secretary, John Volpe, and its impact on ATC research and development. Second is last year's DOT takeover of NASA's Cambridge, Mass., Electronics Research Center, now the Systems and Technology Center [*Electronics*, April 13, p. 48].

By putting more long-range transportation planning and R&D authority in the Secretary's office, Volpe sought to expand on his predecessors' powers, and asked for $22 million for that fiscal 1971 function—double the existing appropriation. But the House has cut that money to $14.5 million.

However, air traffic control studies were not affected. The Secretary's office got a $3.5 million increase in funds earmarked for long-term looks at "full automation of the air traffic control system and techniques for increasing the capacity of urban airports." But $8 million for STC will hardly support the center. "It takes $25-30 million just to keep the doors open," says one top department official.

Tradeoff. Whether the STC contribution to air traffic control will be worth the anticipated two-year delay required to bring it on stream is the subject of some debate, to be resolved only by the center's performance as it begins to look at "full automation" beyond ongoing programs. Virtually all sources agree with Ben Alexander's observation that the center "is bleeding off any spare money" that DOT may have had to implement the report's recommendations.

Alexander also believes the recommendations are not getting much support from the Department of Defense, which is due to assess the report in about a month. A check with the Pentagon confirms his suspicion. Discussing the Alexander report's most controversial recommendation—use of intermittent positive control to divide airspace into three-dimensional cells—sources at the Pentagon question whether the investment for military aircraft is worth it. Similarly, DOD has zeroed in on the call for development of a "Super Beacon" which would upgrade existing ATC radar beacon systems in two steps. "Unless we can see an improvement for the expense, it's not going to get very far," says the Pentagon.

DOD believes cooperation by the general aviation community will be difficult to obtain, so the cost benefit to the military to equip its aircraft would be limited if general aviation were not obliged to participate.

How much would upgrading of existing beacons cost? It's a question of critical importance to the private aircraft owners and pilots who make up the general aviation community. Dr. Lawrence Goldmuntz, the special assistant to the DOT Secretary who monitored the Alexander report, estimates a data link would "add 10% to the cost of a beacon—about $250 a plane." Yet the Air Transport Association's Siegbert Poritzky calls it "a $1,000 modification; nothing costs $250."

Policy. However, as ATA's Poritzky puts it, "We want to see a policy first, a definite direction. We would like to see R&D move ahead rapidly. But we also want to see it defined more specifically." Poritzky says carriers want defined goals for R&D—"to promise something better, not just different." One such goal for a terminal area computer system, for example, should be to offer a definite increase in the airport's capacity.

As for the Super Beacon concept itself, Poritzky observes: "This is an attractive possibility because it would appear that this approach could be implemented with relatively less pain than some others. We do have some twinges, however."

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Circle 115 on reader service card

bility data link on the ATC Radar Beacon, "we need to move forward smartly on a universal digital communications system if we're really going to get ATC automation in a reasonable time," Poritzky argues. He contends Federal footdragging, not technology, is air traffic control's biggest hangup.

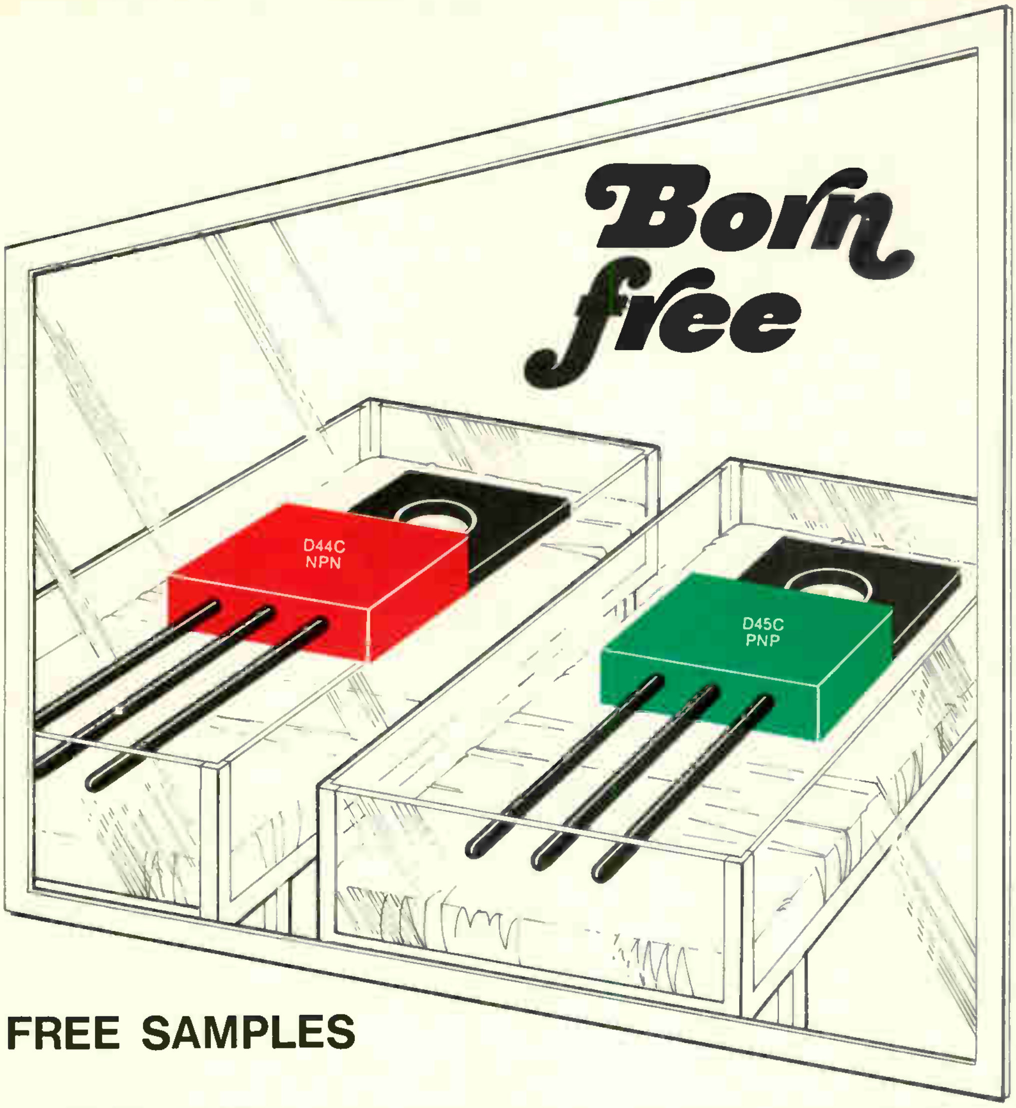
Of the ARTS III displays, he asserts that "we have been practically begging FAA for years to provide small, accurate target symbols on which to base ATC separation. It seems almost inconceivable that the bright and shining new ARTS III system, which FAA hopes to implement in 1971, still keeps the 1943-size raw beacon slash as the basis of control. Better techniques were developed and proven to be feasible by FAA 10 years ago. . . ."

On sidelobe suppression, Poritzky says, "The procurement of important ground hardware was held up for nearly two years in FAA, apparently because of misunderstandings between various of the responsible offices."

On alphanumeric displays, he suggests FAA has been reinventing the wheel. Alphanumeric characters on radar displays were in use in the SAGE air defense system back in the 1950's, he says. And in 1964 the FAA installed ARTS I, an alphanumeric terminal area ground display system for ATC radar beacon, primary radar and automatic altitude data. ARTS III, to be implemented in 1971, will be more modern but less capable, he notes.

Thus does Poritzky, who generally speaks kindly of the expertise and effort that went into the Alexander report, make a hard-nosed point for ATA. "We tend to be a little gun-shy about the bright, bold future for fear it may be a mirage. We believe strongly that great effort is necessary now to implement systems we know how to implement, to finally use the technology we've had for years."

Similar views can be found among aviation professionals in the Department of Defense and elsewhere. These are not necessarily criticisms of the Alexander report as such—far from it. They are, instead, sharp raps at past FAA inaction and may soon turn to criticisms of FAA's uncertain parent, the Department of Transportation.



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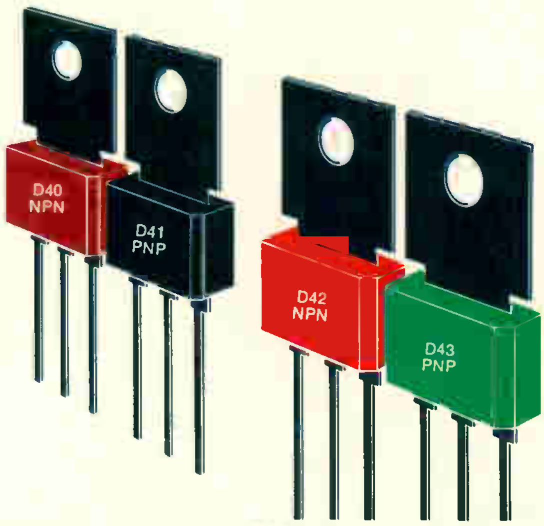

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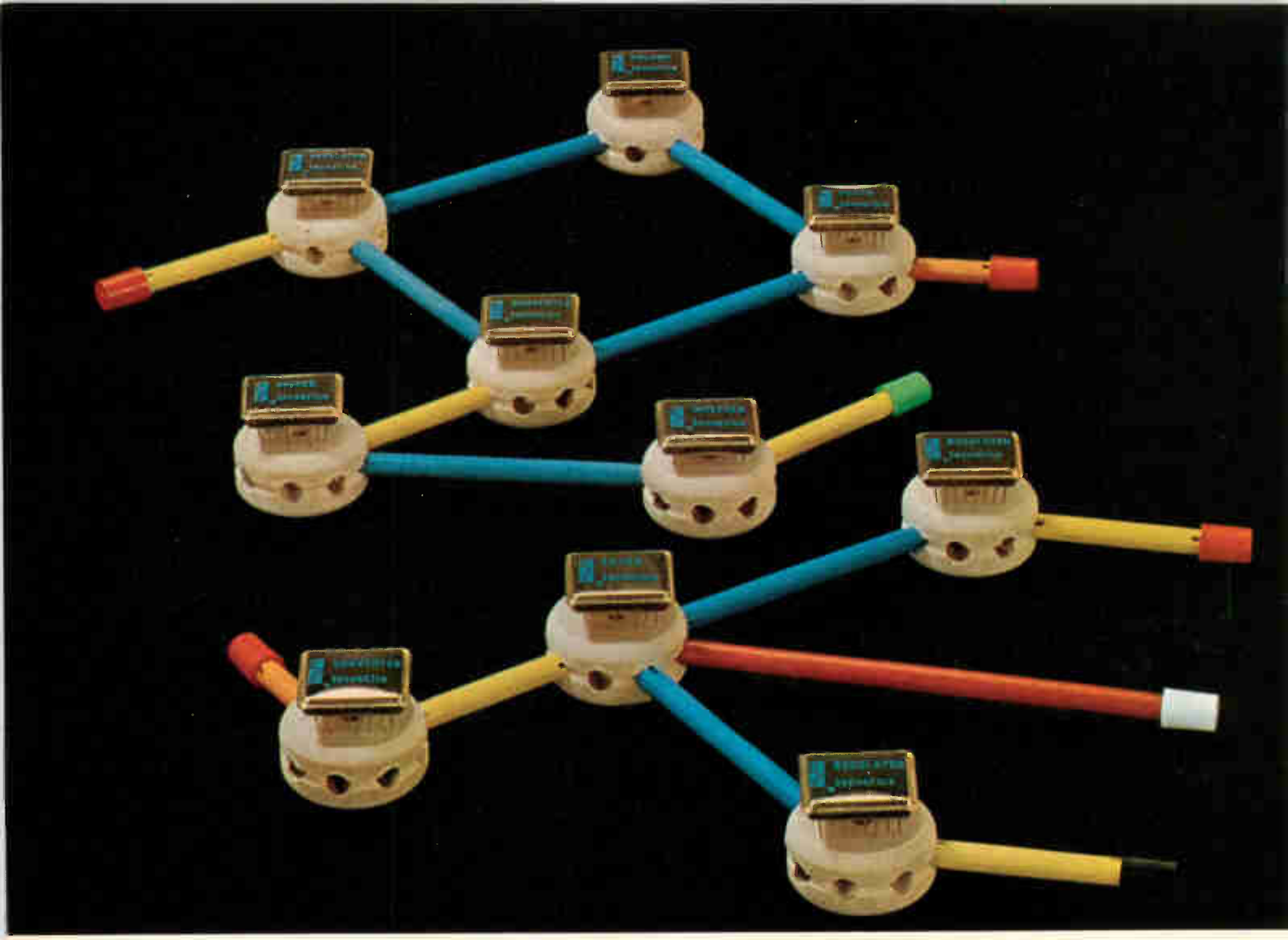

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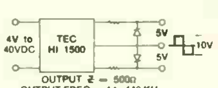

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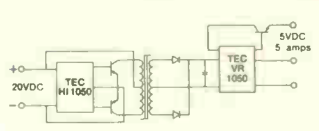

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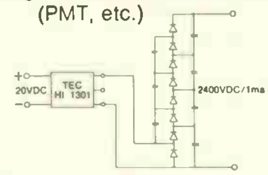

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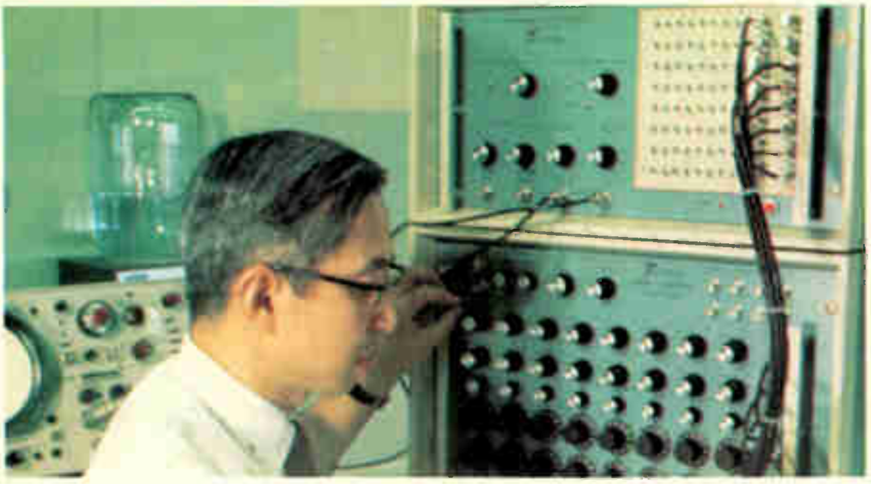
The innovators in power conditioning

Tester outraces IC memories

Aimed at replacing costly banks of hard-to-synchronize pulse generators, modular equipment anticipates storage devices with 10-nanosecond access time

By James Brinton
Boston bureau manager



High-speed exerciser. Test system designed for fast-access memories has two modules, a data generator (top) and a digital format converter. The tester is aimed at quality control jobs in the memory maker's plant and at incoming inspection duties in the user's.

As logic speeds continually increase, and as semiconductor memories appear in quantity, users find themselves with a testing problem: there's not much test gear around that is fast enough to check these devices under operating conditions.

Even metal oxide semiconductor memories achieve access times below 500 nanoseconds—150 nsec, or so, in four-phase circuits—while emerging emitter-coupled and transistor-transistor logic memories access data in 30 to 50 nsec with ease. Film and other advanced memories present similar problems—they can access data in 70-75 nsec or less.

Keeping up. The DFE-1 from Tau-tron Inc. represents an answer to the testing problem. It can generate pulse trains at up to 125 megabits per second and synchronize pulses to within ±500 picoseconds. This pulse rate translates into about a pulse every 8 nsec, giving the DFE-1 an edge over the fastest memories in use. It would replace costly banks of hard-to-synchronize pulse generators used to test fast memories with repetitious chains of 0-1-0-1, etc. In many instances, these devices lack the necessary speed.

The DFE-1 consists of two modules: the WG-111 data generator and the FC-201 digital format converter. The WG-111 puts out eight parallel channels of data, each a series of arbitrarily programable eight-bit words—an immediate advantage over other schemes, as some logic "locks up" only after uninterrupted streams of zeros or ones, something the pulse generator jury rigs can't produce.

