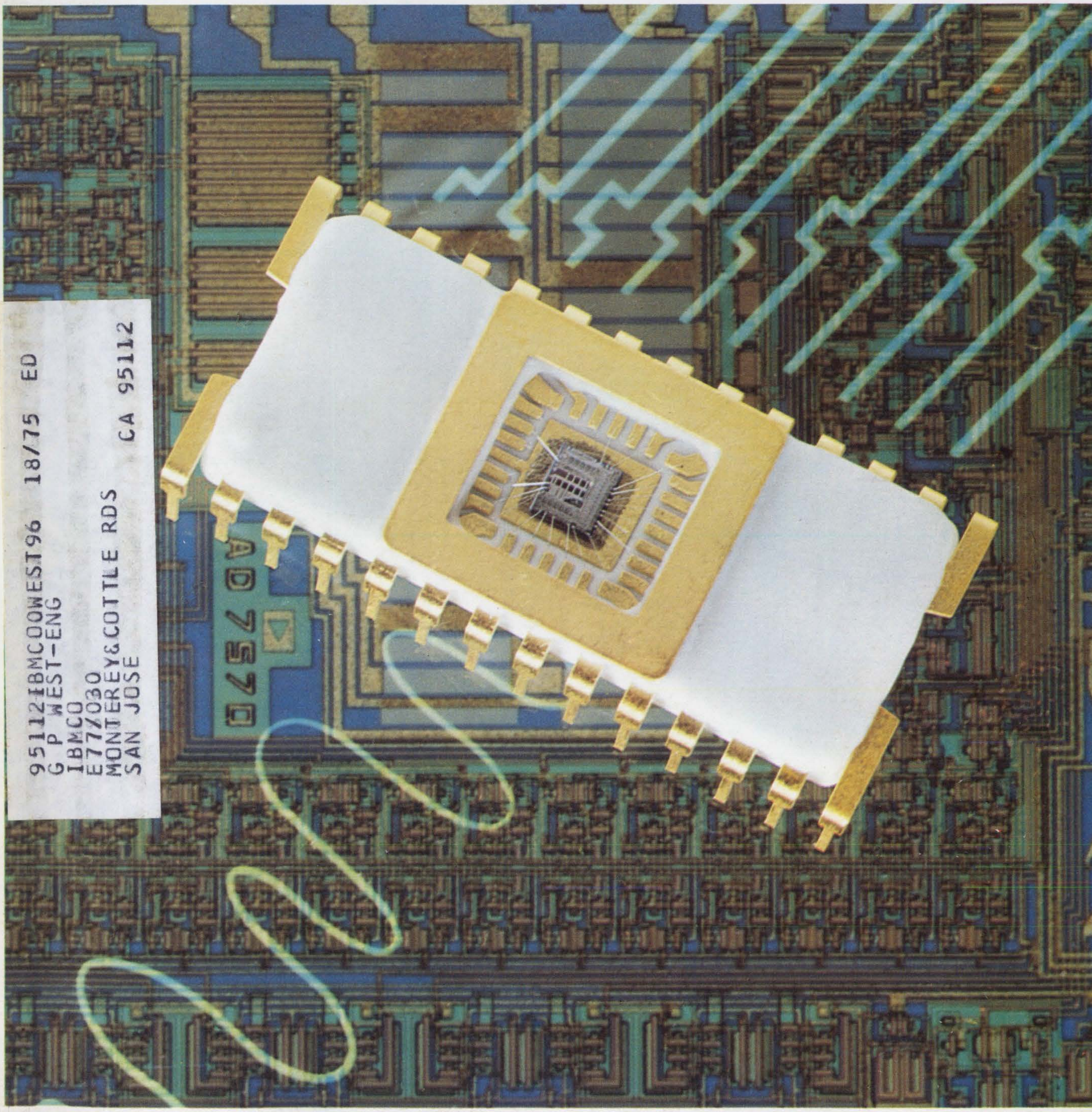
VOL. 23 NO. 2

Electronic Design®

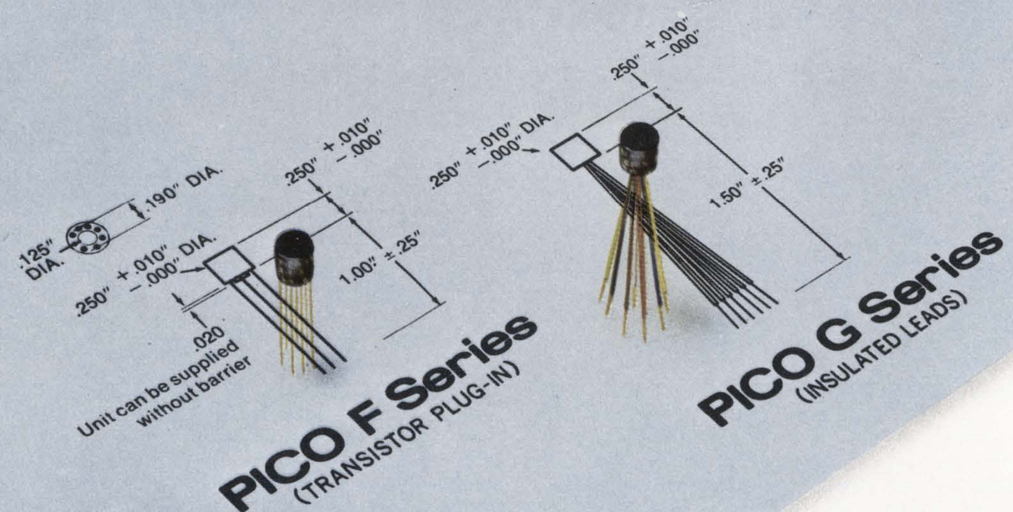
FOR ENGINEERS AND ENGINEERING MANAGERS

JAN. 18, 1975

The first 10-bit CMOS ADC chip features direct interfacing with LSI microprocessors. The analog-to-digital converter uses successive approximation for fast data acquisition. The chip has thin-film circuitry but needs an external comparator and reference. CMOS cuts power and increases voltage range. More on p. 81.



ultra-miniature transformers ¼"x¼"



SPECIFICATIONS

- **MIL-T-27D:** All Units Are Designed to MIL-T-27D and Are Hermetically Sealed in a Metal Case. PICO is a QPL source.
- **Frequency Response:** ±3 db, 400 Hz-250 KHz at 1.0 milliwatt.
- **Maximum Distortion:** 5% With Rated Power Level at 1 KHz.
- **Dielectric Strength:** All Units Tested at 200 V RMS.
- **Insulation Resistance:** Greater than 10,000 Megohms at 300 V DC.
- **Weight:** 1.1 GRAMS.
- **Operating Temperature:** −55°C to 105°C (All Units Can Be Supplied to Class S Requirements 130°C maximum).
- **Terminals:** .012 Diameter Gold Plated Dumet Wire In Accordance With MIL-STD-1276 Type D. Leads May Be Welded or Soldered.
- **Thermal Shock:** 25 Cycles, Method 107C, MIL-STD-202D, Test Condition A-1

PICO PART NUMBER F Series	PICO PART NUMBER G Series	PRIMARY IMPEDANCE OHMS	SECONDARY IMPEDANCE OHMS	POWER MILLIWATTS at 1 KHz	PRIMARY UNBALANCED DC CURRENT ma	PRIMARY DC RESISTANCE OHMS	SECONDARY DC RESISTANCE OHMS	MILITARY DESIGNATION
F5705	G6005	50	50	100	5.0	7.5	9.0	TF5RX17ZZ
F5710	G6010	100	100	100	5.0	15	18	TF5RX17ZZ
F5715	G6015	120 ct	3.2	100	4.5	15	0.75	TF5RX17ZZ
F5720	G6020	150 ct	12 split	100	4.0	20	2.4	TF5RX17ZZ
F5725	G6025	300 ct	600 split	100	3.0	40	90	TF5RX17ZZ
F5730	G6030	400 ct	400 split	100	2.5	54	58	TF5RX17ZZ
F5735	G6035	500 ct	50 split	100	2.0	62	10	TF5RX17ZZ
F5740	G6040	500	600	100	2.0	62	90	TF5RX17ZZ
F5745	G6045	600 ct	600 split	100	2.0	70	90	TF5RX17ZZ
F5750	G6050	900 ct	600	100	1.5	130	90	TF5RX17ZZ
F5755	G6055	1K ct	1K split	100	1.5	110	140	TF5RX17ZZ
F5760	G6060	1.5K ct	600 split	100	1.2	175	69	TF5RX12ZZ
F5765	G6065	2K ct	8K split	80	1.0	200	1000	TF5RX12ZZ
F5770	G6070	10K ct	500 split	80	0.5	1000	60	TF5RX12ZZ
F5775	G6075	10K	500	80	0.5	1000	60	TF5RX12ZZ
F5780	G6080	10K ct	12K split	80	0.5	1100	160	TF5RX12ZZ
F5785	G6085	10K	1.2K	80	0.5	1100	130	TF5RX12ZZ
F5790	G6090	10K ct	2K split	80	0.5	1100	250	TF5RX12ZZ
F5795	G6095	10K ct	10K ct	80	0.5	1100	1100	TF5RX12ZZ
F5800	G6100	10K	10K	80	0.5	1100	1100	TF5RX12ZZ
F5805	G6105	10K ct	10K split	80	0.5	1100	1100	TF5RX12ZZ
F5810	G6110	25K ct	1K split	50	0.3	2100	130	TF5RX12ZZ
F5815	G6115	25K	1K	50	0.3	2100	130	TF5RX12ZZ
F5820	G6120	30K ct	1.2K	50	0.3	2300	180	TF5RX12ZZ

Send today for PICO's Designers Kit!

PICO now offers a Designer's Kit containing ten (10) representational ¼" x ¼" transformers. The kit contains PICO's F5710 and G6025; F5730 and G6045; F5755 and G6065; F5770 and G6090; F5795 and G6110.