The WG-111 provides twin outputs for each channel, true and true's complement, for a total of 16 available channels; one WG-111 thus can trigger two FC-201's. Output is ±1 volt into 50 ohms impedance. There's also a clock output at the same level and impedance, but clock pulse width is continuously variable from 3 nsec to 10 milliseconds with vernier adjustment.

Though top speed is 125 megabits per second, the user can get anything from one bit per second on upward in nine ranges. Crystal control of these pulse repetition rates and of clock frequency is optional. A sync bit follows each 8-bit word and can be delayed from 0 to 10 msec in six ranges, each with vernier adjustments. The bits are typically 20 nsec wide, and amplitude is +1 volt into 50 ohms.

Waveshape control. Coaxial cables link the WG-111 to the FC-201 format converter. This second module allows variable width, time delay, amplitude, and voltage offset of pulses in each channel. It also is an eight-channel system, with each channel independent in operation and adjustment. But once again, both true and true's complement are available at each channel.

Inputs from the data generator feed the FC-201's control and logic bank. At this point pulse shape variables for all eight channels are decided, except for baseline voltage offset—whether the output of a given channel is to be in non-return-

... tester can be used for incoming inspection or quality control of high-speed arrays ...

to-zero or return-to-zero format, the delay of pulses in one channel relative to those in other channels, pulse width, etc.

Control logic is made from Tau-tron's Univer modules. These use a current steering, tunnel diode switch approach that allows clock rates well into the uhf range [*Electronics,* Feb. 17, 1969, p. 56]. The Univer modules are derated, therefore, even in this high-speed test system, and spokesmen hint that Tau-tron has left itself growth capability to cope with logic several times faster than available right now.

Univer logic characteristically results in clean pulses; rise time typically is 1.2 nsec, fall time typically 1.5 nsec. Maximum waveshape aberration in the whole FC-201 is 7%, and this helps to keep ringing, overshoot, and droop low.

Pulse width is continuously variable from four nsec to 10 msec through six ranges and a vernier adjustment. Relative delay is continuously variable from 0 up to ten msec in six ranges with vernier fine control. With this capability, test engineers can skew pulse timing among the various channels, making it possible to test multiphase MOS, for example, with ease and with tight control of conditions.

After waveshape and delay are set, pulses are amplified with current switching, back-matched amplifier circuits capable of providing + 12 volts at 120 milliamperes short circuited, or 5 volts into 50 ohms. Attenuators then cut output amplitude to the needs of the experimenter in 1-decibel steps to a maximum of — 10 db. Once again, the use of vernier control allows fine tuning.

The final setting is for voltage baseline offset, variable to ± 3 volts when driving 50 ohms. Baseline and attenuation adjustments don't affect each other in the system.

Self control. With this much control over output, the user not only can use the DFE-1 for incoming inspection or quality control, but also, in computer laboratories, he can effectively measure the transfer characteristic of a memory. He knows exactly what went into his subassembly and so can match this against the output through a comparator or through real-time data recording.

This allows flexibility not possible before in computer design—now the DFE-1 can be used to peg a bit rate, then design a multichannel input train of pulses shaped to the needs of the memory and capable of yielding specific outputs.

Also, since the DFE-1 simultaneously tests the read-write circuitry on or outboard of the memory, engineers can design associated electronics to suit exact needs. Formerly, it was sometimes necessary to overspecify associated components in order to be safe. Now the added cost of overspecifying can be saved.

For incoming and quality control testing especially, Tau-tron offers an eight-channel high-speed comparator, the DSU-350K/8. Its settling time is fast—typical performance is in the neighborhood of 4 nsec; minimums are running at 2.5 to 3.0 nsec.

The DSU-350K/8 takes outputs directly from the device under test and from the DFE-1 system and compares them with a resolution of better than ± 10 millivolts. It then provides outputs for magnetic tape storage for later computer processing. There is also a "strobe on error" output available to flag improper responses and therefore catch bad parts. The strobe would be suited to incoming test applications; the data processing output would be more useful in memory engineering and parts control data logging.

The comparator is modular and is sold at $200 per channel. The DFE-1 itself can be assembled modularly; by adding FC-201's, 48 or more channels of data can be obtained without degrading any of the specifications.

Price for an eight-channel DFE-1 is $17,750: Tau-tron is quoting four-to-six weeks delivery.

Tau-tron Inc., 685 Lawrence St., Lowell, Mass. 01852 [338]

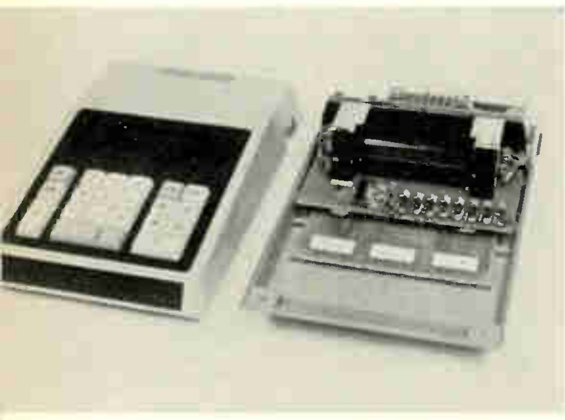
Six MOS chips equal one calculator

IC's are sold as standard products, but user builds proprietary machine; control read-only memory unit can be customized for special functions

By Stephen Wm. Fields,
San Francisco bureau manager

One promise of large-scale integration was that a subsystem could be reduced to a single chip in a single package, providing compact building blocks for the systems designer. This promise is being fulfilled, but while it made things somewhat easier for the designer, the semiconductor maker faced a new problem: the world outside was turning into a custom market.

The electronic calculator market was especially sensitive to the need for proprietary chips because all calculators have essentially the same format: they have a keyboard, an arithmetic unit, an output unit, and a display. The difference, and thus the selling point, is usually the type of keyboard, the available arithmetic functions, or the type of display. Before LSI devices, the difference was engineered in the circuit design, but with LSI available, the difference is in the devices themselves. On the other hand, because the electronic calculator market is so big, and still growing, semiconductor manufacturers have been looking for a way to turn this custom market into a standard one. That's what Electronic Arrays has done with its calculator chips.



Tryout. Calculator (with case off at right) was built to test chip set.

According to Earl Gregory, vice president and director of marketing at Electronic Arrays, the calculator set—which consists of six circuits—will offer "reduced labor costs because of the reduced assembly time. This will open up the calculator market to companies that otherwise wouldn't get into it—and it will open up the market in a hurry." Gregory expects to deliver approximately 200,000 sets during the next 18 months. He is reasonably sure about this figure because close to half of it is already contracted. Amperex Electronic Corp., a subsidiary of North American Philips Corp., has signed a contract that Gregory values at $5 million. "Amperex will handle the European market and we'll take care of the U.S.," says Gregory.

As for selling the same circuits to different customers, Gregory says that "all of our customers will benefit from the high volume—it will be cheaper for all. And besides, the circuits offer options so the calculators will not be copies of each other." New markets are on the horizon, too. Gregory says there has been a decline in American-made calculators during the past few years, primarily because of high assembly costs, and customers have been looking to Japan. But now, says Gregory, the U.S. companies can put their own units together, and with Amperex selling in Europe, the European companies also can compete with Japan.

Gregory projects a price per kit of six devices at about $35 by mid-1972. This is about half the present quantity price of $60 to $70. He says a complete calculator would cost from $100 to $200 depending on the quantity, case, keyboard, and type of display.

The kit consists of six chips: an input unit; a control read-only-memory chip; a control logic device; a register; an arithmetic unit; and an output chip. The input chip receives digit and command signals from the keyboard. An address code is generated through use of a six-bit read-only memory in the chip. At the appropriate time the address is transmitted to the control chip; the input chip then waits until the control chip is not busy before honoring new inputs.

The control ROM chip contains the read-only memory unit 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 which causes a data movement associated with a program step; a portion of each word specifies address of the next program step within the ROM. The control logic chip contains counters which require shifting and accumulate digit counts during multiply and divide operations. It also provides ROM address sequencing control, bit timing, and point-position and single-digit storage.

The register chip is made of three 64-bit shift registers, one four-bit shift register, and register selection gating logic. The three 64-bit registers are the accumulator, the input, and multiplier/quotient registers. Each has individual clear capability and can shift right or left. The input register receives keyboard figures, and also is one of the inputs to the adder on the arithmetic chip. The accumulator accepts arithmetic outputs, and the M/Q manipulates multiplier, divisor, and quotient digits.

In addition to full binary-coded decimal 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. Selection gates driven by ROM microprograming determine the data paths entering the arithmetic chip from the three registers.

The output chip supplies signals for the bcd digit value for 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's arithmetic capability is capable of accumulating sums and products up to 16 digits, but the 16 digit positions are viewed eight at a time by selecting an upper-half (most significant) or a lower-half (least significant) register. In the upper half, no decimal point is displayed and leading 0's are suppressd. In the lower half, leading 0's are suppressed until the decimal point position is reached.

Certain design constraints had to be followed, one of which was package size. Says Samuel Wauchope, Electronic Arrays' director of engineering, "In order to meet the cost objectives, we had to live with 24-pin packages, and this ruled out a truly parallel machine. Even the keyboard output had to be in serial form."

Customizing is accomplished easily. Since the control and arithmetic chips were designed to handle more than just the simple configurations, more input functions can be added by simply putting on another input chip. Similarly, if a full 16-digit output is required, all that is needed is another output chip. And non-standard functions can be provided by changing the programing in the ROM's in the control chip.

Sample sets can be ordered from stock for $150.

Electronic Arrays, 501 Ellis St., Mountain View, Calif. [339]

Circle 123 on reader service card

. . . or 4, 5, 6 or maybe over 100! If you're using a crystal ball to determine bit error rates of digital links, tape recorders, modems, or any digital transmission or storage device . . . investigate the unique advantages of LINK-BERC (Bit Error Rate Calculator). For the first time, a single 5¼ inch unit offers so many advantages.

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DCS

DATA·CONTROL SYSTEMS, INC.

I see bit-errors...two, maybe three...

Low-priced tester seeks low-volume work

Built to check out digital circuits, this programable unit reads a character a second, costs $7,000 and has 24 outputs

A family squabble has brought forth a versatile digital-circuit tester that's inexpensive and programable. Called the minitester, the unit was built to smooth the passage of new products from development to production at Canadian Marconi Co. Previously, any disagreement over writing test procedures, building test fixtures, or interpreting results usually wound up with designers and production chiefs pointing accusing fingers at each other. "There was continuous harassment and arguing about how to test properly," recalls Harvey Kolodny, Marconi's manager of avionic testing.

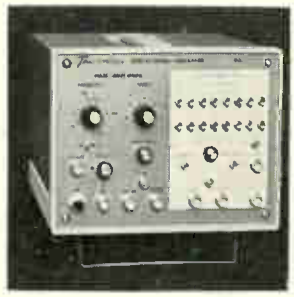
Now, engineers write a test program as they develop a product, continually checking out their latest prototype with a minitester. When development is over, the engineers turn over a test program along with final designs. With a minitester of their own, the production people have little trouble, and take little time, setting up test stations and checking out new products.

In fact, the minitester has worked so well testing new products, says Kolodny, that now it's going to be

Digital voltmeter/multimeter model 7005 features a 5½-digit readout, 10-microvolt resolution, and an accuracy of ±0.005%. Measurements can be made at a rate up to 5 samples per second, and readings include an auto-positioned decimal point, polarity sign, and annunciator. Base price is $1,295. Systron-Donner Corp., 888 Galindo St., Concord, Calif. 94520 [361]

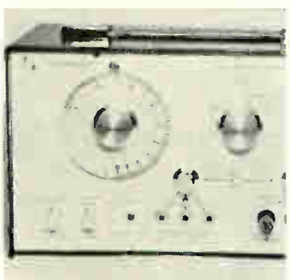
Sampling digital voltmeter model 1166 measures true root-mean-square or peak of continuous or bursts of complex waveforms. It employs a square law detector that measures waveform over an interval as short as 10 μsec with a sample period of 3.3 msec, making it suitable for computer controlled measurements. Scientific Atlanta Inc., P.O. Box 13654, Atlanta, Ga. 30324 [362]

Pen recorder model 310 has a full scale span of 1 mv to 100 v, accuracy better than ½%, pen response up to 10 in. per sec, and single or dual chart speeds of ¼ in. per hr to 6 in. per sec. Four-inch fan-fold paper offers a quick-reference feature. All electronics are on an easily replaceable p-c board. Laboratory Data Control Inc., 42 Shelter Rock Rd., Danbury, Conn. [363]



Digital signal generator DG-7 operates from 1 hz to 35 Mhz with its own internal oscillator. It provides a serial data stream 16 bits long, plus a parallel pulse stream, and can operate in either RZ or NRZ format. Output signals feature ±4 v offset and 10 v signal amplitude with 5 nsec rise and fall. Price is $990. Tautron Inc., 685 Lawrence St., Lowell, Mass. 01852 [364]

Reel time analyzer model SD301B provides digital selection of important analysis parameters. Input range attenuation is precisely calibrated in 1 db steps from −5 db to −35 db from full scale, and output gain is increased to 26 db to provide optimum dynamic range for broad-band power spectral density measurements. Spectral Dynamics Corp., Box 671, San Diego, Calif. [365]



Multifunction generator TWG 501 is for use in research, development, production test, field servicing and educational laboratory situations. It covers a frequency range of 0.01 hz to 1 Mhz, a full 8 decades with 10% overlap each end of each decade range. Accuracy of frequency setting is ±2% with less than 0.1% drift. Feedback Inc., 438 Springfield Ave. Berkeley Heights, N.J. [366]

Digital integrating microvoltmeter DS-100 solves instrument drift and repeatability problems suffered by aerospace and industrial technicians involved in physical measurements and other low level instrumentation. Zero drift due to time and temperature is stopped with the Auto-Zero method of a-d conversion. Doric Scientific Corp., 7601 Convoy Court, San Diego, Calif. [367]

Six portable Cassegrainian telescope systems combine the autoranging, direct digital readout, and wide dynamic range of optical test instruments with the power and precision of the finest small telescope. They make possible precise measurement of radiance, irradiance, luminance, or illuminance at any distance. Cintra Inc., 440 Logue Ave., Mountain View, Calif. 94040 [368]

←Circle 124 on reader service card

a product itself. Marconi engineers are reading a commercial model.

A paper-tape reader controls the 3-foot-high minitester. With 24 output and 24 sense lines, the unit checks most digital networks, be they integrated circuits, printed-circuit cards, or subassemblies.

In Marconi's avionics division, where the minitester was developed, a large production run is 200 or 300 units. So the minitester isn't for high-volume testing and automatic handlers. Section leader Frank Woo says that the instrument could be made to accept commands faster than its present 60-characters-per-second rate, but the tradeoff would be a doubled or tripled price tag. As it stands now, the minitester will sell for under $7,000 when it comes to market late this year.

Test time. To use the minitester, a tape must be put onto the reader, which is mounted on the front panel. The tester must be connected to an adapter which holds the product to be tested. All that's left is a push on a button. Each type of product has its own adapter, which can be anything from a pin-to-pin connector to a multiplexer.

Programs are written in ASCII code on one-inch tape, with one character to a line. A single test may require as many as 17 lines or as few as one.

The commands from the reader go through an input/output register to a digital comparator. Test signals then pass back and forth between the comparator and the adapter.

The minitester has three operating modes. In manual, it reads one line each time the START button is pushed. In the semiautomatic mode, the tester runs through a block of commands—17 lines—and then stops. The third mode is automatic; here a complete program is executed with no stop unless there's a failure detected.

Seeking supplies. The minitesters running at Marconi have 5-volt supplies for logic circuits, and 12-volt supplies for operational amplifiers. However, the company will be able to match supply voltages to customer needs.

Marconi engineers are repackaging the commercial version of the minitester and shopping for better power supplies. Modular units are in the company's testers, but Kolodny says that supplies on plug-in cards would be more versatile and cost less.

Kolodny still faces the problem of service. The minitester will be Marconi's first off-the-shelf product for the U.S., where the company has no sales or service force. Kolodny is looking for distributors who'll sell and fix the tester.

Canadian Marconi Co., 2442 Trenton Ave., Montreal 301, Canada **[369]**

New instruments

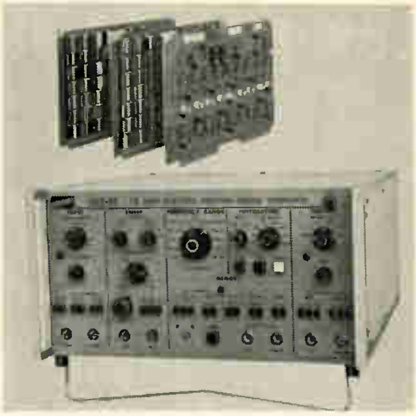
Old analyzer looks like new

Built to resolve 0.1 hz, spectrum measuring unit can now do twice as well

Not everybody is happy when a product is improved; in fact someone who has just laid out the cash for the old model may get downright angry. But an engineer with the SAI-51 spectrum analyzer & digital integrator shouldn't be upset, even though the new SAI-52 will have twice the resolution. Engineers at Signal Analysis Industries Corp. (Saicor) knew this improvement was coming when they were designing the 51; so they built it to be converted to the higher resolution.

Here's how it works. Just a few months old itself, the SAI-51 analyzes, in real time, spectrums over ranges from d-c to 20 hertz up to d-c to 1 megahertz. In the 9-by-17-by-22-inch box with the analyzer is a digital integrator which takes noise out of a spectrum by averaging it over a number of sweeps.

Like most other spectrum analyzers, the 51 breaks an input signal into segments, each with the same bandwidth. Then the energy in each segment is measured. Roughly speaking, this energy level is proportional to the amplitude of a segment's center frequency. Thus, for a given frequency band, the more segments an analyzer looks at, the better the analyzer's frequency resolution. Since the 51 can break a band into 200 segments, it can resolve 0.1 hz when set to its 20-hz range. Now there's the 52, which breaks a band into 400 segments, giving this instrument a top resolution of 0.05 hz.



Card trick. A rewiring job and three cards double this analyzer's resolution.

The 51 can be converted into a 52 by Saicor engineers, who put in additional memory cards, change some wiring, and replace a front panel. The price for the job is $4,700. That's the difference in price between the $17,500 for a 52 and the $13,300 for a 51, plus a $500 service charge. Sales manager Frank Kasper says the conversion takes no more than 30 days.

On special orders, says Ira Langenthal, director of research, Saicor will build analyzers with even better resolution. He points out that his company already has built 1,000-segment units for military radars.

Langenthal says that the military was the first customer for Saicor's early analyzers and integrators. But now industry is starting to use them, particularly to monitor vibrations—in aircraft engines and huge chemical vats, for example.

Signal Analysis Industries Corp., 595 Old Willets Path, Hauppauge, N.Y. 11787 **[370]**

Loop tracer's accurate to 0.5%

Integrator also expands versatility of magnetic flux testing

A hysteresis loop tracer for testing transformer cores promises to make things easier for production engineers. Many have had to put up with instruments that provide only minimal accuracy, allow gauging of only one or two selected magnetic characteristics of a material, and require frequent calibration.

The loop tracer built by Hallmark Standards Inc. provides 0.5% accuracy, says H.R. Brownell, vice president of engineering. This is attained by using a sweep that automatically or manually adjusts to the steepness of the measured curve. Furthermore, the direction of the exciting current can be reversed along any point of the upward half of the loop by pushing a button while recording. Sweep speed is 6 to 30 seconds and H-amplitude, 1-120% of full scale, is adjustable.

The Hallmark loop tracer applies an exciting voltage through a coil that's wrapped around the material under test. A second coil covers the first, and is attached to a Miller integrator that replaces the conventional electromechanical converter. It calculates the flux by measuring the difference between the input voltage of the first coil and the output voltage of the second. Soft materials are measured by an exciting current with a resistance, and an air gap magnetizing force using an H-coil with integrator measures hard materials. Calibration for measuring hard or soft materials is required only when the equipment is installed. After this initial calibration, all that's required to check different material is turning several dials to preset positions.

The price is between $13,000 and $25,000, depending on options.

Hallmark Standards Inc., 257 Washington St., Mount Vernon, N.Y. 10551 **[371]**

Multidigit display has single-unit construction

Corresponding cathodes of nine-segment gas discharge tubes are bused by metal strips; design eliminates welded connections

Just about everything in the design of desk calculators is integrated—except, of course, the display, which usually is a group of discharge tubes. The display in most calculators still consists of a separate tube for each digit plus associated decoding, driving, and strobe circuits. Although solid state displays are increasing in popularity, they still do not compete with tubes on a cost basis. A new multidigit display, which includes all digits in a single envelope, further advances the design simplicity of calculators using gas discharge tubes, and contributes further to cost reductions. Designated the Segmatron, the nine-segment display is made by Burroughs Corp.

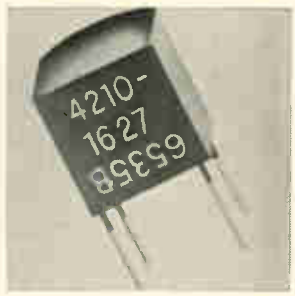
To the manufacturer of calculators and other readout instruments, the single-envelope construction means doing away with handling individual tubes and inserting them into printed circuit boards, interconnecting and soldering the individual leads of the tube, and aligning the digits.

"The integrated display will house 9, 14, or 16 digits and be price-competitive with Nixies and with other segmented displays,"

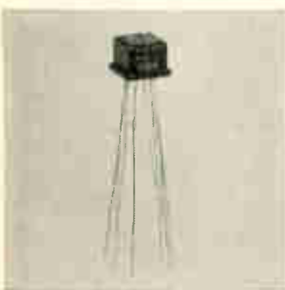
Beryllia-core Acrasil precision/power wirewound resistors are silicone-coated. Standard power ratings of the axial lead units range from 1 through 15 w with resistance values from 0.1 ohm through 25 kilohms maximum in the 15 w rating. Standard resistance tolerance is ±1% with tolerances as close as ±0.05% available. Sprague Electric Co., North Adams, Mass. [341]

Light controlled, variable resistor called Pi-Switch provides a solid state isolation switch. The CSN 756 is rated at 0.75 w and 600 v; and CSN253, rated at 0.25 w and 350 v. Units feature current capability to 10 ma in the light source element, and a dynamic range of 200 to 10^6 ohms in the resistance element. Pulsar Instruments Inc., Hurlingame Ave., Redwood City, Calif. [342]

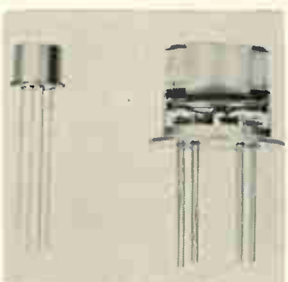
Ceramic capacitors type CK06 have a range of 1,200 pf to 1,000,000 pf per MIL-C-11015/19. Units have proven failure rates of less than 1% per 1,000 hours. Operating temperature range is −55° to +125°C with capacitance tolerances of ±10% and ±20%. Standard lead material is solder coated copper. Vitramon Inc., P.O. Box 544, Bridgeport, Conn. [343]



High-voltage, blocking oscillator transformer model 4210-1627 is designed to operate over a temperature range from −55° to +125°C, has a fast rise and fall time (0.4 μsec and 1 μsec, respectively), and meets MIL-T-21038, grade 7 requirements. Dielectric strength is 1,120 v a-c; insulation resistance, 10,000 megohms. Bourns Pacific Magnetics Corp., Romoland, Calif. [344]

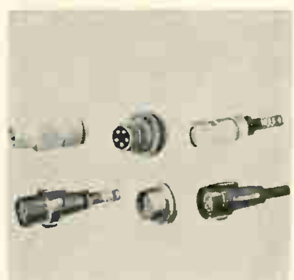


Square microminiature relay series T is suited for high isolation switching and r-f application. The 2pdt unit is rated at dry circuit through 1 amp resistive, operates from −65° to +125°C, and has a life at rated load of 100,000 cycles. Contact bounce is at a low 0.0015 sec maximum, and dielectric strength at sea level is 500 v rms. Leach Corp., 5915 Avalon Blvd., Los Angeles [345]



Hermetically sealed, TO-5 relay model CBR40 is for industrial applications. It is available in coil voltages of 6, 9, 12, 18 and 26 v d-c. Operate/release time is 4 msec and 3 msec max., respectively. It will withstand shock of 30 g's (11 msec) and vibration of 10 g's, over a range of −55° to +71°C. Babcock Electronics Corp., 3501 Harbor Blvd., Costa Mesa, Calif. [346]

Inexpensive, octal base, plug-in time delay relay known as Sensitak model 41 uses a solid state timing module. The timer is of the "on delay" type. When voltage is applied to the control circuit, the timer contacts transfer only after a preset time delay, and then return to normal after power is removed. Price (1-24) is $19.80. Struthers-Dunn Inc., Pitman, N.J. 08071 [347]



Waterproof audio connectors MIL-C-10544 (10 contacts) and MIL-C-55116 (5 contacts) are designed for use in communications equipment. Both series meet rigid military environmental specifications for resistance to immersion, salt spray, temperature cycling, and vibration. Plugs and receptacles mate quickly and easily. Elco Corp., Maryland & Computer, Willow Grove, Pa. [348]

← Circle 128 on reader service card

says John R. Bethke, sales manager. In addition to the seven segments comprising standard displays, the Segmatron also contains two vertical center segments, which, when decoded, form a 1. In most displays, the digit is formed by the rightmost segments, and this creates the appearance of a blank or a burned-out tube.

Conventional gas discharge devices have welded connections. The cathode is welded to a pin which makes the connection to the circuit board. The Segmatron, however, has no welded joints in the tubes. There are 11 individual pieces—nine cathode strips plus a decimal point cathode strip, and one common etched strip which forms the anodes of the display. The same segment of each digit is bused and etched out of a single piece of metal.

The cathodes fall into grooves cut out of a glass plate at the back of the display. Each cathode is made up of a single piece of metal that is brought out as a connection to the circuit board. Each digit's anodes consist of an etched screen or wire mesh. The anode structure also comprises one metal sheet upon which the pattern is exposed and etched. Circuit connections are made via tabs located at the top and bottom of the digit.

Circuit operation of the Segmatron is similar to other multidigit displays and uses the same decoding and driver logic circuits. Since corresponding segments of the individual digits are internally connected in the multidigit tube, the display is suitable only for strobed use in a time-shared mode. This mode is more desirable than d-c because it saves a considerable number of driving circuits. One driver circuit is needed for each segment of the pattern, plus one for each digit. This also reduces the number of printed circuit board connections.

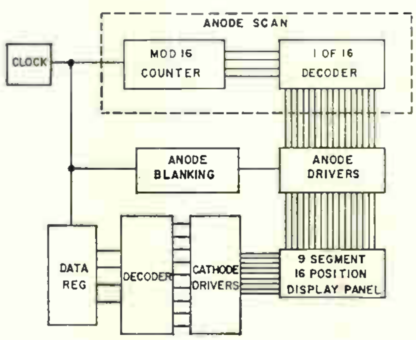
A 12-digit Nixie display needs 144 connections, and a comparable segmented display 96. The integrated display, on the other hand, requires only 22 connections.

Another advantage is in the closer spacing achieved between the characters. The Segmatron's center-to-center spacing is 0.375 inch versus the 0.540 inch for standard Nixie tubes. The viewing angle also is improved because of its inherent in-plane structure. All cathodes lie in the same plane close to the viewing surface of the device. There's no partitioning between the digit positions.

Perhaps the most significant feature to come out of the integrated structure is the reduced cost for manufacturing the device. According to Bethke, prices will run on the order of $1.50 per digit for a 12-digit display in OEM quantities. This should amount to almost a $1 per digit savings over Nixies, which run about $2.50 per digit in large quantities. Bethke estimates that customers will realize cost savings for multidigit displays down to about six digits, below which Nixies are cheaper. Displays using light-emitting diodes run from $3 to $5 per digit.

Engineers at Burroughs predict an average life of up to 200,000 hours at brightness levels comparable to Nixie tubes operated in a multiplex mode.

The display operates from a supply of 200 volts d-c. The anode driver switching voltage requires a 100-volt swing, a cathode driver switching voltage of 80 to 100 volts, with a peak cathode current for each segment between 1 to 3 milliamperes. The time duration of the strobe requires a minimum 150-microsecond pulse for each digit position.



Behind the scene. Logic circuitry needed to drive display results in fewer connections, simpler wiring.

The display panel is available in sample quantities, with production quantities expected shortly. The display will be on view at the Wescon Show in August.

Burroughs Corp., Electronic Components Division, Plainfield, N.J. 07061 **[349]**

New components

Pot handles high power

Trimming device has resistance element elevated above base

Big things sometimes come in small packages—like the power capability in an ultra-miniature potentiometer, measuring only 3/16-inch square by 0.060-inch high.

The trimming potentiometer, made by Mark Micro-Electronics Manufacturing Co., can dissipate more than 50 watts per square inch due to what the company describes as an unusual package design. The single-turn potentiometer, which incorporates a Cermet element, has the resistance structure on an alumina substrate elevated above the base of the device. This raised structure is said to enable the device to remove heat more efficiently than units which mount the resistance element flush with the base.

The unit employs a true crossbar design for making contact. "Because of the elevated design, we can make a rotary contact look like a crossbar to the resistance, as opposed to point contacts, brooms, or balls," says John Rector, chief engineer. And, according to Rector, the design allows very accurate resistance values. Tolerances of stock units are 1%, 5%, and 10%. The trimming potentiometer is available in 16 resistance ranges from 10 ohms to 1 megohm.

The contact material is the same as the resistance material, resulting in a bulk-effect ohmic interface for uniform current flow through the contact.

The units are available in four mounting configurations and are sealed to withstand wave soldering and immersion cleaning. The price is 47 cents each in hundred unit lots.

Mark Micro-Electronics Manufacturing Co., Potentiometer Products Division, 21 Cottage Street, Bayonne, N. J. 07002 **[350]**

small wonders: big news

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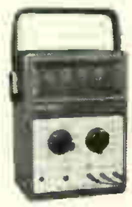

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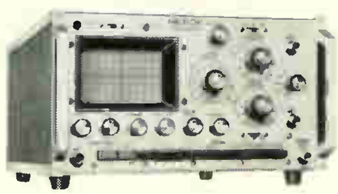
MODEL 5000 & 5002



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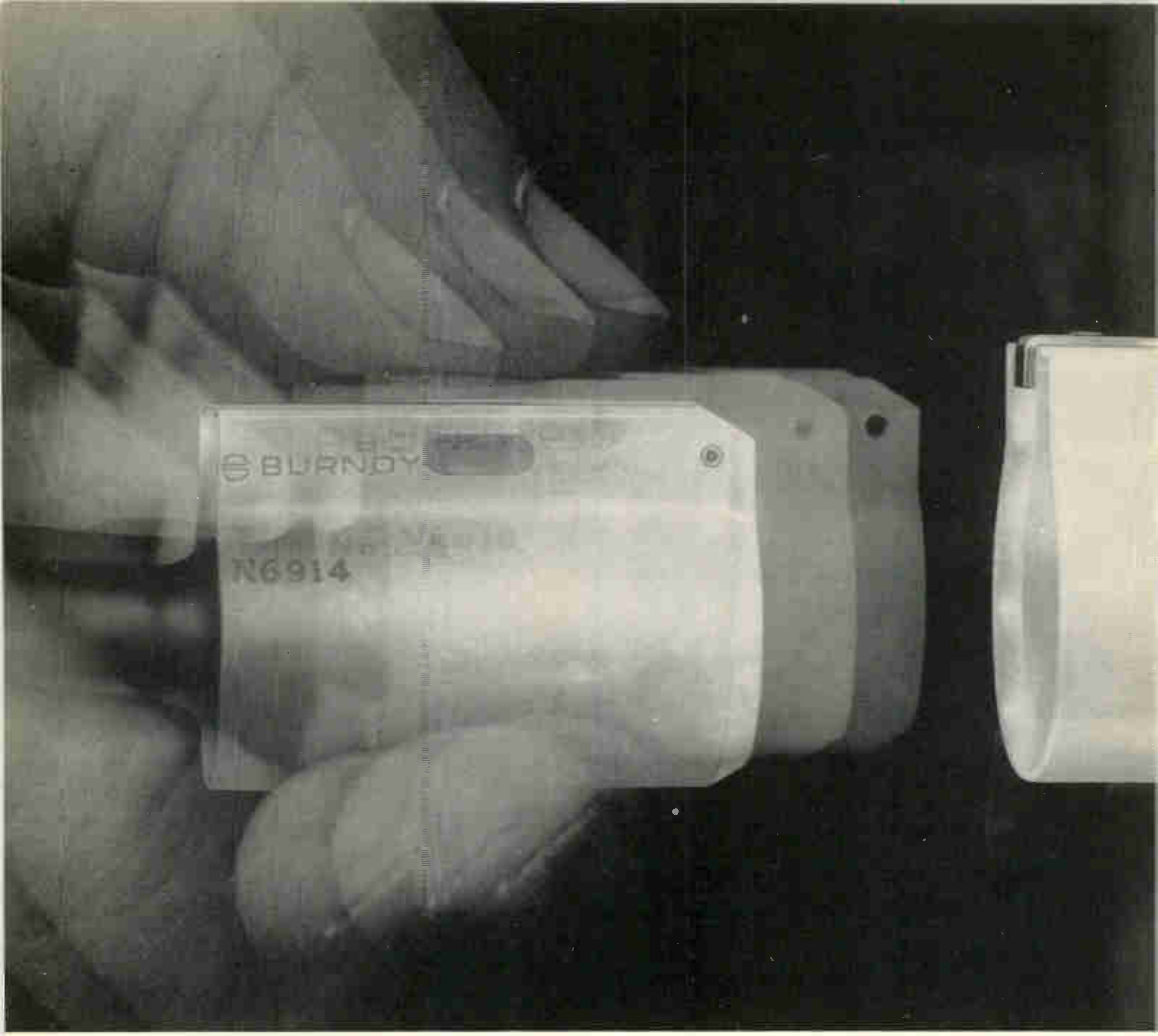

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(And practically indestructible.)