PICO's Designers Kit No. FG-100 . . . **$50.00** each

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INDUCTORS

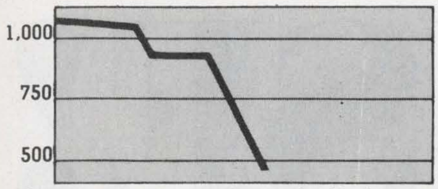
PICO PART NUMBER F Series	PICO PART NUMBER G Series	INDUCTANCE HENRIES		DC CURRENT ma	DC RESISTANCE OHMS	MILITARY DESIGNATION
F5825	G6125	SERIES	10.0	0	2250	TF5RX20ZZ
			2.75	2		
		PARALLEL	2.5	0	560	
			.65	4		
F5830	G6130	SERIES	5.5	0	1000	TF5RX20ZZ
			1.5	2		
		PARALLEL	1.3	0	250	
			.40	4		
F5835	G6135	SERIES	.85	1	240	TF5RX20ZZ
			.25	6		
		PARALLEL	.21	2	60	
			.06	12		
F5840	G6140	SERIES	.6	0	144	TF5RX20ZZ
			.15	5		
		PARALLEL	.15	0	36	
			.04	10		

PICO Electronics, Inc.

50 South MacQuesten Pkwy., Mt. Vernon, New York 10551 • Telephone 914-699-5514

*For immediate pricing and engineering information— **call collect***

INFORMATION RETRIEVAL NUMBER 243

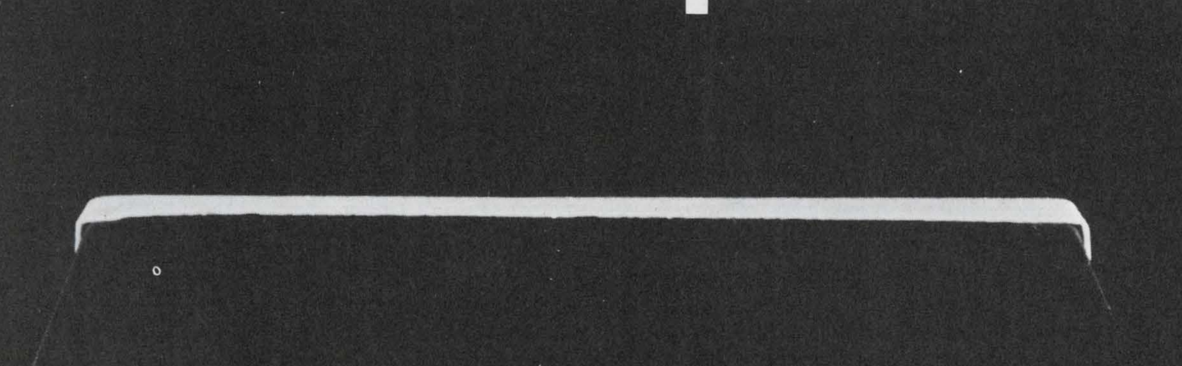


For years, we've been bullish on high-priced sweepers. Sure, there were plenty of low-priced offerings, if you wanted to speculate with hobbyist quality. But if you really wanted to make a clean sweep, you looked to the blue chips—and to spending about a grand. But now Wavetek has issued the Model 1050, an instrument that everyone can afford (even those in a tight capital equipment spending predicament). It sweeps from 1 MHz to 400 MHz with the signal quality needed for both lab and production use. The instrument features ±0.25 dB output flatness, 2% display linearity, spurious signals 30 dB below output, and a maximum amplitude of +10 dBm. It's available in 50-ohm and 75-ohm versions, and the price for either is just $495. In our opinion, this is the time to buy. Write or call us for a complete statement of the Model 1050's performance. Wavetek Indiana, Inc., P.O. Box 190, Beech Grove, Indiana 46107. Tel. (317) 783-3221. TWX 810-341-3226.

WAVETEK®

INFORMATION RETRIEVAL NUMBER 2

The bottom just dropped out of the sweeper market.



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WIDE BEAM 5082 -	4655	4555	4955
	4650	4550	4950

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INFORMATION RETRIEVAL NUMBER 3

VOL. 23 NO.

Electronic Design 2

FOR ENGINEERS AND ENGINEERING MANAGERS

JAN. 18, 1975

NEWS

TECHNOLOGY

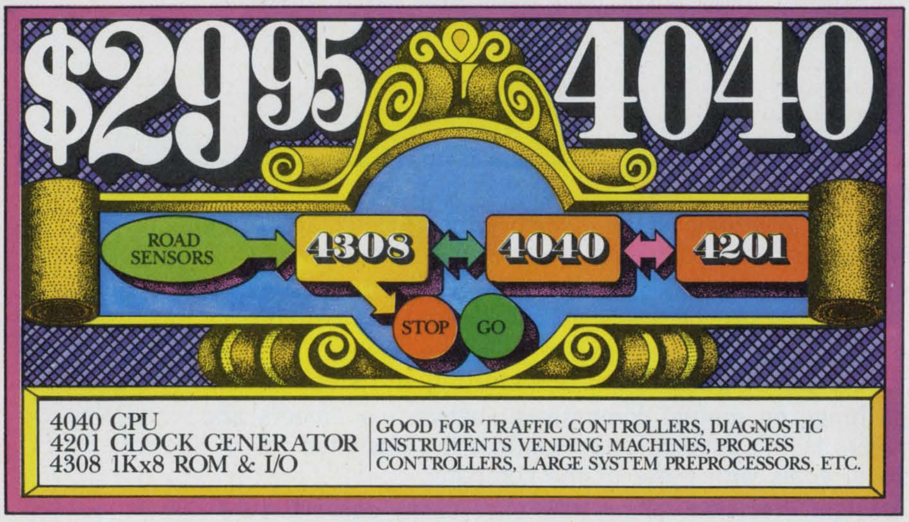
PRODUCTS

DEPARTMENTS

Cover: Photo by Paul Wagner, courtesy of Analog Devices, Norwood, MA.

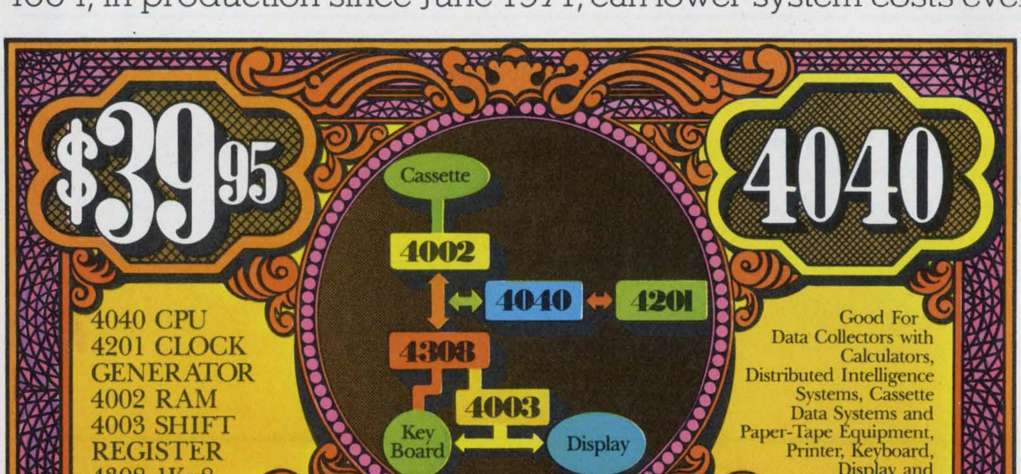
ELECTRONIC DESIGN is published biweekly by Hayden Publishing Company, Inc., 50 Essex St., Rochelle Park, N. J. 07662. James S. Mulholland Jr., President. Printed at Brown Printing Co., Inc., Waseca, Minn. Controlled circulation postage paid at Waseca, Minn., and New York, N. Y., postage pending Rochelle Park, N. J.

Put a complete your system for less



Cash in on the demand for economical intelligent products with Intel's inexpensive new 4040 CPU, 4201 integrated system clock, 4308 high density, low cost program memory and three new I/O components. Faster and more versatile than any other MOS 4-bit microprocessor unit, the 4040 can totally automate a smaller system or large portions of a big system. Yet an MCS-40 microcomputer system with CPU, clock, memory and I/O costs as little as $29.95.

Many equipment manufacturers are replacing hardwired logic and bulky electromechanical assemblies with MCS-40 systems. Most moderate speed control logic built with TTL can be replaced. The savings certificates show only a few 4040 applications. MCS-40 devices can be used with our 4004 central processor unit, too. The 4004, in production since June 1971, can lower system costs even more.

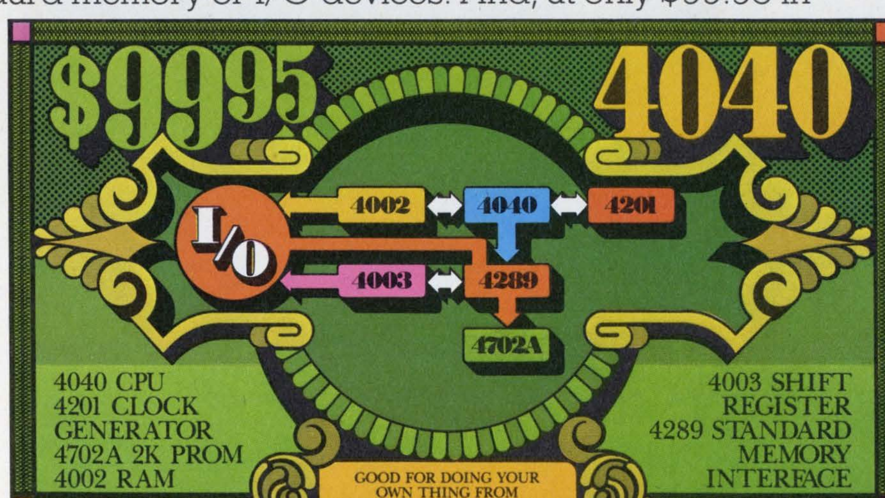


With either CPU, you'll save development time, lower component count and reduce assembly costs. You'll save even more as microcomputer costs decline while other system costs rise. And you'll gain valuable insurance against product obsolescence. Any design is easy to program and update with Intel's total development support, assemblers and Intellec 4/MOD 40 development systems. Our training centers will even teach you how to use Intel microcomputers.

microcomputer in than $30.

In high volume for just $29.95, you can buy an MCS-40 system with the 4040 CPU, 4308 1Kx8 ROM with four independent I/O ports, and 4201 system clock generator. The 4040 itself has 60 instructions, 7-level subroutine nesting, 24 index registers, interrupt processing, memory and index register bank switching, single-step operation and a low power standby mode.

A few dollars more buys extra computation flexibility. Use our 4289 interface, for example, to attach standard memory or I/O devices. And, at only $99.95 in quantity of one, the system with the 4702 erasable PROM is ideal for prototypes and low volume production.