Apply gentle pressure on the locking latch of this coupling connector and the ejector spring pops the plug assembly into your hand.

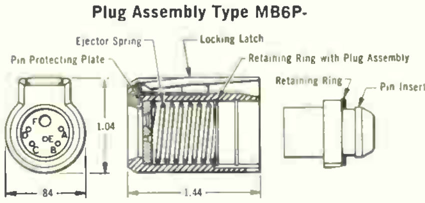
It's the MB6 series, and it connects easily, too, especially in limited access areas. Manipulation for blind mating is convenient and safe, and a dead-front pin-protecting plate makes the plug "more than scoopproof". When inserted, a quick "click" lets you know it's connected . . . securely.

Burndy uses resilient nylon for both the plug and receptacle. Lightweight, reliable and low-cost, it will withstand many times more disconnects than a metal connector, without any wear or galling. Even if accidentally stepped on, it cannot be deformed.

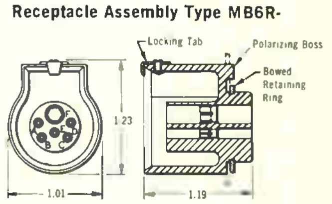
Unaffected by humidity, the MB6 is rated for temperatures from −55°C to +100°C and is shock and vibration resistant. Uses standard copper alloy gold-plated contacts installed with standard tools.

Burndy has more connectors like this, with and without the self-ejecting spring feature. Write for complete information, including test results.

Plug Assembly Type MB6P-



Receptacle Assembly Type MB6R-



Accepts five standard contacts for No. 24-20 wire, plus either one standard contact for No. 14-12 wire, or one coaxial cable contact.

70–26

BURNDY

Electronic Products/Norwalk, Connecticut

INTERNATIONAL SALES HEADQUARTERS & MANUFACTURING FACILITIES: CANADA/ENGLAND/BELGIUM/MEXICO/BRAZIL/JAPAN/Sales Offices in Major Cities

Circle 132 on reader service card

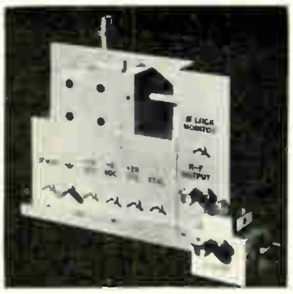
New microwave

Gunn unit shoots for millimeter-wave jobs

Oscillator delivers 5 milliwatts at 50-60 gigahertz; it's tunable over 200 megahertz, needs only 3.2-volt supply

Increased demand for solid state power sources is reaching up to the millimeter-wave region. A Gunn diode oscillator developed by Varian Associates operates at 50-60 gigahertz with a c-w output of 5 milliwatts. Believed to be the highest-frequency Gunn device on the market, the oscillator is intended to replace reflex klystrons and frequency multipliers in radiometry systems, secure military communications, and laboratory local oscillators.

Of the two bulk-effect devices—Gunn and limited space-charge accumulation—under development as possible replacements for traveling wave tubes and klystrons, Gunns seem to have the edge, at least for the moment. Although both LSA and Gunn devices use gallium arsenide as the active material, the requirements on the GaAs are not as stringent for Gunns as they are for LSA's, because Gunn diode structures, with their much narrower active region, do not need the large, defect-free junction of critically doped GaAs required in LSA devices. And at higher-frequency c-w operation, the LSA junction structure becomes very



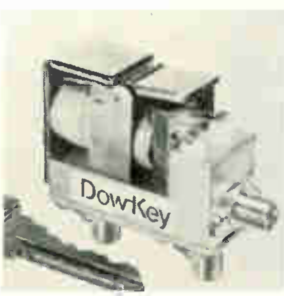
Power sources series P8060 feature phase-locked stabilization of a Gunn oscillator. The units, called Gunnloc, are applicable for any requirement where spectral purity and high stability are needed in conjunction with higher microwave levels in X-band at output powers to 100 mw or more. Price for 1 to 9 units is $1,850. Philco-Ford Corp., Spring City, Pa. 19475 [401]

Low cost, L-band doubly balanced mixer model DBM-181 comes in a miniature, shielded pin package. It accepts r-f and l-o inputs from 300-1750 Mhz and provides i-f outputs from d-c to 500 Mhz. Model DBM-300B, provided with 3 mm SMA connectors, operates with r-f and l-o inputs from 300-1500 Mhz and i-f outputs of d-c to 500 Mhz. Vari-L Co., 3883 Monaco Pkwy, Denver. [402]

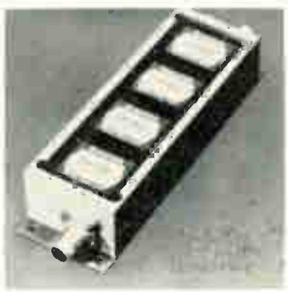
Low profile, double balanced mixer model DBM-500 PC occupies 0.08 cu in. and is designed to plug into a 14-pin dual-in-line socket or mount directly to a p-c board. It has an r-f and l-o input range of 2 to 500 Mhz, and an i-f that operates from d-c to 500 Mhz. Unit contains matched, low noise Schottky barrier diodes. Elcom Systems Inc., West Industry Court, Deer Park, N.Y. [403]

Sweep generator model 103 covers, without plug-ins, a frequency range from 10 Mhz to 12,400 Mhz. Range is divided into 3 bands (0.01-4.2 Ghz, 4.2-8 Ghz, 8-12.4 Ghz), selected by a front panel control. Continuous sweep is up to 4,200 Mhz. Output power is 2 mw minimum to 8 Ghz, 20 mw minimum above that level within ±0.5 db. Space-Kom Inc., P.O. Box 10, Goleta, Calif. [404]

Voltage-tuned, transferred-electron oscillator S293, a solid state replacement for klystrons, operates at 10 Ghz. It can be tuned throughout a 6% bandwidth centered at 10 Ghz, and a minimum power output of 10 mw. Unit makes use of a differential negative resistance in the bulk of a GaAs diode. Price (1-10) is $700 each. RCA Microwave Solid-State, Harrison, N.J. 07029 [405]



Spdt coaxial relay type 61-2308, which measures only 2 3/16 x 4½ x 21/32 in. over-all and weighs only 4 oz, will withstand a 15 g 11 msec shock, and will withstand vibration at 10 g from 10 to 2,000 hz. It will handle 125 w of r-f power at 100 Mhz and 75 w at 1,000 Mhz. Maximum vswr at 1,000 Mhz is 1.15. Dow-Key Co., P.O. Box 348, Broomfield, Colo. 80020 [406]



Video detector UD-901 is designed for systems using wideband, high frequency i-f circuitry to provide a-m detection and amplification of 1 khz to 50 Mhz modulation components on any carrier in the 100 to 1,000 Mhz pass band. Typical rise time is 15 nsec. Maximum pulse overshoot is 5%. Price is $90 in small lots. Avantek Inc., 2981 Copper Rd., Santa Clara, Calif. 95051 [407]

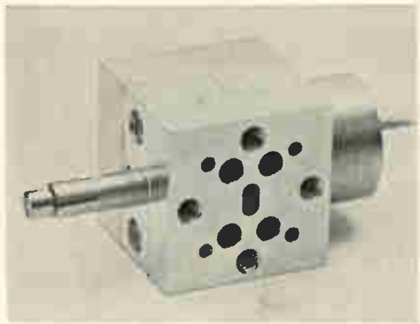
Thruline coaxial wattmeter is an insertion type instrument for measuring forward and reflected c-w power in ⅞ in. EIA as well as in r-f cable transmission lines. It measures r-f power flow with an accuracy of ±5%. Price of a complete package, including a line with two female N connectors and one element, starts at $119. Bird Electronic Corp., 30303 Aurora Rd., Cleveland [408]

. . . device can be tuned over 200-Mhz range . . .

difficult to fabricate with good reproducibility.

The new oscillator makes use of the low-noise characteristics of the bulk effect in gallium arsenide. As a fundamental r-f frequency source, it's free of spurious and harmonic signals commonly found in harmonic multipliers. In fact, the device's noise output is comparable to that of a reflex klystron.

Labeled the VSE-9020 by Varian, the Gunn oscillator is mechanically tuned by means of a single-screw unit over a 200-megahertz range selected between 50.1 and 59.9 gigahertz. An oscillator with a tuning range of 1 Ghz is available at extra cost.



Compact. Volume of 50-60 Ghz source is less than one cubic inch.

Although the VSE-9020 lacks a reliability history, Varian says it has accumulated 262,330 hours on 19 Gunn oscillators—X-, K_u-, and K-band units—without a failure. One manufacturer has decided to use the mm-wave source as a radiometer local-oscillator in a weather satellite scheduled for launch in 1971.

The VSE-9020 is designed to operate over a temperature range of 0 to 50°C and can withstand vibrations up to 20 G's. It is biased using a single 3.2 volt d-c power supply and draws 500 milliamperes. Housed in an aluminum structure only 1¾ by ¾ by ¾ inches, the oscillator weighs less than 2.5 ounces.

The VSE-9020 is priced at $5,000 in quantities of 1-9.

Varian Associates, 611 Hansen Way, Palo Alto, Calif. 94303 [409]

Hybrid converters aimed at MOS systems

Small, low-power, thick-film units have high resolution;
a-d device contains equivalent of more than 600 discretes

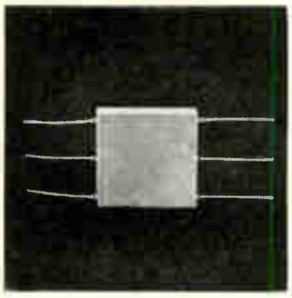
Analog medium-scale integration is the tag that Beckman Instruments' microcircuits operation puts on two hybrid thick-film devices—the model 871 analog-to-digital converter and the model 847 digital-to-analog converter. Resolution for the a-d unit is 12 bits; it's 10 bits for the d-a device.

"Our hybrid technology plus recent advances in monolithics make it possible to put complete analog circuit functions in a package," says George Smith, director of research and development. The a-d converter has the equivalent of more than 600 discrete devices in it. All the user has to add is a reference voltage and a system clock.

Both units fit into hermetically sealed metal plug-in packages measuring 1.8 by 1.2 inches, and both are built with MOS converter chips for MOS system compatibility. "We see systems people getting more and more interested in MOS," says Smith. "Instrument manufacturers, military and airborne systems users are the ones who will make MOS go because they need it for small size and low power dissipation."

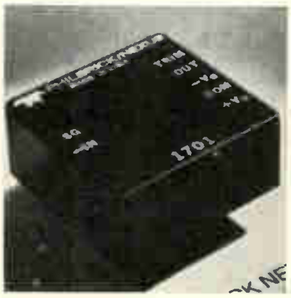
Smith says that if the a-d and

Modular instrumentation amplifiers 3345/14 and 3346/14 are for transducer readout in portable battery-powered equipment. The encapsulated units have high impedance differential inputs with common-mode rejection in excess of 100 db. Price (1-9) is $64 for the 3345/14; $44 for the 3346/14. Burr-Brown Research Corp., International Airport Industrial Park, Tucson [381]

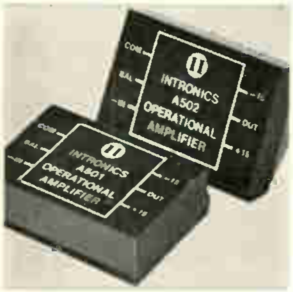


Hybrid thin-film preamplifier features a wideband, low-noise, and low-input capacity design. Size is 0.5 x 0.5 x 0.1 in. Performance factors include bandwidths of d-c to 10 Mhz, 40 db gain, 2 db max. noise figure at 2 khz for source resistance between 1 kilohm and 5 kilohms, input capacity of 4 pf max. Odetics Inc., 1845 S. Manchester Ave., Anaheim, Calif. 92802 [382]

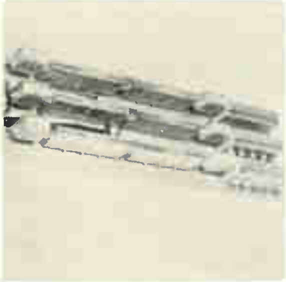
A-d converter model 501 converts 10 bits in less than 30 μsec. Input signal range is from 0 to +10 v. Unit contains its own references, its own clock, and all the digital logic required for operation. It will operate from 0° to +70°C. It is fully encapsulated and suited for p-c mounting. Hybrid Systems Corp., 95 Terrace Hall Ave., Burlington, Mass. [383]



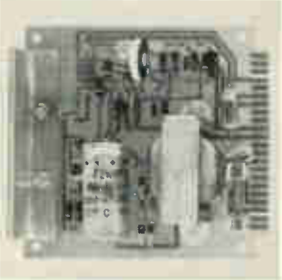
Chopper-stabilized operational amplifier model 1701 combines low voltage drift (0.1 μv/°C, −25 to +85°C), low input bias current (±50 pa max.), low flicker noise (1 μv peak-to-peak), and a choice of power supply operation from ±8 v to ±20 v. It comes in a package measuring 1.5 x 1.5 x 0.6 in. Teledyne Philbrick Nexus, Allied Dr. at Route 128, Dedham, Mass. [384]



Operational amplifier model A502 is for high frequency inverting applications. It offers a slew rate capability of 1,000 v/μsec and 100-Mhz gain-bandwidth product. It features a 0.1% setting time of 60 nsec. Unit will drive loads up to ±50 ma at ±10 v and operate over a temperature range of −25° to +85°C. Price (1-9) is $125. Intronics, 57 Chapel St., Newton, Mass. 02158 [385]



Solid state amplifier provides phase linearity of ±1° at 4 Ghz. Units provide a gain of 30 db, 6.5 db noise figure and an essentially flat 500-Mhz bandwidth; 1,000 Mhz at the 3 db points. Amplifiers use advanced strip-line fabrication techniques that provide band-pass flatness to ±0.25 db. Applied Research Inc., 76 S. Bayles Ave., Port Washington, N.Y. 11050 [386]



Plug-in power supply PC5-1.2A can power approximately 120 IC's and will deliver 5 v d-c at 1.2 amps. It operates from 105-125 v a-c, 60 to 400 hz. Line and load regulation is held to ±25 mv max., with ripple and noise held to 10 mv rms max. After warm-up stability is ±5 mv. Price (100 lots) is $23.95. Armour Electronics Corp., 51 Jackson St., Worcester, Mass. [387]

Compact power supply series PS-100 is designed to meet the particular needs of small computers and data processing equipment. It is for the digital data equipment OEM market, and features multiple regulated output voltages. Power density is 2 w per cu in., and a typical unit is 4 x 4½ x 9½ in. Killian Engineering Corp., 281 Wood Rd., Braintree, Mass. 02184 [388]

... MOS arrays perform conversion function, permitting smaller package for devices ...

d-a functions were accomplished with bipolar integrated circuits in a hybrid package, they would require a much larger package because more IC's would be needed and because the smaller package couldn't dissipate the heat generated by the higher-powered bipolar circuits.

Power consumption of the model 871 analog-to-digital converter is 950 milliwatts maximum. In the model 847 digital-to-analog unit, it's 350 milliwatts maximum. Equivalent bipolar circuits would dissipate three or four times more power, according to Smith.

He says the closest things to the 871 in a-d converters are potted modules that usually measure 2 by 3 inches, adding that no monolithic IC can do the a-d conversion without some outboard parts. There is one other hybrid d-a converter available, but Beckman engineers claim theirs is more accurate and less expensive. The top-of-the-line model 847 has a guaranteed accuracy of ±0.0025% at 25°C, which is equivalent to resolving one-half bit in 11; the competitive d-a converter typically resolves one-half bit in nine, and sells for $225.

The model 847 price for quantities of one to nine—and for the most accurate version of the d-a unit—is $195.

The model 871 ranges in price from $295 for the most accurate version—±0.025% at 25°C—to $195 in quantities of one to nine for the version whose accuracy is ±0.1%. Smith looks for customers among instrument designers who have to convert from analog to digital to get data into a computer. "In the past, they've had to pay as much as $1,000 for an a-d converter," says Smith.

He points out that while the units aren't aimed at the super-high reliability market, such as satellite systems, they should find applications in shipboard, ground, and aircraft equipment. Both units meet environment specifications in Military Standard 883. They have a typical temperature coefficient of ±0.005%/°C.

"The model 871," Smith says, "could easily be used to put the output of a transducer amplifier into digital form in a system where you have one to a few channels of data."

The logic 0 level for both units is 0 to —2 volts; the logic 1 level is —9 to —30 volts. The model 871 (d-a) uses the successive approximation technique to convert analog voltages into a corresponding binary code.

It also offers dynamically adjusted offset for 10-bit operation, conversion time of 100 microseconds for 10 bits (10 kilohertz), free-

Compatible. Converters' voltage levels are suited to MOS systems.

running or synchronous conversion with return-to-zero capability, and two analog input configurations to accommodate bipolar (—5 to ±5 volts) or unipolar (0 to 10 volts) operation.

The model 847 d-a converter will accommodate digital word entry into the input register serially or in parallel, selectable by logic command, and settles to 0.1% of full scale in 30 μsec maximum. Its full-scale output voltage range of 0 to 10 volts can be offset for —5 to +5 volt operations.

Delivery of both units is from stock.

Helipot Division, Beckman Instrument Inc., 2500 Harbor Blvd., Fullerton, Calif. 92634 [389]

Mesa process widens Darlington market

Prices reduced as much as two-thirds from level of planar units; simplified heat-sinking also seen opening up industrial, consumer jobs

In the military marketplace, Darlington transistors—usually made by the planar process—sell for $10 to $20 each. In an attempt to broaden their application, engineers at Motorola's Semiconductor Products division adapted the group's epitaxial-base mesa technology to the manufacture of power Darlingtons and developed a line intended for output devices in complementary general-purpose amplification jobs.

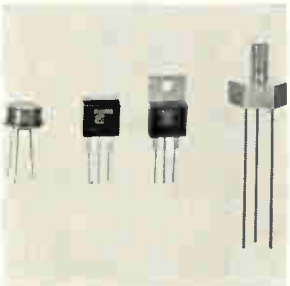
Range of current ratings runs from 1.5 to 15 amperes, with breakdown voltages from 60 to 100 volts. D-c current gains are as high as 1,000. The units are offered in both pnp and npn form.

The family of silicon devices "will revolutionize a lot of thinking, because we're really talking about power integrated circuits," says James Quinn, marketing manager for power transistors. "These units consist of two active devices and a biasing network, or two transistors and two resistors. But since we make them as a single device, we're seeing yields as good as those with a single transistor."

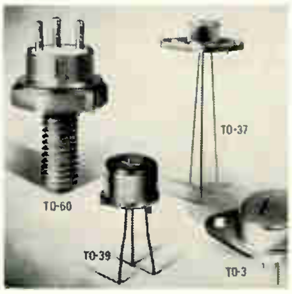
That's one reason for the lower price of the new devices. Also, the

Voltage tuning diodes series MV-1652 through MV1666 are designed for use in electronic tuning and afc applications at lower radio frequencies. The nominal 4-volt capacitance ranges from 120 pf to 330 pf in eight different diode types. The voltage breakdown up to 220 pf is greater than 20 v. MSI Electronics Inc., 34-32 57th St., Woodside, N. Y. [436]

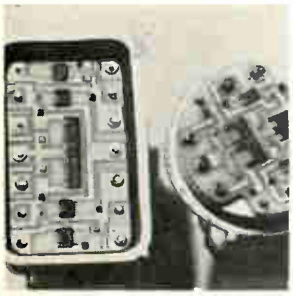
Solid state switches series EL20, EL200 are designed and specified as drivers for electroluminescent displays. They have forward and reverse blocking voltages from 200 to 400 v with high reverse gain for minimum power consumption, and can be driven directly from low-level IC's. Price (100-999) is from $1.85 each. Unitrode Corp., 580 Pleasant St., Watertown, Mass. 02172 [437]



Pnpn gate-triggered scr's are typed with gate sensitivities ranging from 50 μa max., 200 μa max., and 1.5 ma max. They may be used for low-level switching from 12 ma to 10 amps. They are available in several packaging configurations in 30 to 800 v ratings. Units are suited for such uses as feedback controls. ECC Corp., 1010 Pamela Dr., Euless, Texas [438]



Power transistors KS6101 through KS6130 range from 20 v to 100 v. They switch currents from 0.25 amp to 20 amps. Typical turn-on and turn-off times for any of these currents are 35 nsec and 85 nsec, respectively. Packages range from TO-39 for low currents to TO-3 for currents above 5 amps. Kertron Inc., 7516 Central Industrial Dr., Riviera Beach, Fla. [439]



Four hybrid dual-phase clock driving devices operate in conjunction with standard TTL/DTL line drivers. They provide fixed width clock pulses for multiple MTOS (metal thick oxide silicon) shift registers. Units have high output swings (30 v), high output current (500 ma), and a high repetition rate (2 Mhz). General Instrument Corp., 600 W. John St., Hicksville, N.Y. [440]

Six-ampere silicon single phase bridges designated the BRV600 series have been value engineered to those rectifying applications that require surge ratings of 50 amps or less. Voltage types from 50 to 1,500 v are featured, with packaging in a 0.4 in. case having fast disconnect appliance type terminals. Rectifier Components Corp., 124 Albany Ave., Freeport, N.Y. [441]

Npn type phototransistor model BP101 is for use in automatic electronic flashlight units, electronic toys and similar applications. It is packaged in a TO-18 case with the light falling through a translucent epoxy cover. It features a typical photo current of 150 μa for an illumination of 1000 Lux. Siemens Corp., 186 Wood Ave., South Iselin, N.J. 08830 [442]

R-f power transistors series 2N-2877, 2N2878, 2N2879 and 2N2880 are rated at 30 w with a beta cutoff up to 50 Mhz, with collector-to-emitter voltage of 80 v. Applications include high frequency inverters, converters, linear amplifiers, and high speed switching regulated power supplies. General Semiconductor Industries Inc., 230 W. 5th St., Tempe, Ariz. [443]

epitaxial-base mesa process is stable, and, according to Quinn, less expensive than the planar process. These factors will allow the user "to think of power Darlingtons for the consumer market," says Quinn. "He can buy the Darlington cheaper than he could get the transistor pair for the same function, and still not have to worry about heat sinking." The mesa structure makes it easier to dissipate heat from the collector.

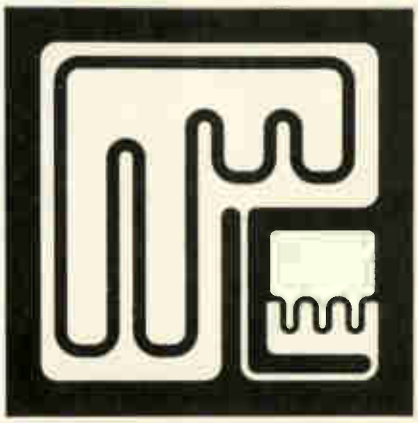
The 10-ampere, 60-80 volt units are designated MJ2500, MJ2501 (pnp) and MJ3000 and MJ3001 (npn). The pnp units sell for $3.65 and $4.05, respectively, in quantities of 100 or more, while the npn devices are priced at $3.05 and $3.45, respectively.

Minimum d-c current gain is 1,000 with a collector current of 5 amps. This means that the input to the device can be as low as 50 milliamps, well within the capability of integrated circuit logic gates. The devices are being marketed initially in a TO-3 package, and are available from stock.

Besides the 10-amp unit, Motorola is stocking quantities of 1.5 and 15-amp power Darlingtons, although no device numbers have been assigned. The 15-amp device is rated at 60-100 volts and has a gain of 750 to 1,000. The 3-amp unit is rated at 60-80 volts, with a gain of 1,000 at 1.5 amps.

Motorola engineers have used the same technology to come up with a 300-volt power Darlington with a 2-amp current rating, but there's no plan now to market it.

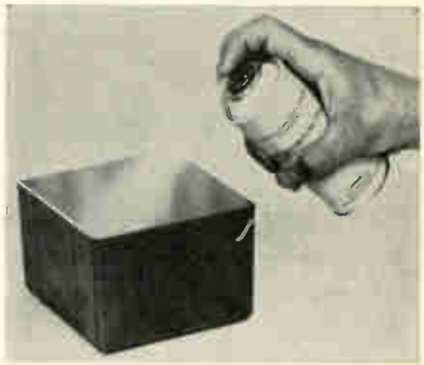
Motorola Semiconductor Products Inc., Box 20912. Phoenix, Ariz., 85035 [444]



Power IC. Chip pattern looks like a maze, acts like a Darlington.

New materials

Spray provides conductive coating



Silver-filled acrylic paint called 4900 is a spray-on, one-component air-drying conductive coating that provides emi/rfi shielding on plastic or other nonconductive enclosures. When applied in a 1-mil thickness, surface resistivity is 0.05 ohm/sq. (max.). Resistivity decreases as thickness increases. The paint is available in bulk quantities for under $45 a pound, and in 6-oz aerosol cans at $16.20 each. Chomerics Inc., 77 Dragon Court, Woburn, Mass. 01801 [421]

Phosphorus Oxychloride-S is a liquid phosphorus compound of 99.99+ purity. It is used for preparing p-n junctions by diffusion technique, for doping epitaxial growth, and for oxide doping as well. It is available in 5-gram ampules, 2-fluid-oz size, and 1-lb size, priced at $2, $5, $20 respectively. Transene Co., Route One, Rowley, Mass. 01969 [422]

Quartz-mat-reinforced, and cross-linked polystyrene is available from stock. Features of this stripline laminate are extremely low electrical loss in a reinforced dielectric material, giving excellent electrical and mechanical properties. The material is available clad or unclad in various sizes and thicknesses. Custom Materials Inc., Alpha Industrial Park, Chelmsford, Mass. 01824 [423]

Thermosetting flame-retardant and track-resistant molding compounds are designated as Plenco 714, 744 and 757 melamine-phenolic and Plenco 1502, 1506, and 1507 alkyd. The materials offer improved, consistent arc resistance, and excellent resistance to tracking under the influence of conductive contaminants. The materials are UL recognized. Plastics Engineering Co., Sheboygan, Wis. 53081 [424]

Dynaloy 479 is a silver alloy polymer coating that exhibits excellent conductivity and contains no carbon or copper. It gives good environmental protection and can easily be soldered with conventional materials. It adheres readily to metals, plastics, glass, rubber and also ceramic surfaces. Uses include component lead terminations, printed circuit repair, electroplating base, and component grounding. It is easily applied by dip, brush, roller coating, or spraying. An evaluation kit of 3 oz costs $9.50. Dynaloy Inc., 7 Great Meadow Lane, Hanover, N.J. 07936 **[425]**

Aremcolox grade 502-1400, a 99% alumina ceramic, readily machinable by the user and operable at temperatures up to 2,600°F, is available in a wide range of standard rods and plates. It is designed for prototype work or in fabricating high-temperature tooling such as firing boats, brazing fixtures, etc. As received, it has a compressive strength of 10,000 psi, flexural strength of 8,000 psi, dielectric strength of 100 v per mil, and resistivity of 10^{10} ohm-cm. Aremco Products Inc., P.O. Box 145, Briarcliff Manor, N. Y. 10510 **[426]**

Latex-based protective covering called Soder Mask is for use while soldering. It is a specially formulated elastomer that comes as a solvent or water soluble formulation. Easy to apply with dispenser, brush or syringe, the material protects holes and areas that must be kept free of solder during reflow and repair operations. The substance may be removed by peeling or rubbing and leaves no residue. Soder Mask is also effective as a conformal coating or paint resist. The material withstands temperatures up to 300°F. Techni-Tool Inc., 1216 Arch St., Philadelphia, Pa. 19107 **[427]**

Two-part RTV silicone rubber Silastomer 70, when cured, is suitable for use between −60°C and +250°C, with excellent dielectric properties, resistance to moisture, weathering, corona discharge, ultraviolet light, and ionizing radiations. Applications include potting and encapsulation of electronic components. Midsil Corp., Box 475, Emerson, N. J. 07630 **[428]**

Passivation glass designated IP 540 is designed to increase yields and give packaging flexibility to planar devices with shallow diffusions, such as MOS and TTL IC's. The glass is applied over the existing oxide and aluminum, hermetically sealing the device while it is still in wafer form. IP 540 is available for as low as $23 per pound when ordered in production quantities. Innotech Corp., 181 Main St., Norwalk, Conn. 06851 **[429]**

Pure copper braid desolderer called Soder-Wick, treated with a special pure rosin, leaves no conductive residue on a dispenser spool of 5 ft. When solder melts it is immediately drawn up into the Soder-Wick. Usual desoldering time is one second. Simply snip off the used portion of Soder-Wick and touch the fresh portion of the material to the connection. Apply soldering iron and the connection is desoldered. Techni-Tool Inc., 1216 Arch St., Philadelphia, Pa. 19107 **[430]**

Circle 139 on reader service card

New Books

Recently Published

Introduction to Nonlinear Network Theory, Leon O. Chua, McGraw-Hill, 959 pp., $22.50

Provides a unified treatment for both analysis and synthesis of nonlinear circuits. Concentrates on developing methods that will allow the reader to easily adapt them to accommodate any new components. Although requiring only a background in calculus, the book discusses different algorithmic methods for computer solution to these types of problems.

Manual of Logic Circuits, Gerald A. Maley, Prentice-Hall, 297 pp., $19.95

Designed to help prevent the practicing logic designer from re-inventing the many previously designed switching and logic networks. The manual covers Boolean algebra and logic symbols and then lists and explains over 100 logic circuits using Karnaugh maps and flow charts; the material covered represents major areas of present logic design activity.

Theory and Applications of Field Effect Transistors, Richard S.C. Cobbold, Wiley-Interscience, 534 pp., $19.95

Deals comprehensively with the theory, fabrication, properties, and application of field effect transistors. Device physics gets strong attention; throughout, the book relates theory to experimental measurements, the performance of real devices, and the restrictions that are usually imposed by fabrication technology.

Government reports

All these reports are available from the Clearinghouse for Federal Scientific and Technical Information (CFST), 528 Port Royal Rd., Springfield, Va. 22151. Price is $3 for each hard copy, or 65 cents for each microfiche.