At these prices, you can even use several microcomputers in large systems. Knowledgeable designers are putting 4040 intelligence into new products at less cost than simple-minded electromechanical parts and single-minded logic cards. Write for details on the MCS-40 family and the industry's most extensive software support. Or call any Intel office for an appointment with our applications engineers.

Intel Corporation, 3065 Bowers Ave., Santa Clara, Calif. 95051 (408) 246-7501.

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INFORMATION RETRIEVAL NUMBER 4

across the desk

Additional thoughts on dc/dc converters

You did a fine job on the "Focus on DC/DC Converters" (ED No. 23, Nov. 8, 1974, pp. 70-78). Here are some additional points:

1. On p. 75 you say: "Alternately you can buy a unit completely enclosed in a metal can. If you do, make sure the unit is surrounded on all sides and that the shield is unbroken. Remember that aluminum doesn't provide magnetic shielding. . . ."

A closed conductive container *will* give shielding against the radio-frequency magnetic fields (see F. Langford-Smith, "Radiotron Designer's Handbook," 4th Edition, 1952, RCA Electronic Components, Harrison, NJ 07029). In addition the proper circuit layout can make a large difference in the external field. The principles behind this layout are well known to competent rf engineers, but they may not be known by engineers with experience in only power supplies and low-frequency equipment.

2. On p. 75: "Because the dynamic input impedance of a converter can become negative under certain conditions, the possibility exists for external impedances to interact with this negative impedance . . . . The system breaks out into neat but rather disturbing, oscillations . . . . Solution: Shuffle the impedances at the input terminals or add damping networks."

For a cure to this problem, refer to N. Sokal, "Watch Out for Problems in Switching-Mode Power Equipment," ED No. 1, Jan. 4, 1974, pp. 144-145.

3. On p. 78: "If you want to build your own, Microtran and others carry a line of dc/dc converter transformers which come with suggested schematics. Or you can get a custom house—such as Design Automation or Prototype Transformer Corp.—to design one for you."

A reader could understand from this that Design Automation is a source for custom designs of only the transformers. Design Automation will supply a custom design for the entire dc/dc converter, as well as for the transformer—properly designed and documented so that the client can manufacture it bug-free.

Nathan O. Sokal
President
Design Automation, Inc.
809 Massachusetts Ave.
Lexington, MA 02173

Digital power meters neat, but not unique

In the article "It's a New World of Measurement at 1 GHz and Higher" (ED No. 24, Nov. 22, 1974, pp. 114-119), the digital readout of General Microwave's Model 475 power meter is described as a "unique feature for power meters." It is far from unique! We know of at least four other manufacturers of digital power meters, including our own company, with hundreds of units in the field.

To ignore other products in a survey article of this type is understandable. But to brand falsely one instrument as "unique" is playing fast and loose with either

(continued on page 16)

Electronic Design welcomes the opinions of its readers on the issues raised in the magazine's editorial columns. Address letters to Managing Editor, Electronic Design, 50 Essex St. Rochelle Park, N.J. 07662. Try to keep letters under 200 words. Letters must be signed. Names will be withheld on request.


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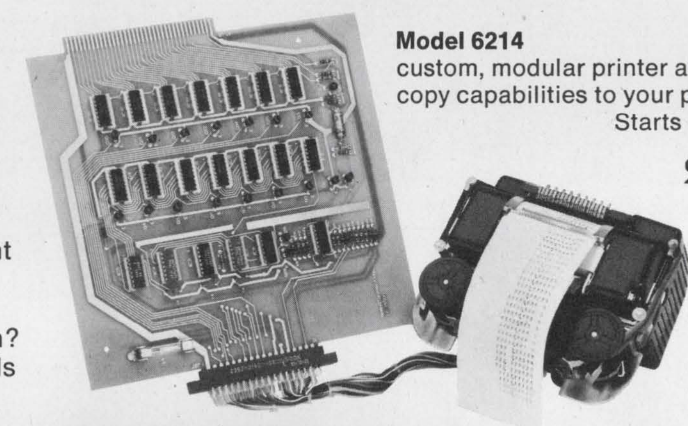

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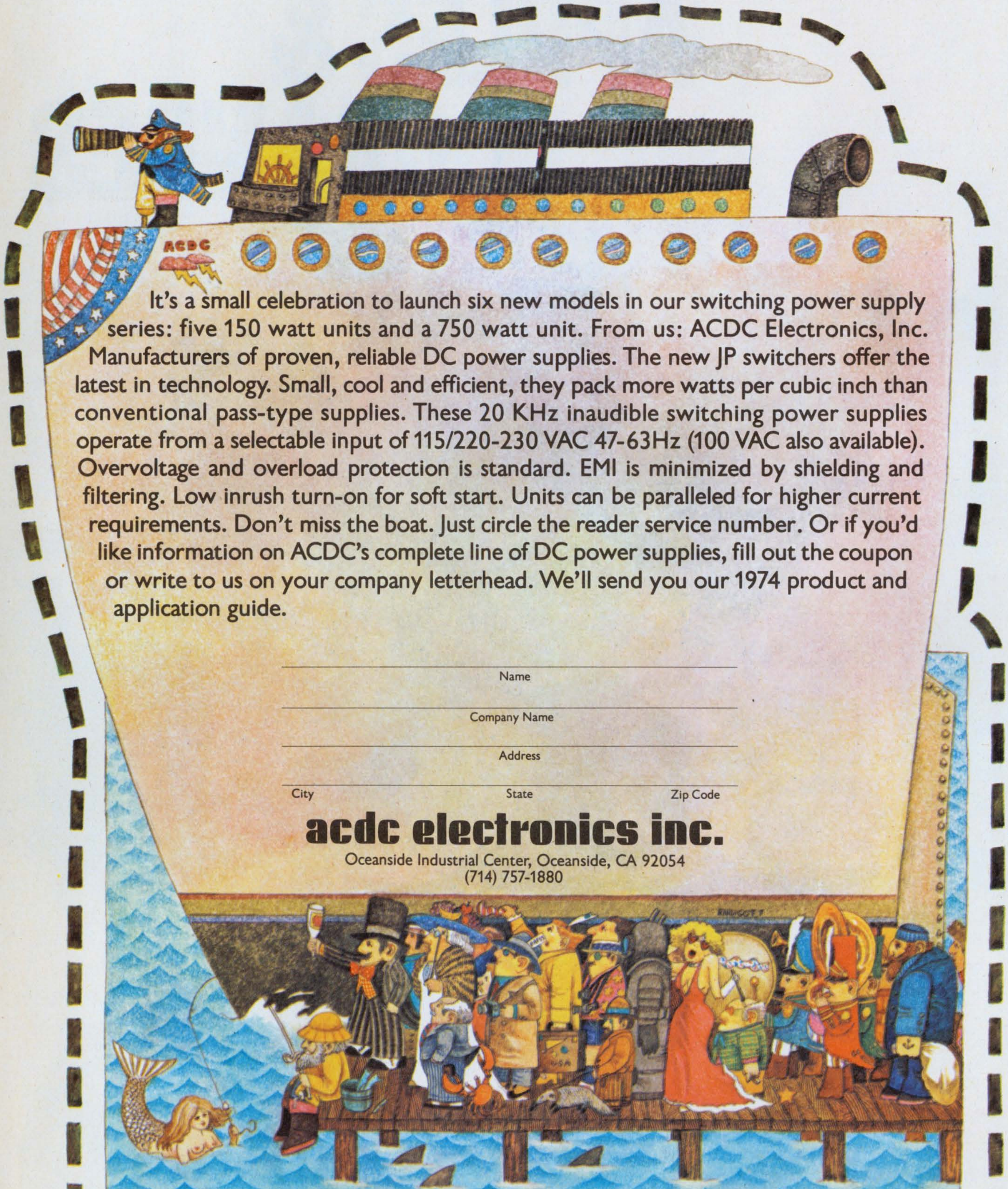