Dual input transponder AD 696 958

Describes a dual-input transponder system developed in an effort to eliminate signal loss, which may occur when an aircraft is maneuvering and the fuselage or wing interrupts line-of-sight transmission between the transponder and the Air-Traffic Control ground interrogator.

Experimentation and analysis of radar siting criteria AD 693 541

Discusses procedures for determining the sites for future radar beacons and includes various methods for minimizing the signal-reflection problems at existing sites.

Technical Abstracts

Micro makes it

An asynchronous digital controller
A.A. Frank
Department of Electrical Engineering
University of Wisconsin
Madison, Wis.

Introducing a single central digital computer isn't always the best and most reliable way to control an industrial process. To handle the calculations required for many process points, such a central unit may have to be prohibitively large. And failure could put the entire plant out of operation.

As an alternative, today's integrated circuit technology makes it feasible to locate small, preprogramed microcomputers at each of several control sites along the line. The central computer then is relegated to monitoring and performing set-point calculations.

A microcomputer could be as small as a pack of cigarettes and cost $100. It could perform standard control functions, including proportional, rate, and reset controls generally handled by an analog controller. A combination of such computers would perform asynchronously, each working only when necessary.

This type of design is feasible because control calculations don't have to be extremely accurate. Thus a machine that handles digital words with as few as three bits could be used; a four- or five-bit machine would be more than adequate in most cases.

The microcomputer consists of three basic parts: an error computer, a compensating logic computer, and a pulse modulator. In one configuration, the error signal is computed using a look-up subtraction table implemented with diode gates. The computed error signal then goes to the compensating logic, where its rate is calculated.

The error signal and rate are applied to the pulse modulator which converts it into a pulse-width modulated signal. Output pulses from the modulator are amplified by power switches which operate the plant's controls. Only design studies have been made so far.

Presented at the IEEE Solid State in Industry Conference, Cleveland, June 15-17.

New Literature

Linear IC's Fairchild Semiconductor, Box 880A, Mountain View, Calif. 94040, offers an 88-page, pocket-size catalog describing its complete line of linear IC's.
Circle **446** on reader service card

Miniature recorder. Esterline Angus, division of Esterline Corp., P.O. Box 24000, Indianapolis 46224. A four-color brochure describes the Minigraph recorder, which is 3⅝ in. wide, 5⅝ in. high and 4⅜ in. deep. [447]

Elapsed time indicators. A.W. Haydon Co., 232 N. Elm St., Waterbury, Conn. 06720. Bulletin M1600-RI introduces a line of five-digit elapsed time indicators designed for industrial and commercial use. **[448]**

Interactive graphic system. Computek Inc., 143 Albany St., Cambridge, Mass. 02139. Series 400 interactive graphic terminal, graphic tablet and joystick input devices are described in a four-page brochure. **[449]**

Data gathering for EDP. Motorola Instrumentation and Control Inc., P.O. Box 3409, Phoenix 85010. Use of the MDR optical mark reader to obtain data for a computer directly at the source, eliminating the delay and costs of keyboarding, is featured in an eight-page bulletin. **[450]**

Silicon triacs. RCA, Commercial Engineering, Harrison, N.J. 07029. File 431 covers a new series of 2.5-amp sensitive-gate silicon triacs for low-power phase control and load switching applications. **[451]**

Computer cassette. Auricord division, Scovill, 35-41 29th St., Long Island City, N.Y. 11106, has available a data sheet on its CM series metal computer cassette, which cuts static charges. **[452]**

Universal circuit system. Robinson-Nugent Inc., 800 E. Eighth St., New Albany, Ind. 47150. A universal circuit system for test and breadboarding is fully detailed in a six-page catalog. **[453]**

Ladder networks. Beckman Instruments Inc., 2500 Harbor Blvd., Fullerton, Calif. 92634. A two-page catalog sheet features the series 862 BCD ladder networks designed for FET switching. **[454]**

Stampings capabilities. Volkert Stampings Inc., 222-34 96th Ave., Queens Village, N.Y. 11429, has issued a six-page booklet describing its expanded capabilities for producing small precision parts for the electronics, data processing and allied industries. **[455]**

Microwave communications system. Canadian Marconi Co., 2442 Trenton Ave., Montreal 301, P.Q., Canada. An illustrated folder contains a detailed description of the MCS 6900 microwave communications system. **[456]**

IC packages. Sylvania Electric Products Inc., 12 Second Ave., Warren, Pa. 16365. Specification sheets describing three new glass-ceramic IC packages may be secured by writing on company letterhead.

Digital IC's. National Semiconductor Corp., 2900 Semiconductor Dr., Santa Clara, Calif. 95051, has published a report describing two types of operational life tests it uses on digital IC's **[457]**

Paper tape readers. Dataterm Inc., 1611 Maning Blvd., Levittown, Pa. 19057, has published a six-page interface guide to the HS-300 series of paper tape readers. **[458]**

Push-button switches. Cinch Mfg. Co., 1501 Morse Ave., Elk Grove Village, Ill. 60007, has prepared a brochure covering 66 styles of Ucinite momentary contact, push-button switches. **[459]**

General-purpose transistors. KMC Semiconductor Corp., Parker Rd., Long Valley, N.J. 07853. A four-page pamphlet contains practical reference data on general-purpose transistors from vhf through S band. **[460]**

D/A converter. Beckman Instruments Inc., 2500 Harbor Blvd., Fullerton, Calif. 92634. A complete digital-to-analog converter in hybrid IC form is described in catalog sheet 843. **[461]**

Operational amplifiers. Fairchild Controls, 423 National Ave., Mountain View, Calif. 94040. "Selection Guide To Operational Amplifiers" is a new catalog describing modular products and linear integrated circuits. **[462]**

Digital motor-controller. Theta Instrument Corp., Fairfield, N.J. 07006. Engineering bulletin 67-13A describes in detail a new digital control system for prime movers. **[463]**

Dual power supply. Hewlett-Packard, New Jersey Division, 100 Locust Ave., Berkeley Heights, N. J. 07922, has available a technical data sheet describing the DPB series dual power supply. **[464]**

Variable Capacitors. Johanson Mfg Corp., 400 Rockaway Valley Rd., Boonton, N.J. 07005. Variable capacitors with higher Q's than previously available are featured in stock catalog 170. **[465]**

Differential video amplifiers. Silicon General Inc., 7382 Bolsa Ave., Westminster, Calif. 92683. A four-page technical bulletin covers the SG733 and SG733C, monolithic two-stage wideband amplifiers that are particularly suited for applications requiring a fast linear function. **[466]**

Modular power supplies. North Electric, Galion, Ohio 44833. A 12-page catalog introduces a modular line of standardized shelf power supplies and accessories. **[467]**

Miniature r-f connectors. Sealectro Corp., 225 Hoyt St., Mamaroneck, N.Y. 10543. Four-page catalog 981A covers the SRM line of miniature r-f connectors that conform to MIL C-39012, series SMA. **[468]**

Data-logging printers. Datadyne Corp., Bldg. 37A, Valley Forge Center, King of Prussia, Pa. 19406. Four-page folder 3070A gives complete specifications, illustrations and prices for 10 and 20 line per second data-logging printers with a 64-character ASCII capability. **[469]**

Videotape recorders. Ampex Corp., 2201 Estes Ave., Elk Grove Village, Ill. 60007. Comparison sheet V70-1 contains essential specifications, other descriptive data and suggested list prices on a complete range of one-inch, closed circuit videotape recorders and players. **[470]**

Silicone gasket. Metex Corp., 970 New Durham Rd., Edison, N.J. 08817, offers a pamphlet describing Polastick, a pressure sensitive, adhesive-backed silicone gasket for both emi shielding and pressure sealing. **[471]**

R-f connectors. Bendix Corp., 401 N. Bendix Dr., South Bend, Ind. 46620, has issued a 161-page illustrated catalog covering all major r-f connector classifications and sub-types. **[472]**

Scr drive controllers. Randtronics Inc., 465 Convention Way, Redwood City, Calif. 94063, has released a specification sheet on the series SFB single-phase, full-wave, bidirectional scr drive controllers. [473]

Power supplies. Electronic Measurements Inc., 405 Essex Rd., Neptune, N.J. 07750. A four-page brochure describes the SCR series power supplies for high power applications. **[474]**

Audio connectors. Switchcraft Inc., 5555 N. Elston Ave., Chicago 60630. Product bulletin 198 describes three new additions to the Q-G (quick-ground) series of audio connectors. **[475]**

Servomechanisms. Weston-Transicoil, Components Division of Weston Instruments Inc., Worcester, Pa. 19490. A 12-page catalog shows electrical and mechanical specifications for servo motors, generators and motor generators, synchros, resolvers, stepper motors, d-c torquers, and servo amplifiers. **[476]**

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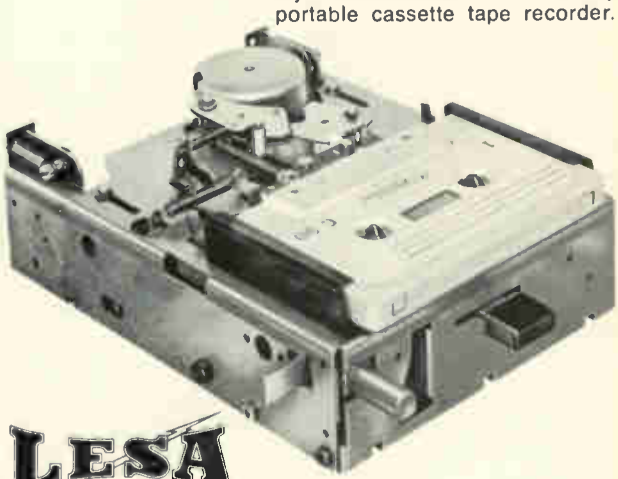

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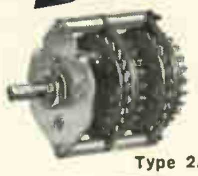

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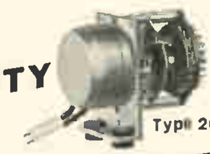

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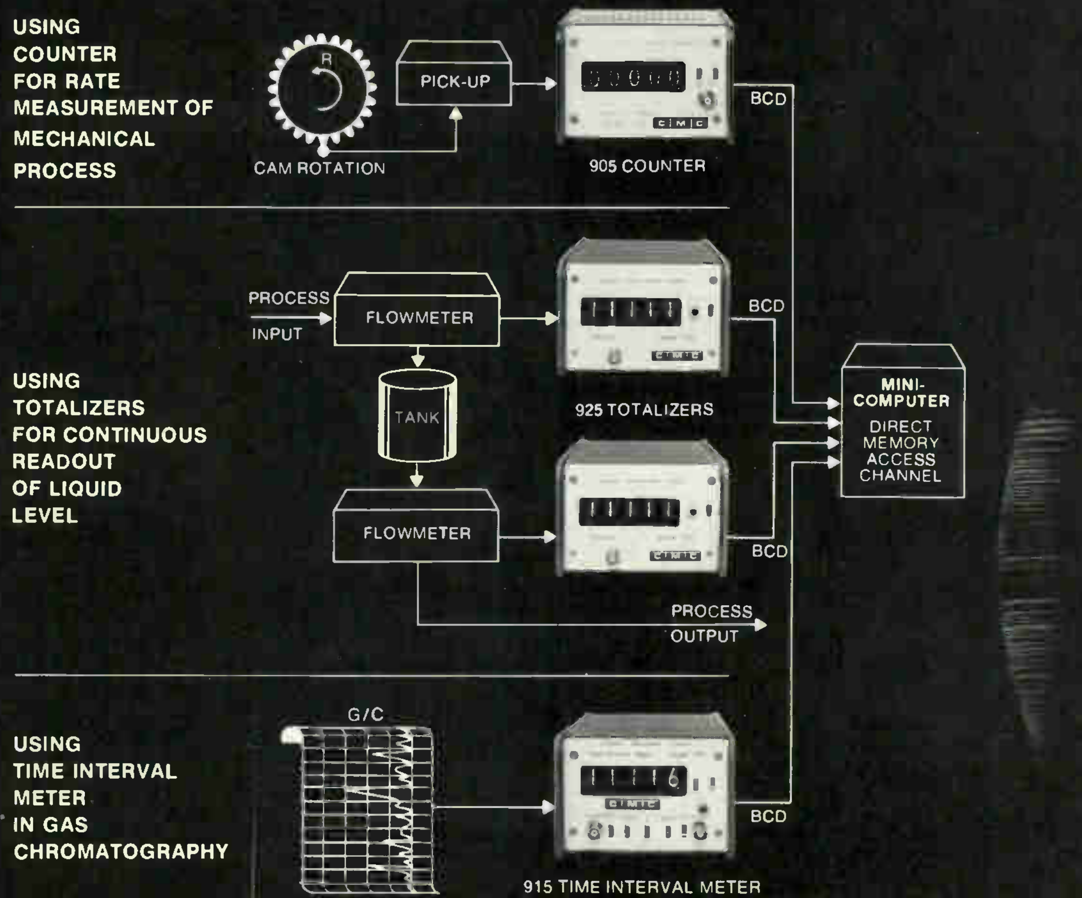

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Circle 144 on reader service card

July 20, 1970

TTL prices tumble in West Europe . . .

U.S. integrated circuit makers, sitting on large unsold stocks of 74 series transistor-transistor logic as a result of over optimistic growth forecasts and stagnant home demand, are intensifying efforts to unload it in Europe. **In Britain, basic gates have gone for only 20 cents each in mixed orders of 250,000 at a time. The going rate in a 5,000-to-10,000-gate mix is 35 cents or less, compared with 45 to 50 cents a month ago and 70 to 80 cents six months ago.** Dual J-K flip-flops have been offered at less than 50% more than basic gates, full adders at $2.40, and dual eight-bit shift registers at $6.60 in four figure mixes.

In France, one of the big instrument makers thinks TTL has been cheaper than anywhere else in Europe until the last few weeks. Six months ago, it paid 45 cents a gate in quantities of 100,000—now it is paying 32 cents a gate. In Germany, current prices are similar to those in Britain, but the price war started slowly there six months ago.

Diode-transistor logic is following TTL down—but not so violently. DTL is now a few cents more than the lowest TTL levels, and opinion is that it may have already stabilized. The resilience of DTL, which was always generally cheaper than TTL, is due to a bigger spread of buyers, some characteristics that mean it's not a direct alternative to TTL, and less surplus production.

. . . as U.S. makers trigger shake-out

Price cutting pacesetters are Texas Instruments and National Semiconductor. Both buyers and sellers expect prices to go lower yet before they stabilize. National Semiconductor's British marketing manager says: "It's our policy, at today's price levels, never to lose an order on pricing." **In the long run, insiders expect some of Britain's suppliers will be forced out of the 74 market, though not necessarily out of IC production.** Though this might look ominous for the non-American suppliers—Ferranti and Mullard, a Philips subsidiary—both maintain they've no intention of abandoning 74. Furthermore, Marconi-Elliott Microelectronics is using its Fairchild license to enter the 74 market, and SGS, owned by Olivetti of Italy, is tooling for production later this year. Asked how he expects to compete successfully, M-E's marketing manager says: "By pushing hard on MSI, which we will be able to make economically at our Scottish plant."

Who's No. 2 in computers? The Japanese

Japan claims the second highest number of computers in operation in the world. **At the end of March, according to the Japan Electronic Computer Co., the government-sponsored computer-rental joint venture of Japan's six computer manufacturers, there were 6,718 computers in operation.** That gives Japan 48 more than West Germany, says the company, but is still far short of the 47,997 computers in operation in the U.S. However, compared with 0.24 computers per 1,000 persons in U.S., Japan lagged behind Germany, England, France, Canada, and Australia with only 0.07 computers for each 1,000 people.

Installations of computers during the year ended March 31, 1970 rose 20% in number compared with the beginning of the year, and nearly 40% in value. Of these, 1608 were domestic computers worth $338.3 million, a 45% increase in value. During the same period, 527 imported computers worth $251.1 million were installed, a gain of only 34.5%.

London's Heathrow first to record plane landing data

Preparing for automatic landing, London's Heathrow Airport will start automatically recording the flightpath and speed of landing planes, the point of touchdown, and the rolling distance for one runway. Pulling in the initial contract is Elliott-Automation Radar Systems Ltd., which will install the system next year.