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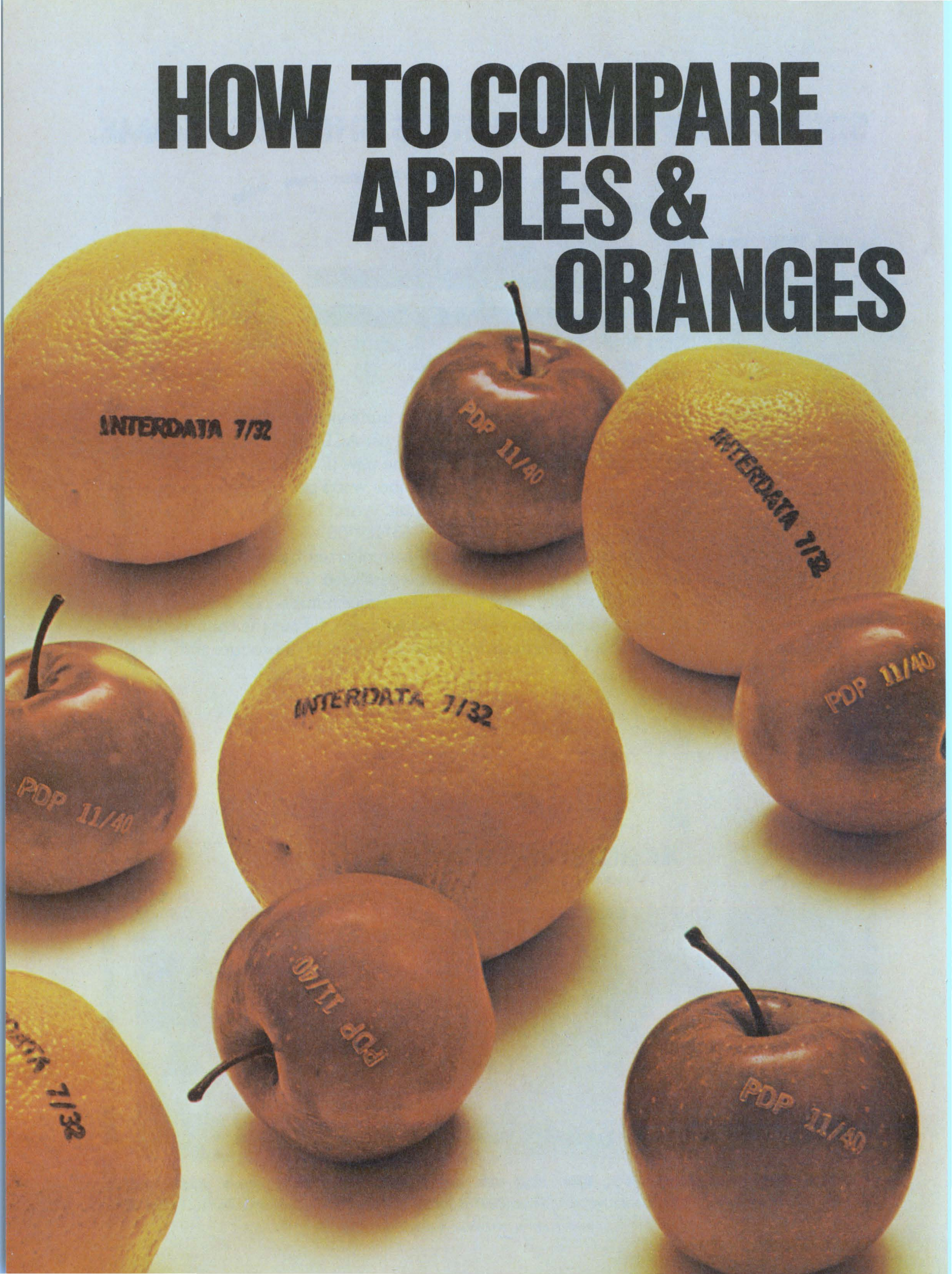
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PDP 11/40
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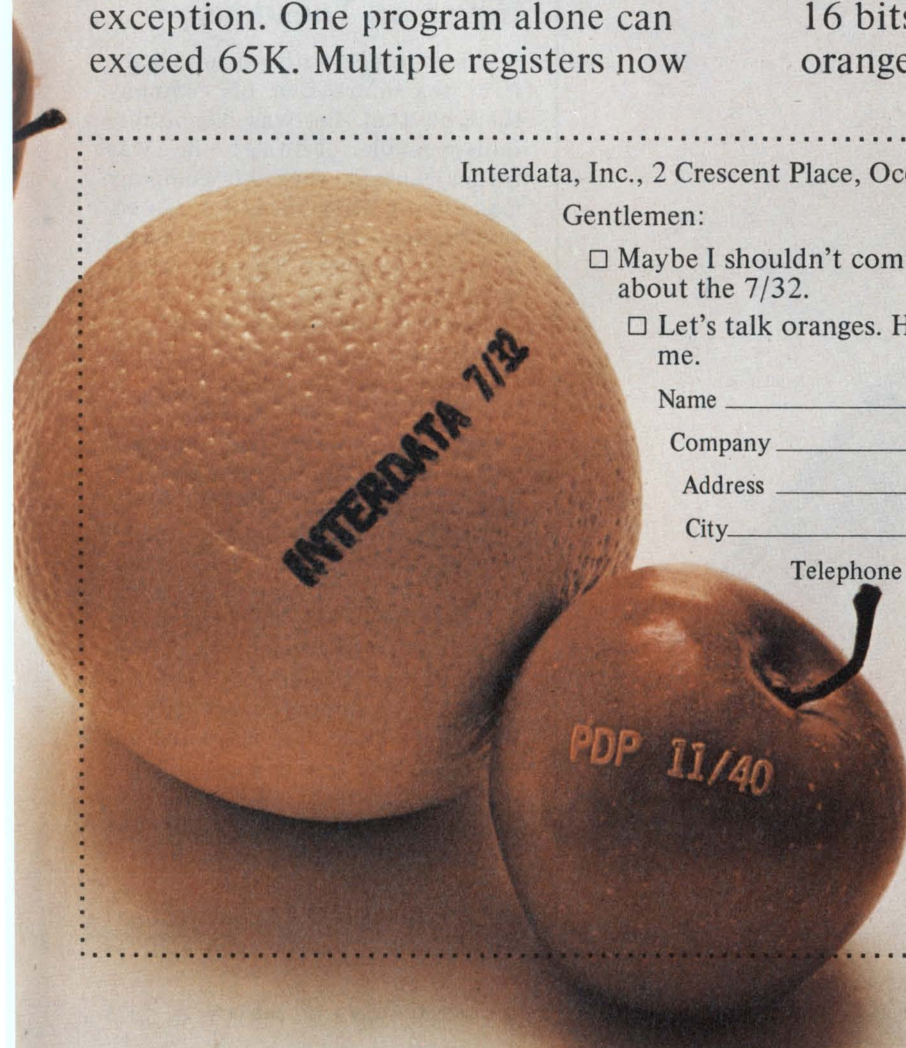
Large memories are the rule – not the exception. One program alone can exceed 65K. Multiple registers now mean 32. And most of your dollars are spent on software.

That's why Interdata made the 7/32 happen – to make your software simpler and cheaper.

For example, the 7/32 has a Real Time Operating System you can understand. A system optimized for FORTRAN programs. And a set of editors, debuggers, and file packages to brighten any programmer's day. All with a Common Assembly Language that gives you efficient code and is compatible not only with Interdata 7/32's but with our 7/16's as well.

So don't try to compare apples and oranges. It's unfair to the apple. Especially when their apple only has 16 bits to help their software and our orange has 32.



Interdata, Inc., 2 Crescent Place, Oceanport, N.J. 07757 (201) 229-4040.

Gentlemen:

☐ Maybe I shouldn't compare, but I've got to try. Send me more about the 7/32.

☐ Let's talk oranges. Have an Interdata representative contact me.

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INFORMATION RETRIEVAL NUMBER 10

ACROSS THE DESK

(continued from page 7)

the English language or the interests of your readers.

Wallace F. White
Marketing Manager

Boonton Electronics
Route 287 at Smith Rd.
Parsippany, NJ 07054

Ed. Note: You're absolutely right. A typewriter glitch, that "unique." Most units are analog; the digital are, shall we say, nifty?

Please, stop phoning

We missed by just one digit in EECO's telephone number in Electronic Design's GOLD BOOK, and the Orange County Department of Education is really miffed. The folks there have been getting three or four calls a day that are intended for EECO, whose number is (714) 835-6000—not (714) 834-6000.

Never on Tuesdays

An engineer with an aerospace firm was so creative, his company thought that he was absolutely indispensable. Though he was rather cantankerous, his company made many allowances for his eccentricities—and even allowed him to take every Tuesday afternoon off with full pay.

One Tuesday afternoon he took off and stayed away. At first nobody paid any attention when he didn't show up on Wednesday. But about a week later they checked with his home and found he hadn't been heard from. In fact, they checked all over and found no sign of him. He had simply disappeared.

He returned one Tuesday morning some eight months later and his boss was so delighted that he started telephoning everybody in the plant. When our wayward engineer asked the purpose of the calls, he was told: "Well, we're so glad to have you back, I thought we'd have a welcome-home party for you this afternoon."

To which our friend replied: "What? On my afternoon off?"

We asked A/D converter users what they really wanted, and they said accurate high speed 10 and 12-bit resolution, small size, reasonable prices and NO EXTERNAL COMPONENTS! So, we designed an A/D converter that offered all that, and then some. It's called the ADC85, and it's today's fastest, most accurate IC A/D converter. It's also the first complete IC converter around.

We started with some pretty advanced IC processing techniques and a small 32-pin DIP compatible hermetic metal package. We developed, and designed in, one of the neatest D/A converters around, and for extremely low drift and high initial accuracies, we added Burr-Brown produced and laser trimmed thin-film components. Then, so you don't have to mess around adding external components, we built in a selectable input buffer amplifier, a reference, and a user adjustable internal clock. It can operate from an external clock, too. All you have to do to make the ADC85 work is to add input power and logic control signals.

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INFORMATION RETRIEVAL NUMBER 14

Latest scientific calculators displayed at conference

A host of new computational functions, built into hand-held scientific calculators, was highlighted last week at the Winter Consumer Electronics Show in Chicago. And these machines offer more computing power per dollar than ever before.

Texas Instruments unveiled the new SR-51 for $225—it looks like the SR-50—that incorporates nine new features giving statistical as well as scientific capability. One feature is a random-number generator that can generate two-digit random numbers from 00 to 99. The generator is used in statistical analysis.

Other statistical features include automatic computation of mean, variable and standard deviation, factorials and permutation. Least-square linear regression, useful in plotting and correlating test data, can be performed for a maximum of 99 data points.

The number of storage registers has been increased from one in the SR-50 to three in the SR-51. [For a direct comparison of the SR-51 with the SR-50 and other calculators, see the table of "Key Scientific Calculator Features" in this issue's special report, page 24].

Although Hewlett-Packard was not at the show, its HP-45 for $325 was directly challenged by Mostek's Corvus 500 (less than $200). Like HP, the Corvus machine uses reverse Polish notation and has nine storage and four stack registers. Mostek is one of HP's chip suppliers.

The Corvus 500 omitted HP's conversions for decimal degrees to degrees, minutes and seconds. But the Corvus machine added hyperbolic and n-th root functions.

National Semiconductor's new Novus Mathematician ($80) was the only calculator shown—other than Corvus—that has reverse Polish notation. But unlike the Corvus (and HP) unit, the Novus has an eight-digit, floating-point arithmetic and display rather than scientific notation. Also, the Novus has only one storage and three stack registers.

Rockwell unveiled its 63R machine ($100), which improves the 61R by these added features: scientific notation; degree-to-radian (and inverse) conversion; a factorial key; two levels of parentheses; and keys that multiply or divide memory by the displayed quantity.

Canon revealed a new $250 algebraic-arithmetic calculator—the F-7—that competes with the TI SR-51 and the Corvus 500 in math power. But the F-7 has special functions and additional memories to make computation easier.

For example, the F-7, which uses scientific notations—has two directly accessible storage registers that can be recalled and displayed. In addition, the Canon unit incorporates seven memory registers for parentheses—the highest number in any hand-held unit presently available. Calculations using seven nested parentheses can be performed.

A fractional key (/) is also included in the F-7. This key permits a user to enter nondecimal fractions (like 1/3) directly.

A unique feature among the scientific calculators at the show was the digital-timing function built into Microelectronic Systems Corp.'s Model 3030. The unit, useful to time and calculate costs directly for operations such as long-distance calls, can count up or down in increments of 0.1 s. The maximum total count is 2777 hours, which is longer than the battery will last.

Not exhibited at the show was Hewlett-Packard's newest machine, the $395 HP-55 which also has a digital timer, this one with a resolution of 0.01 s. The Model 55 is programmable but has only 49 steps compared with 100 in the HP-65. Also, the HP-55 has no provisions for programmed storage.

However, the new calculator has 20 addressable registers compared with nine in the HP-45 and 65 calculators. A total of 86 preprogrammed functions come with the HP-55.

Solid-state amplifiers crowd low-level TWTs

A decline in the OEM market for low-level traveling-wave tubes is seen in the U.S. in a report, "Microwave Component Forecast," by Gnostic Concepts, Menlo Park, CA. The report says the market has reached a "plateau" of about $60-million a year.

Robert G. Simko, Gnostic Concepts associate, says the major reason for the decline is the increasing availability of solid-state amplifiers that can handle moderate power levels—such as 1 W at L band (0.4 to 1.5 GHz) and 0.3 W at K band (10.9 to 36 GHz.)

By 1978, the total market for discrete transistor amplifiers should increase by 226% over 1973, the report says, and microwave integrated circuits should show a total growth of 249% over the same five-year period.

So far the solid-state, small-signal amplifiers, both discrete and MIC, have been dominated by bipolar transistor technology, and this trend will continue in the microwave frequencies through 5 GHz, according to the forecast. Gallium-arsenide FETs and parametric amplifiers using varactor diodes will dominate the X band (through 11 GHz) and higher frequencies, the report says.

High-school lab using floppy-disk time-sharing

A mathematics laboratory at Channel Island High School in Oxnard, CA, is using what is believed to be the first floppy-disk-based time-sharing system. The school has been using a Data General Nova computer with 12 k of core memory since 1970, and it has four time-shared Teletype terminals for student use.

The floppy-disk, an AED 2500 from Advanced Electronics Design, Inc., Sunnyvale, CA, employs the IRIS software system, developed by Educational Data Systems.

Richard Brunner, chairman of the school's Mathematics Dept., says: "The floppy-disk system is used to store the various mathematics and computer-assisted instruction programs used by the classes in the lab. We used to input the programs into the computer core memory with a paper-tape reader before each class—which took at least five minutes. If any diagnostic work was needed, we could have wasted up to 10 or 15 minutes of class time. Now we call up the necessary programs instantly."

Virtually all ninth-graders, with the exception of basic-algebra and algebra 1 students, use the facilities—a total of 300 to 350.

"The real reason for a computer lab in our mathematics program is to motivate students to continue taking math courses," Brunner points out. "We still require students to learn math using conventional teaching techniques, but now they are very anxious to take the classes, so they can get to use the computer."

New computer aims to set speed record

A super-fast computer that promises to be up to 15 times faster than currently available units is being prepared for market. The machine, the Cray-1, is the first product of Cray Computer, a small company in Chippewa Falls, WI, headed by Seymour Cray, the architect of Control Data's 6600 and 7600 computers.

According to Cray, the new computer uses 1024-bit ECL memory chips and other small and medium-scale ECL integrated circuits to achieve its speed. The Cray-1 is reported to have a CPU cycle time of 12 ns and a memory-cycle time of 48 ns; its closest competitor, the CDC 7600, has a 2.75-CPU cycle time and a 275-ns memory-cycle time. The word length of the Cray-1 is 64 bits.

Building computers that operate as fast as the Cray-1 presents problems, Cray notes. For example, it's necessary to measure each length of wire in the machine to make sure that pulses arrive at their desination on time.

Another problem is that the high-speed ECL circuitry requires more power, Cray says. The Cray-1 needs about 50% more power than the 75-kW CDC 7600. This puts consumption at well over 100 kW, and that's just for the mainframe. The freon system used to cool the unit requires still more power.

The new mainframe, which takes up only 25 square feet of floor space, is being built by Cray's 25 employees and will sell for $7.5-million. That's the same price the 7600 and the 6600 went for when they were first offered.

The market for the Cray-1 is quite narrow, Cray admits. It is intended mainly for applications requiring a mass of scientific calculations. This is where the speed is needed most.

While a prototype of the Cray-1 has been built, the machine is not expected to be ready for the market until the end of the year. Literature, however, will be available in the spring, says Cray.

HD/CMOS II features small cells, low power

A new version of HD/CMOS, Micro Power Systems' high-density CMOS process has been introduced. Called HD/CMOS II, the new process features cell sizes that are approximately 50% smaller than those of the earlier HD process and roughly 75% smaller than those of the 4000 series.

In one implementation of the process, Micro Power is producing a watch chip with all the processing and frequency division circuitry needed to display hours, minutes, seconds and date within a 12,000-square-mil area. Other watch circuits using the process can operate from 1.5 V at 200 nA. The 0.3-μW power consumption is seven times less than that of a similar circuit using the original process.

The cell-size reduction is attributed to a combination of improved cell design, new circuit techniques and improvements in interconnects. HD/CMOS II shares most of its technology with its predecessor—including two-layer interconnect, one layer of polycrystalline silicon and one of electron-beam deposited aluminum. The polysilicon layer has a resistivity of less than 1 Ω per square mil, making long interconnections possible. Both the original and the new series also use a low voltage cell with a maximum applied voltage in the 6.5-V range, as opposed to the 15 V of conventional CMOS.

Micro Power Systems is a manufacturer of custom circuits for such applications as digital watches, hearing aids, cardiac pacemakers, pocket pagers and digital meters.

R&D rise forecast in U.S. this year

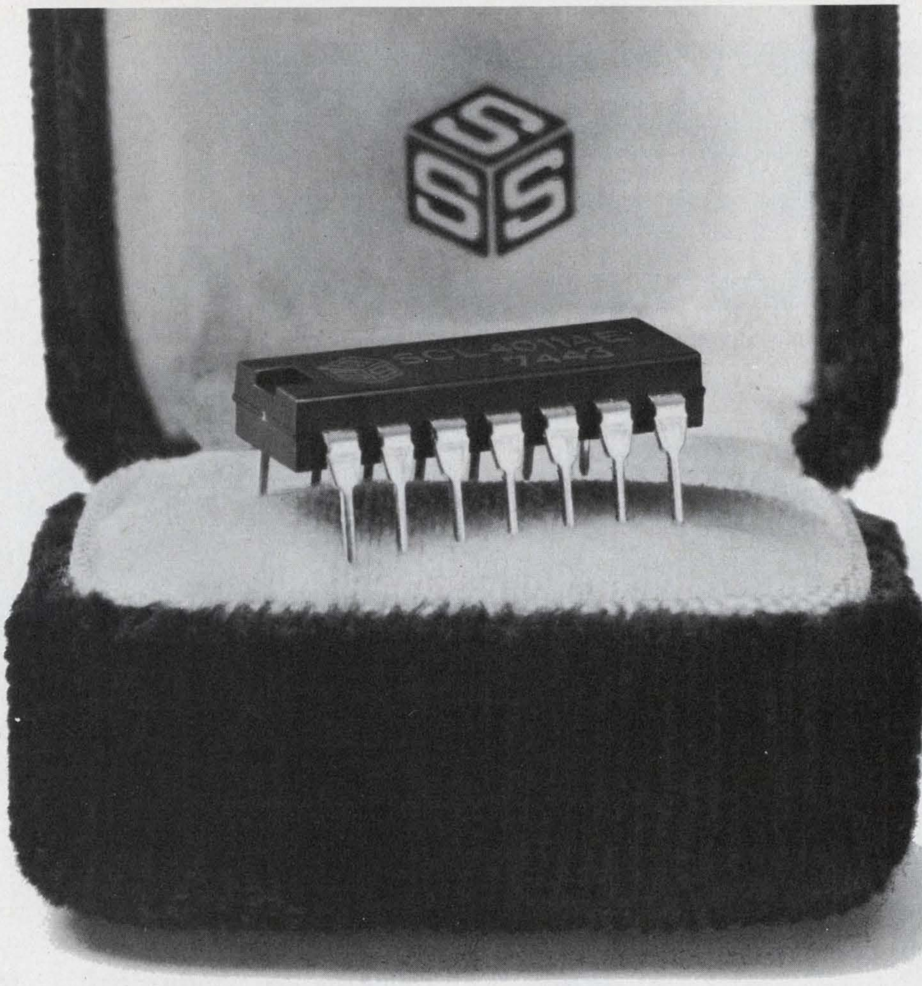
Spending for research and development in the United States is expected to increase 11% this year —from $32.1-billion in 1974 to $35.6-billion, according to a forecast by Battelle's Columbus Laboratories, Columbus, OH.

The forecast links the rise to increased support from the Federal Government and industry. Government support is deemed likely for research that will be directed increasingly toward short-term goals. The forecast sees an increasing emphasis on pragmatism, with some shift of support from socially related R&D to work directed toward solving more immediate resource scarcities.

The expected increase in Federal support is based on assumptions that the following will occur:

- Increased emphasis on R&D aimed at reducing U.S. dependence on Middle Eastern oil and gas.
- Selected use of R&D for counterinflationary purposes.
- Increasing awareness by state and local officials of the contributions that R&D—supported in part by Federal revenue sharing—can make to the needs of their constituencies.

Breaking down the R&D estimate for calendar 1975 by source of funds, the forecast sees the Federal Government spending about $18.5-billion, industry $15-billion, colleges and universities $1.6-billion and other nonprofit organizations $515-million.