Approach performance will be measured by passive optoelectronic detectors mounted on the ground below where the plane should be at altitudes of 200 feet, 100 feet, and 50 feet. As the plane passes over the detector, the shadow triggers an output. At night the plane's lights serve the same function. Speed information is provided by detectors separated by a fixed distance and sensitive straight upward; altitude information by detectors sensitive at precise vertical angles, and centerline information by detectors sensitive at vertical and horizontal angles. Once on the runway, the aircraft breaks horizontal infrared beams angled to provide speed and centerline information, and seismic devices record touchdown and rolling distance.

Hot color tv sales in West Germany may cool off

Surging labor costs and a chronic shortage of parts may cripple the West German boom in color television sales. Both domestic sales and exports of color sets have leaped ahead of expectations. This year's domestic volume, predicts Germany's electronics industry association, is likely to hit 750,000 sets, nearly twice as many as were sold in 1969. That volume would put total installed color sets in West German homes by the end of the year at roughly 1.5 million, the highest in Europe. The association sees little reason for demand to slacken because only 5% of the nation's households now own a color receiver. Exports, too, are climbing, up to 150,000 this year from 100,000 last year.

All the weaknesses in the picture are on the production side. With wages for electrical workers up 15% and more this year—and thus far outpacing productivity—manufacturers are up against diminishing profits on color sets. They are fighting hard to keep set prices at their current levels—an average of $500 for a 25-inch set. What's more, with demand outstripping earlier estimates, there is an increasingly serious shortage of components. For some items—deflection units and picture tubes, for example—delivery times of up to six months are commonly quoted.

Tv telephone service set for Britain

The British Post Office plans to open early next year what it believes will be the world's first closed-circuit television network on rental to businessmen wishing to confer at long distance. Initially studios will be in London and Glasgow, and later in Birmingham, Manchester, and Bristol. Up to five people will be able to sit at a table in each studio, and controls on the table will focus a stationary camera on either one, three, or five of them. In addition, a vertical camera over a table has a zoom lens to examine documents or products. Charges are not set yet, but are expected to be about $2.50 per hour for each mile separating the studios.

Japan's next satellite to have working payload

Japan will attempt to orbit its first "useful" satellite, a 143-pound package of scientific experiments, within a month. The rocket to be used for the launching, scheduled for August 19, will be the four-stage M4S1, Japan's largest rocket. The planned orbit will have a perigee of 375 miles, an apogee of 1,250 miles, and a period of 100 minutes.

Future of Europe's space effort rides on imminent go/no-go decision

French propose a superagency with strong management and longterm budgeting, replacing ESRO and ELDO; British acceptance or rejection will be crucial

Europe's space program, the fate of which is continually in doubt, goes on the block this month for what may be the last time.

Members of the satellite-building ESRO and the rocket-developing ELDO—particularly the French—are weary of the agencies' perpetual crisis atmosphere and want to build a more solid edifice in which they can take to truly cooperative space work—or leave it.

About time. For cliff-hanging drama, few space exploits can surpass the earthly crises the two agencies brave every few months. Members menace both agencies with reduced budget contributions. Italy perpetually gripes that its payouts exceed hardware orders for Italian industry. Britain threw ELDO into chaos in 1968 by announcing plans to drop out next year and by withholding new funds in the meantime. France threatened to sabotage ESRO as a result.

Even with funds, management impasses hobble the space agencies. Many decisions require two-thirds and even three-quarters votes by member countries. Each stage of ELDO's three-stage Europa-1 rocket is built independently in Britain, France, and Germany. As a result all stages fired successfully only on the tenth try.

Ministers of the countries participating in ESRO and ELDO are due to meet in Brussels this week for the annual European Space Conference at which there's a good chance for some positive action.

New look. The French, backed by Germany, are pushing hardest to recast Europe's space effort. Paris has revived a long-standing plan to dump ESRO and ELDO, replacing them by one superagency having a strong, independent management and longterm budgeting that would run all European space activities outside national programs.

At a preconference meeting of Common Market and British science ministers in Brussels last month, only Britain hestitated over the superagency plan. However, London promises to accept or reject it a few days before this week's planned meeting.

The British stand is crucial. Only if Britain accepts the new agency will this week's meeting be held at all, because the French say they intend to drop out of European space work unless their plan is accepted—and they feel Britain's weight is essential for stability.

But the French say they're optimistic London will join the new agency. The Conservatives seem more pro-European than the defeated Laborites, according to the French, who also feel that a British rejection of the space agency would go down badly just when London is negotiating to join the Common Market.

Role. In the French and German view, the new agency would concentrate on applications satellites. Its first major project would be a European telephone and television relay satellite, which could carry several thousand telephone conversations and link national tv networks. A 4,400-pound experimental satellite would be launched first.

The new agency would hopefully also build half the hardware for the proposed aircraft communications and navigation satellite system, being studied with U.S. agencies. ESRO and NASA are already planning a tentative system based on L-band frequencies, which this week's European conference is expected to endorse.

Finally, the French and Germans hoped the agency would join with NASA in developing the proposed post-Apollo space shuttle. NASA has been sponsoring technical meetings in Europe this spring and summer to induce European participation in the program.

Strings. France and Germany are attaching two conditions to participation in the shuttle program. One is that the European role include developing identifiable satellites, shying away from projects that could compete with the U.S.-backed Intelsat communications network.

If Washington sticks to its "restrictive" policies and "forces" Europe to continue launcher development, says a Bonn science ministry official, the Europeans would have no money left to join the post-Apollo program.

The British have long maintained that Europe is duplicating American efforts by building rockets—the reason London decided to pull out of ESRO. But a British aerospace official comments: "I doubt if the Americans could give a launcher guarantee that would satisfy the French."

Great Britain

Velocity of blood

In developing a sophisticated piece of medical electronics gear, a British researcher has devised a new printout device which may find applications far away from doctors' offices. Indeed, the printout unit can show real time, three-dimensional spectrums of transient velocities ranging from automobile vibrations to speech waveforms.

Henry Light of the National Institute for Medical Research at Hampstead developed the instrument. It's in two parts: the first section comprises an ultrasonic probe and doppler processing section; the second is a real time printer which registers 18 velocity categories and shows, following each heartbeat, the proportion of the total bloodflow falling into each category. The clock-marked printout paper marks off each flow pulse in time. Thus, the device can show the maximum velocity of flow in a curved blood vessel, and if used on a straight blood vessel where the ultrasonic wave approach angle is known, the 18 categories indicate the distribution of velocities across the vessel.

Check-up. When a doctor checks bloodflow, as in cases of poor circulation, by measuring the doppler shift of applied ultrasonic radiation, the velocity readout is generally an average derived from all doppler shifts detected where the radiation crosses the blood vessel. When the vessel is near the surface it is easy enough to estimate the angle at which the radiation crosses the vessel and get a good idea of true maximum velocity, but when the vessel is deep in the body estimation is not so easy.

What's more, the main output vessel from the top of the heart, which is most useful for determining heart condition, curves continuously which renders a single reading derived from reflected radiation almost meaningless. What was needed was some way to capture in real time all the doppler shifts detected. The old way of obtaining a complete velocity spectrum readout involves sampling and off-line analysis. This is not much use to a doctor, who wants an on-line reading so that he can move the probe about.

Light is now experimenting with a prototype system. The ultrasonic detector he's using in it at present is a standard $300 instrument that is moved around, along with the printer, on top of a small cart housing power supplies and most of the electronics. He estimates that in series production the complete system could be made for less than $2,000. The printer alone might cost about $300.

Departure. The ultrasonic probe and doppler processing is along established lines. The applied frequency is 2 megahertz and the range of doppler frequencies is extracted from the reflections. But then Light applies the doppler frequencies to 18 parallel filters. Each filter passes a band of about 170 hertz and the highest frequency passed is 3 kilohertz which corresponds to a blood velocity of about 4 feet per second.

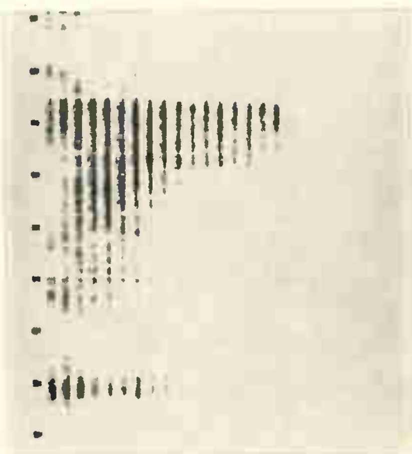
These filter outputs drive the printer. The 18 currents pass to electrodes laid out side by side and in contact with the bottom surface of electrolytic printout paper. On top of the paper, opposite the electrode array, is a stainless steel ribbon anode. As the paper passes the electrodes, it is printed with 18 lines, which vary from pale grey to dense black according to the current through its electrode.

The paper passes the electrodes at a fixed speed, but in Light's application the paper does not show 18 continuous lines because between heartbeats the bloodflow out of the heart more or less comes to a stop. In fact, the slope of the leading edge of each pulse print is a good measure of blood acceleration, says Light, and the area of the pulse shape is a measure of the total amount of blood passed.

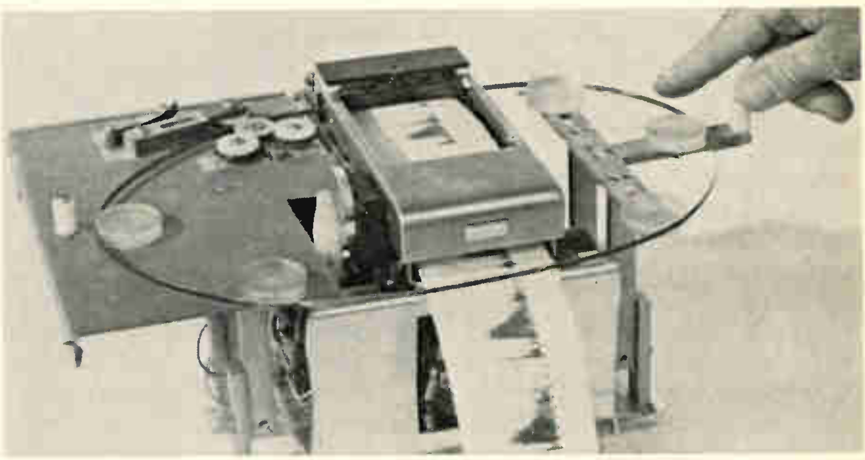
Light points out that the printer is inherently cheap, and there are no expensive components in the whole system. The most expensive element is the filter array. In the prototype, the filters are inductance-capacitance networks, but suitable active or digital filters could be made much less expensively for a production system.

Glass breakthrough

Glass delay lines have been around a long time but since they are not easy to make nobody contemplated volume production before the advent of the West Ger-



Printout. Blood pulse leaving heart shows velocity spread across vessel.



Ribbon. The system's printout unit has 18 electrodes on one side of paper and a loop electrode, to distribute ionic corrosion, on the other side.

man approach to color tv. Color receivers that use PAL, for phase-alternating-line, standards incorporate a delay equivalent to one tv line—63.943 microseconds at the European 625-line, 50-field-per-second standard. This is far too long for a practicable metal delay line.

In Europe both Philips and ITT have developed volume production of glass components. Philips has the larger market share and supplies European Free Trade Association countries from its Mullard plant at Blackburn, England, and the European Economic Community countries from its Dutch plant. The Mullard plant, the bigger of the two, is working up to an output of around 20,000 units per week by the end of the year. Much of the original work on the Philips delay lines was done at Mullard's Research Laboratories, which has released some details of its production process.

Reflections. Mullard's glass blocks are about 3.5 inches long. Their ends are ground flat. On one end are two vacuum-deposited squares of Nichrome overlaid with copper to which the input and output piezo-electric transducers are soldered side by side. The signal is reflected internally from the other end for a total delay line path of about 7 inches.

The biggest problem, say Mullard technologists, has been development of economically suitable glass and production processes. Temperature changes cause changes in both the length of the delay line and the velocity of the signal within it. Mullard Research Labs and Philips Glas Werk in Holland developed a lead-silica-potash glass in which temperatures changes in length and velocity have equal and opposite effects so that delay remains constant.

The transducer bonds are critical, and each has to be individually checked. Satisfactorily bonded blocks are aged until their characteristics have stabilized, then the reflecting end is finish-ground to the precise length in two stages. In the first stage, the glass is ground until a signal transmitted through it superimposes closely with a reference signal on an oscilloscope. In the second stage, a phase meter is used to reduce the phase difference to zero.

Mullard at present makes delay lines two at a time by sawing the completed glass block in half through the transducers in the plane of the signal path. Eventually the company is likely to prepare glass blocks with very long transducer and reflecting faces for slicing up into many separate delay lines. This technique may be combined with new block shapes incorporating multiple reflected signal paths so that the total volume of glass can be reduced and the delay time made smaller and cheaper.

The Netherlands

A glowing complexion

Using an integrated array of infrared sensors, researchers at Philips Research Laboratories have come up with a fast way of capturing thermograms, or heat pictures. Their prototype produces thermograms with a frame frequency of 50 hertz and temperature resolution of 0.2°C. Moreover, the new system does away with a good part of the complex mechanical scanning mechanisms needed with conventional thermographs.

At the Eindhoven-based laboratories, the late G. E. G. Hardeman and G. B. Gerritsen set about overcoming the limitations of conventional thermographs. Generally based on infrared cameras, these devices use a cryogenically cooled detector that is sensitive to infrared radiation. This detector works with a system using movable mirrors and prisms to effect point-by-point and line-by-line scanning of the heat-radiating object. The sequence of thermal pulses projected onto the detector produces corresponding currents which are decoded and then fed to a display device, usually a cathode ray tube. Not only are such systems complicated, they are also slow, and that's the price that must be paid for resolution when using a single detector.

Arrayed. The key to the Philips thermograph's high speed—some 10 times faster than other systems—is a row of 64 individual detectors, that scans a line instead of a point at a time. The moving optical system that irradiates these elements need therefore scan in only one direction and so can be built more simply than usual.

Each detecting element is about 2 millimeters long, has a cross section of 200 by 250 microns, and is separated from its neighbor by about 50 microns. The detector material—silicon with a little gallium added—is cooled to liquid helium temperature. Elements of uniform quality are made by soldering a homogeneous slice of silicon onto a metal substrate, vapor-depositing an aluminum layer on top and then sawing the slice into 64 side-by-side strips. Individual layers are connected to an IC-based circuit which amplifies the output of each detecting element.

Soviet Union

Behind the curtain

Once veiled in mystery, Soviet electronic components have now become familiar products on the European trade show circuit. Visitors have seen the Russian lineup—often through a haze of vodka toasts—for two years running at the big Paris Components Show, in London, and at Russian road shows in Scandinavia.

But the equipment the Russians use to turn out advanced semiconductor components has remained largely unkown to the West. Moscow lifted that curtain last month with a major display of electronic manufacturing equipment at a Soviet industrial exhibition in Paris. The last such show in the West, also in Paris, was nearly a decade ago.

On the blocks. The Soviets showed off—and offered for sale—their latest integrated circuit diffusion ovens, IC mask-making machines, and some exotic new laser gadgets, including a device to inspect ceramic resistor substrates.

Moscow's mask-maker stole the show. Though able to produce only small masks, up to 40 by 40 millimeters, compared to the 200-by-200-mm masks commonly needed by Western IC manufacturers, the machine will sell in the West for a bargain $110,000. That price is less than half that of large-mask U.S. machines of comparable performance. Moreover, the Russians claim it is the only automatic machine able to make masks on either ordinary photographic plates or on more accurate metallic-film plates with photoresist.

Clever. French engineers were impressed by the unit. "We were surprised that the Russians could make a simple, clever machine with performance equal to Western machines," said Charles Poligoroff, an engineer with France's Cifal. "It should be an attractive solution for small companies."

A punched-tape program, which the user can develop on any small computer, runs the Russian machine. The tape turns on and off an ultraviolet light that scans 225 squares on a photographic or photoresist plate, thus reproducing the programed pattern.