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INFORMATION RETRIEVAL NUMBER 15

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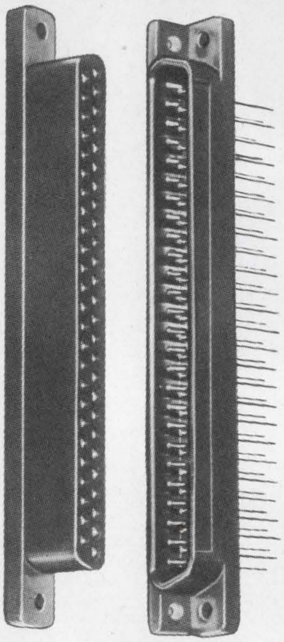

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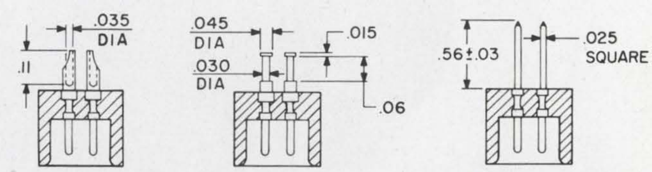

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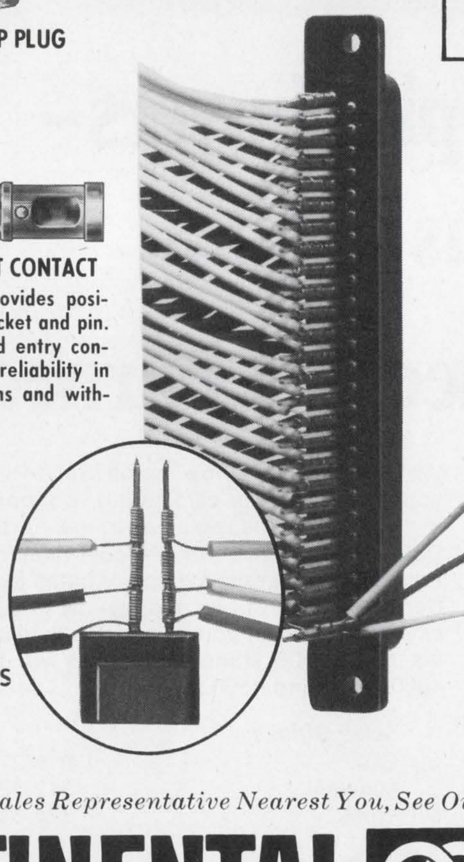

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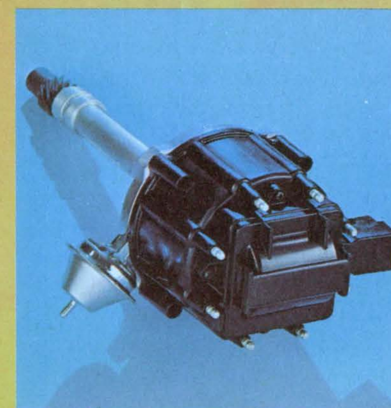
INFORMATION RETRIEVAL NUMBER 16

Celanex sparks high-energy idea in new ignition system.



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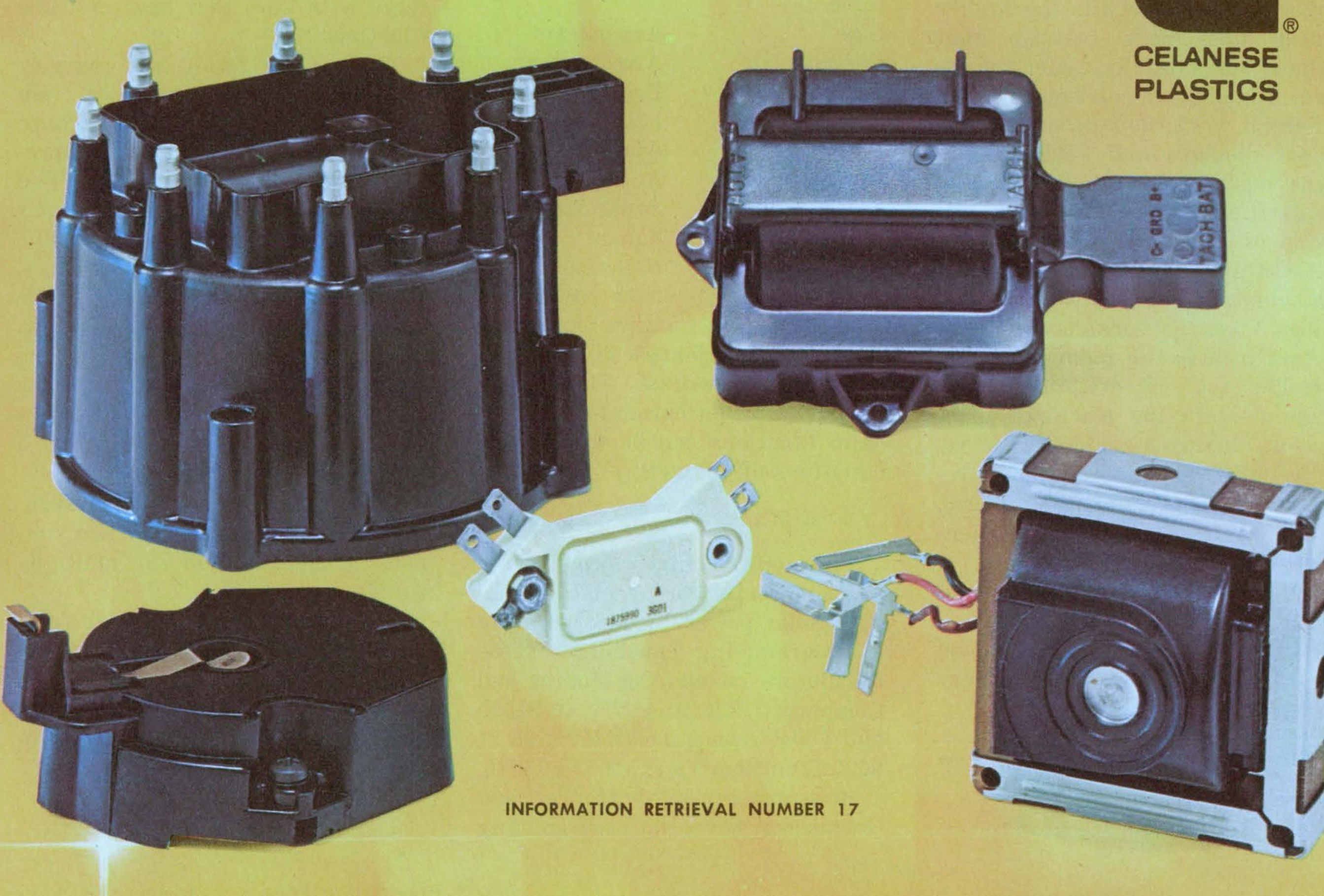

INFORMATION RETRIEVAL NUMBER 17

news

SPECIAL REPORT ON SCIENTIFIC CALCULATORS

Growing family of small machines at $50 and up does complex math

In just a year and a half, microelectronic scientific calculators have grown from lonesome offspring of the semiconductor revolution to a

In June, 1973, only one or two of the machines had been introduced. Today more than 40 types are available, with more to be unveiled later this year. All can perform complex mathematical operations on algebraic, trigonometric, logarithmic and other functions.

The designer buying a scientific calculator has a tough problem comparing them. First, the wide spread in prices—from about $1400 for the top of the line to $50 for the lowest unit—is not proportional to the mathematical capabilities of the machines. The lower-priced models give more math power per dollar, while the higher priced units have features that make it substantially easier to perform complex calculations.

Second, variations in sizes, packaging, displays and keyboard designs mask the close fundamental similarities between the large majority of machines.

And third, factors other than the mathematical capability of the machines must be considered. These factors include the following:

- The type of arithmetic programmed into the machine—plain algebra, hierarchic algebra or reverse-Polish notation—and the related methods of entering problems.
- The use of standard or scientific notation.
- The type of display and number of digits.
- Special visual indicators on the display, such as low battery and overflow.
- The ability to store and recall data.
- The incorporation of simplifying functions, such as single-key entry of constants and conversions (radians to degrees, etc.).
- Special features that may be used in certain calculations, such as polar-to rectangular conversions or factorials.
- The types of batteries used—alkaline dry cells or nickel cadmium (nicad) rechargeable units.

Jim McDermott
Eastern Editor

Low-cost units effective

Even the lowest-cost calculators are effective for engineering calculations. The following functions can be directly—or with a few easy steps—computed on all of the calculators reviewed here (see table):

Sine	Arccosecant
Cosine	Arccotangent
Tangent	Log base 10
Arcsine	Log base e
Arccosine	Antilog 10
Arctangent	Antilog e
Secant	Square root
Cosecant	Square
Arcsecant	N-th root
Cotangent	N-th power

Hyperbolic-function keys are found only on Sharp's PC-1002 and Texas Instruments' SR-50 and SR-51. On other calculators, hyperbolic functions can be solved with equations of the general form:

$$\sinh x = \frac{e^x - e^{-x}}{2}, \text{ etc.}$$

The top machines provide the most powerful and versatile computational power by incorporating a programming capability. These calculators include the Monroe and Compucorp 326 and 324 at $1395 and $694, respectively; HP's 65 at $695; and Sharp's PC-1002 at $645.

Both machines of Monroe and Compucorp have 160 programming steps, but the 326 can also store up to 100,000 program steps in a companion cassette unit.

The HP-65 stores up to 100 program steps on a small magnetic card strip.

Sharp's PC-1002 has 64 programmable steps but no provision for external storage. It does have provision for plugging in PROM chips that contain specialized programs, much like those on HP's magnetic cards. Five of these PROMs will be available, including chips for mathematics and electrical engineering. Other special programs can be written into individual PROMs by Sharp.

Most of the "popular," lower-cost machines fall into two categories: Those with keys that have single mathematical functions and those with keys that have multiple functions.

The single-function category embraces machines that cost from about $250 to $100 and that have between 36 and 40 keys. Representative of these units are TI's SR-50, Ward's P350, Dev-Tronic's SI-36 and Commodore's SR-1400.

These calculators also have scientific notation and (with two or three exceptions) have 10 mantissa and two exponent digits in the display. Most of these units have two sets of parentheses, one nested within the other, as well as a separate memory register.

With all the functions on separate keys, these machines are simpler to operate than the multiple-function calculators.

The multiple-function cost from about $140 to $70 or less. They have 20 to 30 keys. The display is usually eight digits, and a memory register is included. Representative machines are APF Electronics' MK-20 and Rockwell's 61R.

The multiple-function devices

These 16 scientific calculators are a cross section of what's available today. They are compared in a table, with 26 other calculators. The machines shown here (left to right): top row—Heath IC-2100; Bowmar MX0140; Craig 4512A; Canon F-5; Sharp PC-1002; center row—Sinclair Scientific; Wards P350; Commodore SR-1400; Rockwell 61R and APF Electronics MK 20; bottom row—Remington SSR-8; Dev-Tronics SI-36; Sharp PC-1802; Casio FX-10; Hewlett-Packard 65 and Texas Instruments SR-50. New additions to the family are coming this year.

have about the same mathematical capability as the single-function units, but a special function (F) key must be used. Depressing the F key before one of the operational keys gives the latter a second function. Depending upon the keyboard, from 12 to 20 keys may have one or two operating functions.

This design feature is developed to its fullest in Bowmar's MX-140, which has two function keys plus 20 regular ones. The two function keys give 23 additional keyboard functions as well as providing two sets of parentheses, one nested within the other.

Plain-algebra arithmetic is programmed into the chips of most of the calculators to perform add, subtract, multiply and divide operations. Plain algebra is the simplest and most straightforward of any of the calculator arithmetic methods, and operations are generally executed in the sequence in which they are entered. For example: $2 + 3 \times 4 = 20$.

Texas Instruments uses algebra hierarchy in which multiply and divide take precedence over add and subtract. When a string of numbers is entered, multiply and divide are executed first; the add or subtract operation is held until the multiply or divide is complete. For example: $2 + 3 \times 4 = 14$.

For long strings of calculations, the user must keep track of the precedence of multiplication and division, and consequently the order in which the terms are entered.

For entering lengthy calculations in plain algebra machines, the use of nested parentheses to at least two levels—in addition to a single-register memory—is highly desirable. The trend in chip design is to increase the number of parentheses. Canon's F-7 has seven levels of parentheses plus two storage registers.

Stack registers in calculators using reverse-Polish notation perform the same function as parentheses.

Hewlett-Packard's machines use reverse-Polish notation for arithmetical operations. But two new calculators, introduced this month at the Winter Consumer Electronics Show in Chicago, use the same notation. One is National Semiconductor's Novus Mathematician and the other Mostek's Corvus 500.

Data entry for reverse-Polish notation is similar to entering data in computers and is unlike algebraic entry. With reverse-Polish, the numbers are entered first and the arithmetic operation ($+, -, \times, \div$) is performed last.

Capabilities of this eight-digit, floating-point calculator, the Rockwell 61R, are duplicated in a sizable number of other machines.

Over 53 independent-key functions are provided by this TI SR-50 calculator. Arithmetic of this unit is organized as hierarchic algebra.

The only pocket-sized calculator with programming capability, the HP-65, uses magnetic-strip cards containing up to 100 program steps.

Over 100,000 program steps can be obtained by use of the companion cassette provided along with this Monroe 326 portable, battery-operated calculator.

For problems having two numbers and one arithmetic operator, the first number is keyed in and saved by pressing an ENTER key. The second number is keyed in and is followed by the arithmetic operator.

The expression $(3 \times 4) + (5 \times 7)$ would be evaluated by the following steps:

3 ENTER 4 × (12.00 is displayed)
5 ENTER 7 × (35.00 is displayed)
\+ (42.00 is displayed)

While use of this method is awkward for those accustomed to algebraic data entry, an advantage is that the user can solve most problems by keying in the numbers in the same order in which they appear in the original expression.

For handling very large numbers, scientific notation is essential. A 10-digit mantissa plus a two-digit exponent provide a working range of 10^{-99} to 10^{99}, which is typical of the 10 or more calculators in the \$250-to-\$90 range (see table).

Some of the newest machines, like the Canon F-7 and the Rockwell 63R, have an eight-digit mantissa and a two-digit exponent. Calculators with scientific notation have an exponent key (EE, EEX or EXP) that permits separate entry of the powers of 10.

One calculator, the Sinclair Scientific—the smallest and the only breast-pocket-sized unit—is organized for scientific-notation entry only.

Many calculators in the lower end of the price range do not use scientific notation. Instead, they have an eight-digit floating-point display. For many routine calculations this is adequate, since an overflow feature is provided.

These eight-digit calculators will accept and display any positive or negative integer between 0.0000001 and 99999999. Any result larger than 99999999. produces an overflow, which locks the machine. An overflow indicator is then displayed. The user obtains the true value of the displayed number by counting eight places to the right of the decimal point. As a result, the maximum capacity of an eight-digit machine is 9.9999998×10^{15}.

Most eight-digit machines—except for Novus Mathematician—do not have parentheses. As a result, chain calculations are somewhat more involved.

When a designer is dealing with complex strings of calculations, he needs the ability to store and recall data. The high-cost machines are the best here. Monroe's 326 has 12 storage registers and four sets of parentheses, HP's 65 nine storage and four stack registers and Sharp's PC-1002 eight storage registers and six levels of paren-

Key Scientific Calculator Features

Calculator	Models	Approx. List, $	No. of keys	[1]Display, LED or gas**	Scientific notation	[2]Type of arithmetic**	Mantissa/exponent digits	Change sign (+/−)	[3]Trig functions (3) (cos, tan)**	[4]Inverse trig functions (3)**	[5]Deg/Rad capability**	Deg/Rad conversion	Rad/Deg conversion	Deg/min/sec to decimal	Decimal to deg/min/sec	Polar/rectangular conversion	[6]Logarithms (• = bases 10, e)**	[7]Antilogs (• = bases 10, e)**	Hyperbolic functions	Factorial key (x!)	Summation	Reciprocal key (1/x)	Square key (x^2)	Square-root key ($\sqrt{\ }$)	n-th power key (y^x)	n-th root key ($y\sqrt{x}$)	π key	Storage registers, no.	x/y registers exchange	x/memory registers exchange	Parentheses/stack registers, no.	[8]Rechargeable batteries**	[9]Hours, use/recharge**	Battery-saver circuit	Programmable-no. of steps	[18]Conversions**	Special indicators**
Monroe and Compucorp	*326	1395	43	G	•	A	13/2	•	•	•	DR	•	•	•	•	•	•	•		•	•	•	•	•	•	•	•	12	•	•	4	R	4/12		160	•	10, 13
	*324	695	46	G	•	A	13/2	•	•	•	DR	•	•	•	•	•	•	•		•	•	•		•	•	•	•	10	•	•	2	R	4/12		160	•	10, 13
Hewlett-Packard	*65	795	35	L	•	P	10/2	•	•	•	DR	•	•	•	•	•	•	•		•	•	•		•	•	•	•	9	•	•	4	R	3/14		100	•	10, 13
	45	325	35	L	•	P	10/2	•	•	•	DR	•	•	•	•	•	•	•		•	•	•		•	•		•	9	•	•	4	R	5/14			•	10, 13
	35	225	35	L	•	P	10/2	•	•	•	D						•	e				•		•	•		•	1	•	•	4	R	5/14				10, 13
Sharp	*PC-1002	645	29	G	•	A	10/2	•	•	•	DR	•	•	•	•	•	•	•	•	•		•		•	•		•	8	•	•	6	(ac)	—		64	•	13, 15
	PC-1802	120	25	L		A	8/0	•	•	•	DR						•	e				•		•	•		•	1		•	0	O,R	27/A				10, 15
	PC-1801	100	25	G		A	8/0	•	•	•	DR						•	e				•		•	•		•	1		•	0	O,R	29/A				10, 15
Canon	F-7	250	36	L	•	A	8/2	•	•	•	DR			•	•	•	•	•		•	•	•	•	•	•		•	2		•	7	O,R	18/A			•	13
	F-5	140	26	L		A	8/0	•	•	•	DR						•	e				•		•	•		•	1	•	•	0	O,R	7/14				13
Tex. Instr.	SR-51	225	40	L	•	A	10/2	•	•	•	DR	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	3	•	•	0	R	4/3			•	10, 13
	SR-50	150	40	L	•	A	10/2	•	•	•	DR	•	•				•	e	•	•	•	•	•	•	•	•	•	1	•	•	0	R	4/3				10, 13
Corvus	500	<200	30	L	•	P	10/2	•	•	•	DR	•	•			•	•	•	•	•	•	•	•	•	•	•	•	9	•	•	4	O,R	6/12			•	13, 15
Bowmar	MX-140	160	20	L	•	A	10/2	•	•	•	DR						•	•				•	•	•	•	•	•	1	•	•	2	S	4/8				10, 12, 13
	MX-100	130	20	L		A	8/0	•	•	•	DR						•	•				•	•	•	•	•	•	1	•	•	0	S	4/8				10, 13, 15
Kingspoint	SC-40	150	38	L	•	A	10/2	•	•	•	DR						•	e				•	•	•	•		•	1	•	•	2	S	4/8	•			10, 11, 12 13, 14
Montg. Wards	P350	149	38	L	•	A	10/2	•	•	•	DR						•	e				•	•	•	•		•	1	•	•	2	S	4/8	•			10, 11, 12 13, 14
Summit	SI-90	149	36	L	•	A	10/2	•	•	•	DR						•	e				•		•	•			1	•	•	2	S	4/8	•			11, 12, 13
Devtronics	SI-36	140	36	L	•	A	10/2	•	•	•	DR						•	e				•		•	•		•	1	•	•	2	O,R	4/8	•			10, 11, 12 13
Commodore	SR-1400	100	36	L	•	A	10/2	•	•	•	DR						•	e				•		•	•		•	1	•	•	2	S	3/8	•			10, 11, 12 13
Melcor	SC535	100	37	L	•	A	10/2	•	•	•	DR						•	e				•	•	•	•		•	1	•	•	2	S	5/10	•			10, 11, 12 13
Keystone	2050	120	30	G		A	8/0	•	•	•	DR						•	e						•	•		•	1	•	•	0	S	4/8				10, 13, 16
Rockwell	63R	100	25	G	•	A	8/2	•	•	•	DR	•	•				•	•		•		•			•		•	1	•	•	2	S	3/5				13, 15
	61R	80	20	G		A	8/0	•	•	•	DR						•	•				•			•		•	1	•	•	0	S	3/5				13
Colex	ESR70	100	25	G	•	A	8/2	•	•	•	DR	•	•				•	•	•	•		•			•		•	1	•	•	0	S	3/5				13, 15
	ESR50	70	20	G		A	8/0	•	•	•	DR						•	•				•			•		•	1	•	•	0	S	3/5				13
Calcumatic	880	120	26	G		A	8/0	•	•	•	DR	•					•	•				•			•		•	1	•	•	0	S	3/5				13, 15
Royal Type	88T	—	26	G		A	8/0	•	•	•	DR						•	•				•			•		•	1	•	•	0	S	3/5				10, 13
Microelec.		90		G		A	8/0	•	•	•	DR						•	•				•			•		•	1	•	•	0	S	3/5				10, 13
Panasonic	JE5001	100	27	G		A	8/0	•	•	•	DR						•	•				•		•	•		•	1	•	•	0	S	4/8				10, 13, 15
Sears	ESR	100	20	G		A	8/0	•	•	•	DR						•	•				•		•	•		•	1	•	•	0	S	3/5				13
APF Elec.	MK-20	100	26	L		A	8/0	•	•	•	DR						•	e				•		•	•		•	1	•	•	0	S	6/12				10, 13, 17
Unitrex	80SR	100	26	L		A	8/0	•	•	•	DR						•	e				•		•	•		•	1	•	•	0	O,R					13, 17
Craig	4512A	100	26	G		A	8/0	•	•	•	DR						•	e				•		•			•	1	•	•	0	O,R	5/10				13, 17
Unisonic	799	90	26	L		A	8/0	•	•	•	DR						•	e				•		•	•		•	1	•	•	0	O,R					10, 13, 17
Sheen	S90	90	25	L		A	8/0	•	•	•	DR						•	e				•		•	•		•	1	•	•	0	a/R	18/A				
Novus	Math.	80	32	L		P	8/0	•	•	•	DR	•	•				•	e				•	•	•	•		•	1	•	•	0	a/R		•			10, 11, 13
Casio	FX-10	70	29	G		A	8/0		•	•	D			•			•	e				•		•	1-9		•	0			0	O,R	17/A				13
Sinclair	Scientific	50	18	L	•	P	5/2		•	•	R						10	10										0			2	a	25/A				
Kits: MITS	7440	200	36	L	•	A	10/2	•	•	•	DR						•	e				•		•	•		•	1	•	•	2	(ac)	—				12, 13
Kits: Heath	IC-2100	120	26	G		A	8/0		•	•	DR						•	e				•		•	•		•	1	•	•	0	(ac)	—				13
Kits: Netronics	N-1000	90	37	L	•	A	10/2	•	•	•	DR						•	e				•	•	•	•		•	1	•	•	2	R	5/10	•			10, 11, 12 13