The original mask is then reduced 10 times to actual IC size, making copies directly in the machine, eliminating the need for an additional copying machine as in U.S. systems. A complex IC takes about an hour to lay out and eight actual-size copies can be made in 3 hours. For fine work, the Russian machine's scanning system can be moved as little as 1 micron. The accuracy of coordinate adjustments is 1.5 microns.

Superficial. The Russians also showed a machine for evaporating thin films of hybrid IC substrates. Instead of the masks ordinarily used by such machines, the Russian unit is based on photolithography—which Soviet technicians say is cheaper and simpler and gives faster deposits.

Up to 100 substrates are attached to five drums rotating inside an oven that looks like a vertical washing machine tumbler. Three ducts introduce either semiconductor materials, metals or quartz for evaporation. The oven heats to 400°C. The unit will sell for $10,000 in the West.

The laser device to reject flawed resistor substrates works like this. The substrates drop into a bed of turning bars, where each substrate is scanned over its entire surface by a laser beam that reflects into a photomultiplier tube. The machine can check 7,200 pieces an hour, with an accuracy of 0.3 mm for black spots, holes, and other defects. Rejection probability is 0.98. It will sell for $20,000.

The Russians also showed a laser light modulator for voice communications based on the linear electro-optical effect of a lithium niobate crystal. The modulator's main advantage is that it needs little voltage—only 120 volts.

Japan

Floating bubbles

Magnetic bubble devices show promise for many memory and logic applications, but until a few weeks ago only Bell Laboratories had announced success in growing the high-quality single-crystal orthoferrites that were first used to produce the devices. Now a group at Nippon Electric Co. says that by using a floating zone process it can produce excellent single crystals about a hundred times faster then Bell Labs. Although much research has shifted to garnet crystals, the NEC development should ensure large supply of inexpensive magnetic bubble material.

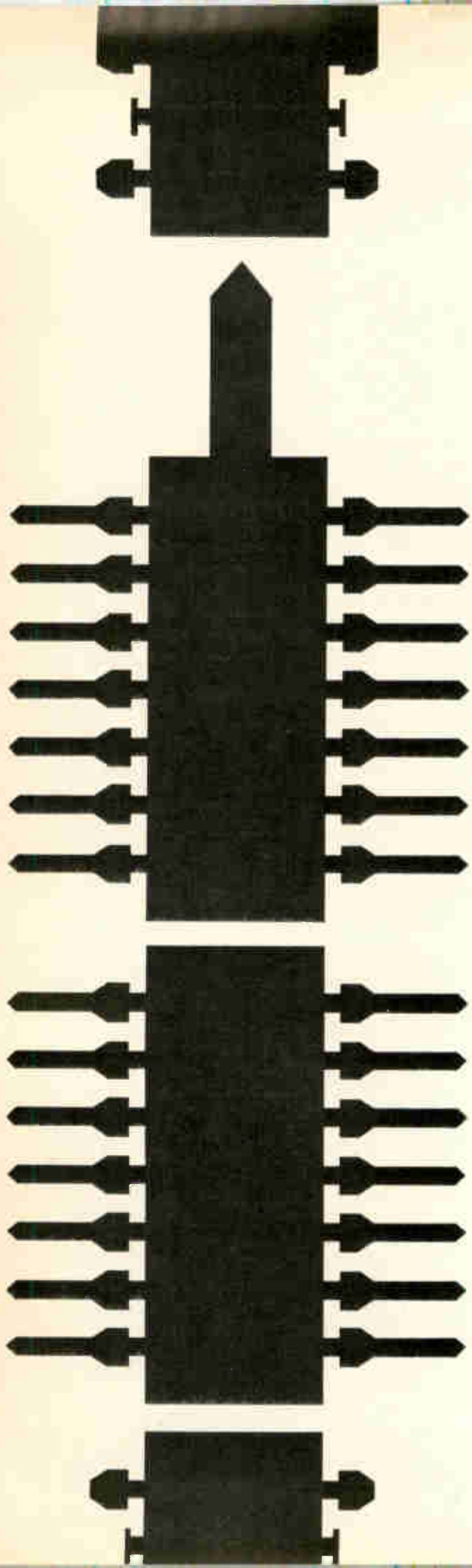
For use in bubble domain devices, orthoferrites must be single crystals, free of defects that may impede the motion of the magnetic domains. Earlier methods of growing the crystals involved placing the starting material in a large platinum crucible, heating it to about 130°C., and then cooling it by 0.5° to 1°C. per hour. With luck a single crystal starts to grow.

Stoichiometry. More recent attempts to adapt the methods used in creating semiconductor single crystals to the production of single-crystal orthoferrites have run into difficulties. The Bridgman method, in which an elongated container with a pointed end is loaded with molten material and then cooled from the pointed end, has failed because of contamination from the container. And, previous attempts to use floating zone techniques had failed because of crystal defects such as pores, twins, subgrains, and sliplike defects.

Floating zone. NEC's process starts with a molten zone between a seed crystal and a sintered ferrite rod. This molten zone is gradually passed through the rod, leaving behind a single crystal that is an extension of the seed. To suppress the formation of pores, however, Nippon Electric researchers found that the single most important condition is control of stoichiometry of the sintered ferrite. For example, they grow perfect yttrium orthoferrite crystals from a mixture of Y_2O_3 and Fe_2O_3, ideally with 50 mol % of each constituent, but never with more than 50.3 mol % of either one. This admittedly is a difficult requirement because even the chemical analysis techniques used by Nippon Electric allow an accuracy of only 0.1 mol %.

Other important conditions are a high oxygen pressure around the molten zone, typically 10 atmospheres, and uniform heating of the molten zone. To realize both these conditions, NEC developed a furnace that has an elliptical reflecting surface, with a large heated-filament halogen lamp at one focus and the molten zone at the other focus. This allows uniform heating of the sample because energy is focused on it from all sides, yet surrounding materials are relatively cool to prevent contamination.

The sample is surrounded by a quartz tube, which permits high-pressure oxygen atmosphere surrounding the sample. The seed crystal is rotated in one direction, the ferrite feed rod in the other, and the molten zone traverses the ferrite rod at a rate of several millimeters per hour. Perfect yttrium orthoferrite rods 8 mm in diameter and 50 mm long have been grown in 8 hours.



General Electric's parade of power control IC's

Voltage, phase, temperature and threshold detector IC's for industrial control

General Electric—long a leader in power semiconductor devices—now offers a broad line of monolithic integrated circuits for power control tasks. Because they're monolithic, these devices provide better thermal coupling and stability. This means increased reliability which is essential to your industrial control applications.

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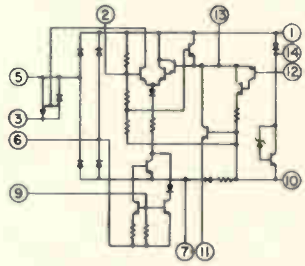
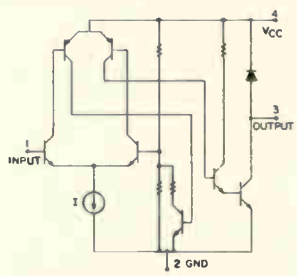


PA436—Phase-control

- controls loads up to 15A and 280V
- internal compensation for temperature and voltage changes
- induction motor speed control

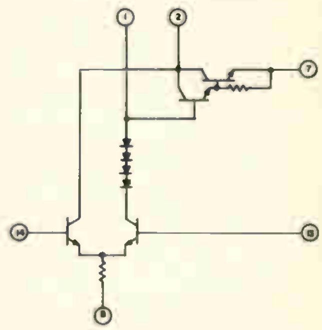
PRECISION THRESHOLD DETECTION



PA494—Threshold detector

- Schmitt trigger action
- 10% hysteresis
- low voltage operation (to 2.3V)
- high sensitivity (typ.1nA)

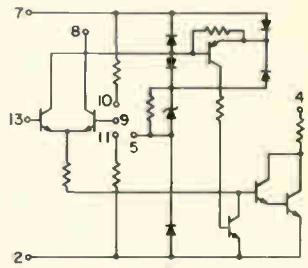
VOLTAGE REGULATION



PA264/PA265—
Five-watt voltage regulators

- 25- and 37-volt ratings
- 5-watt dissipation for on-card regulation
- Up to 1.25 amperes

TEMPERATURE CONTROL



PA424—Zero-voltage switch

- a-c line operation
- eliminates RFI
- triggers power triacs/SCR's

For more information about General Electric integrated circuits, call or write your GE sales representative or authorized distributor, or write General Electric Company, Section 220-87, Room C-2, Northern Concourse Office Bldg., North Syracuse, N.Y. 13212. In Canada: Canadian General Electric, 189 Dufferin Street, Toronto, Ont. Export: Electronic Sales, IGE Export Division, 159 Madison Avenue, New York, N.Y. 10016.

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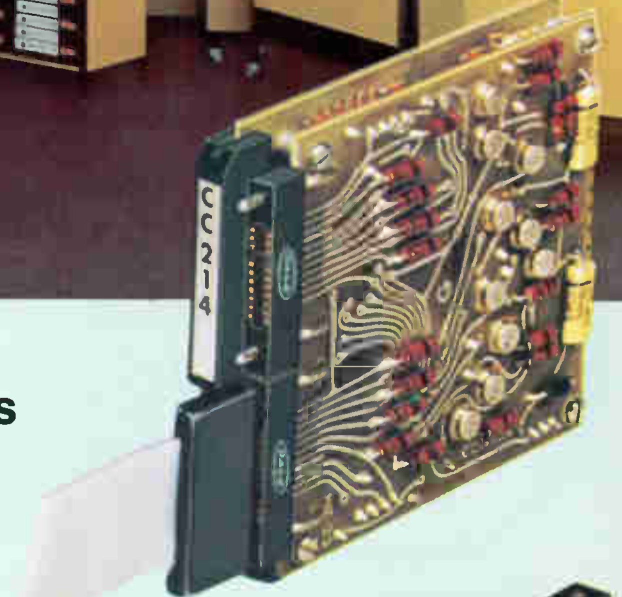
Yellow Pages

The Yellow Pages

Stay thin with Dale



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Contacts: 8, 16, 20, 25, 32, 50 or 64 per side on .050" centers

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1/32" (.027"-.035")

Profile:
.190" (1/16" boards)
.158" (1/32" boards)

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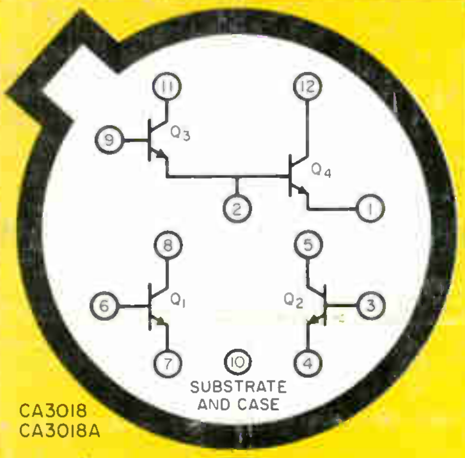
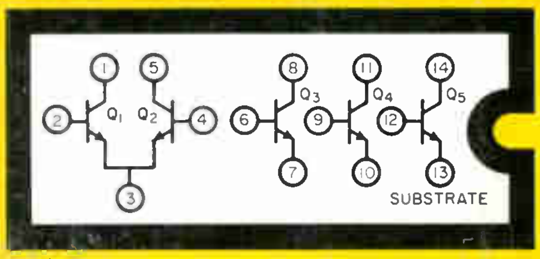
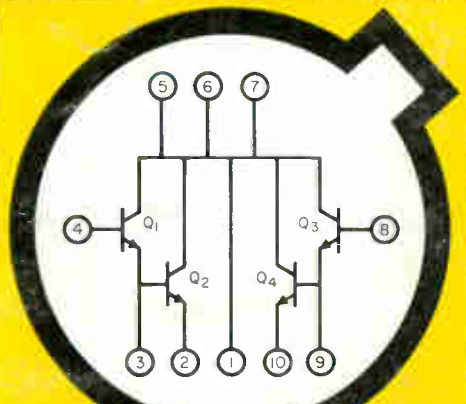


CA3018
CA3018A

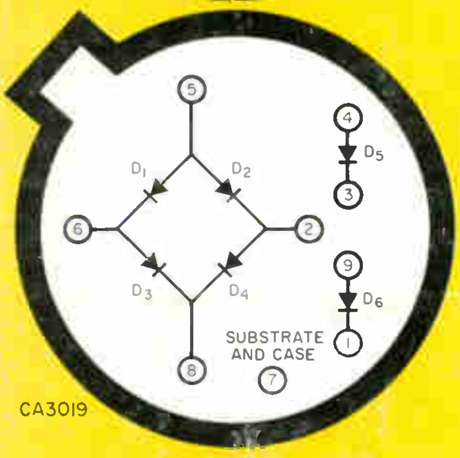


CA3045 CA3046

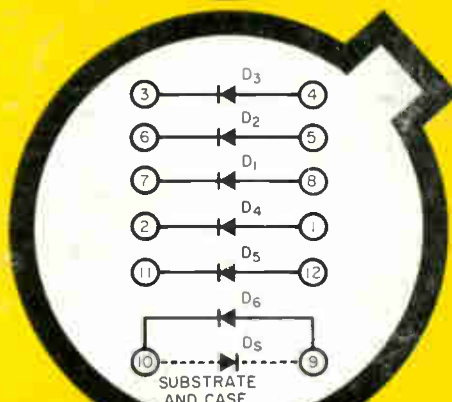


CA3036

Device Type	Package	Description	Technical Bulletin File No.	Price (1000-unit level)
CA3018	12-lead TO-5	Two isolated transistors and Darlington-connected transistor pair	338	$ .98
CA3018A	12-lead TO-5	Premium version of CA3018	338	1.35
CA3019	10-lead TO-5	One diode-quad, two isolated diodes	236	.98
CA3026	12-lead TO-5	Dual differential amplifier	388	1.25
CA3036	10-lead TO-5	Dual Darlington array	275	.89
CA3039	12-lead TO-5	Six matched diodes	343	.98
CA3045	14-lead DIL ceramic	Differential amplifier and three isolated transistors	341	1.50
CA3046	14-lead DIL plastic	Differential amplifier and three isolated transistors	341	.98
CA3049	12-lead TO-5	Dual independent differential RF/IF amplifiers	378	1.95
CA3054	14-lead DIL plastic	Dual independent differential amplifiers	388	1.25



CA3019



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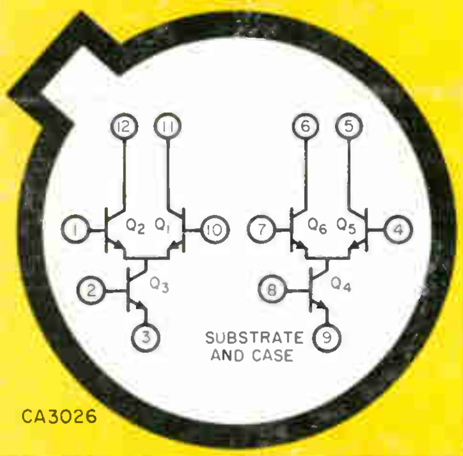
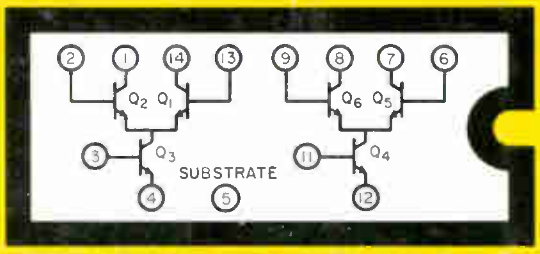
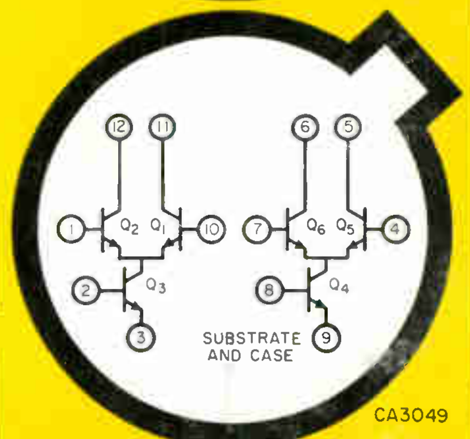


CA3026

CA3054





CA3049

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