* Programmable calculator (see text)

** 1. L = red LEDs; G = green fluorescent tubes
2. A = algebra; P = reverse Polish
3. sin, cos, tan
4. $\sin^{-1}$, $\cos^{-1}$, $\tan^{-1}$
5. D = degrees; R = radians
6. Sinclair has base 10 only
7. e or 10 indicates only that base used

8. R = Battery replaceable
S = Sealed; disassemble to replace battery
O = Optional dry or rechargeable battery
ac = ac-line power only
a = Dry cells only
b = 9-V transistor battery
9. A = Hours for alkaline cells
10. Low-battery indicator

11. Standby mode (digits blanked)
12. Operation in radian mode
13. Overflow, error, or illegal operation
14. Calculator busy (digits blanked)
15. Memory loaded or memory overflow
16. Battery on charge
17. Function-mode in use
18. Metric, wts, vol, length, etc.

theses accessible by key entry.

However, there is a lower-cost challenger: the new Corvus 500. The 500 uses reverse-Polish notation, has nine storage registers and closely matches the HP-45.

Of the lower-cost algebraic machines, the best for complex-string calculations are the machines with two sets of parentheses like Ward's P350, Bowmar's MX-140, Dev-Tronics' SI-36, Kingspoint's SC-40, Commodore's SR-1400 and Melcor's SC535.

Nested parentheses are also found in two kits—the MITS 7440 and Netronics N-1000.

Setting the pace for greater storage capability in algebraic calculators is Bowmar's new $250 F-7. It has two storage registers and seven sets of parentheses.

The selection of a keyboard is a personal matter. To begin with, the keys should be far enough apart to avoid accidental double entry. A keyboard suitable for small hands can be intolerable for a person with large fingers.

A snap or other positive indication of operation when a key is depressed is preferred by many users.

Clear or contrasting key and keyboard markings are important to hold down errors when data are entered on keys with more than one function.

On-off switches should be reasonably rugged, since they are useful in conserving battery energy.

Today's scientific-calculator buyer has two principal display choices: red LEDs or green fluorescent gas tubes. The green digits are substantially larger than the LEDs and are generally found in machines without scientific notation. The largest display is found in Heath's IC-2100 kit.

LED displays differ

With LED displays, differences in sizes and visual quality are apparent, even among machines with the same computational capabilities. LEDs tend to be eye-fatiguing after the calculator has been used a few hours—something to bear in mind when you buy.

In machines with scientific notation, the displays have eight or 10 digits for the mantissa plus two for the powers-of-10 exponents. In addition the displays contain extra characters for mantissa and exponent minus signs, as well as other special indicators.

Calculator reliability is widely reported to be good, but some problems are found in mechanical elements, such as switches and keys.

Nickel-cadmium rechargeable batteries are the principal user problem. For a calculator in constant use, the need to keep the batteries charged demands close attention. Even if the calculator is stored, the battery must be periodically recharged or it will eventually go dead.

For daily use of most calculators, the battery must be charged two hours for every hour of use. There are exceptions, of course. The HP 65 calls for 14 hours of charge for four hours of use. TI says that the "fast charge" battery in the SR-50 will give four hours of use for every three hours of charging.

Most of the calculators are sold with custom nicad batteries. In HP and TI machines, these batteries are replaceable in the field. But other manufacturers, including Bowmar, Kingspoint and Rockwell, seal the battery inside the case. Should the battery fail during warranty, the calculator must be returned to the factory. Owner disassembly voids the warranty.

For extensive field use, HP recommends two sets of batteries.

Some calculator producers, like Dev-Tronics, Sharp, Craig and Casio, have designed calculators to operate with AA penlite cells or rechargeable AA nicad batteries.

For extended field use, the hours obtained from alkaline cells are five or six times those obtainable from a single nicad charge.

Unique among the calculators is the use of a 9-V transistor battery in the Novus Mathematician.

At least three kits are on the market. The Heath unit is small enough to slip into a briefcase, but it requires ac power. The Netronics kit is described in the January, 1974, issue of *Popular Electronics*.

The MITS 7440 is a large desk calculator with individual keys for all functions. A 256-step programmer, expandable to 512 steps, is also available for use with the 7440. ■■

Want more information?

Readers interested in learning more about the individual calculators mentioned in this article may contact the manufacturers and suppliers listed here.

APF Electronics, Inc., 375 Park Ave., New York, NY 10022. (212) 758-7550. **Circle No. 420**

Bowmar, 450 Park Ave., New York, NY 10022. (212) 752-3250. **Circle No. 421**

Calcumatic—Leisurecraft Products, Ltd., 909 3rd Ave., New York, NY 10022. (212) 686-0096. **Circle No. 422**

Canon Inc., 10 Nevada Dr., Lake Success, NY 11040. (516) 488-6700. **Circle No. 423**

Casio, Inc., 1 World Trade Center, New York, NY 10048. (212) 432-9230. **Circle No. 424**

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Commodore Business Machines, 901 California Ave., Palo Alto, CA 94306. (415) 326-4000. **Circle No. 426**

Compucorp (Sold overseas only), W. Olympic Blvd., Los Angeles, CA 90064. (213) 820-5611. **Circle No. 427**

Corvus, 13030 Branch View Lane, Dallas, TX 75234. (214) 620-2454. **Circle No. 428**

Craig Corp., 921 West Artesia Blvd., Compton, CA 90220. (213) 537-1233. **Circle No. 429**

Dev-Tronics, Inc., Route One, Twin Falls, ID 83301. (208) 733-2086. **Circle No. 430**

Heath Company, Benton Harbor, MI (616) 983-3961. **Circle No. 431**

Hewlett-Packard, Advanced Products, 19310 Pruneridge Ave., Cupertino, CA 95014. (408) 996-0100. **Circle No. 432**

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MITS, Inc., 6328 Linn Ave., N.E., Albuquerque, NM 87108. (505) 265-7553. **Circle No. 437**

Monroe Calculator Co. (Sold in U.S. ony), 550 Central Ave., Orange, NJ 07051. (201) 673-6600. **Circle No. 438**

Montgomery Ward. In catalog or at most retail stores.

Netronics R&D Ltd., 27 Eagle St., Spring Valley, NY 10977. (914) 353-7372. **Circle No. 440**

Novus, 1177 Kern Ave., Sunnyvale, CA 94086. (408) 732-5000. **Circle No. 441**

Panasonic, 200 Park Ave., New York, NY 10017. (212) 973-5700. **Circle No. 442**

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FROM THE INTERNATIONAL ELECTRON DEVICES MEETING

New microwave semi fabrication pushing power and reliability up

Steady improvements in the fabrication of microwave transistors and diodes are bringing new devices with increased powers, elevated frequencies and heightened reliability. In some cases, the new devices have been expected; in others, they're surprise winners.

The much talked about race between silicon transistors and gallium-arsenide (GaAs) FETs, for example, didn't come up much at the 1974 International Electronic Devices Meeting in Washington, DC. The reason: GaAs power FETs are pulling ahead, with 1-W devices advancing within sight of 10 GHz.

However, among active diodes one type unexpectedly stole the spotlight by going planar, to usher in the first IC Trapatts. Excelling in high peak powers and high efficiencies, Trapatts haven't reached the commercial availability of say, Impatts, which researchers at the meeting said may be the next diode to benefit from reliability-increasing planar techniques.

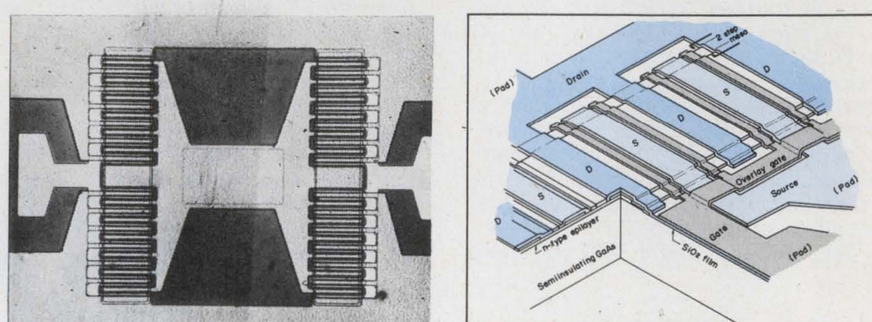
In the latest advance of GaAs FETs, researchers at Fujitsu Laboratories, Kawasaki, Japan, are within sight of a milestone: X-band output powers in excess of a watt.

"Within about a year, we expect to reach 3-W saturation output power [0-dB gain] at 10 GHz," said Masumi Fukuta, senior engineer at Fujitsu and a prime developer of the power-increasing mesh structure used in GaAs and silicon transistors.

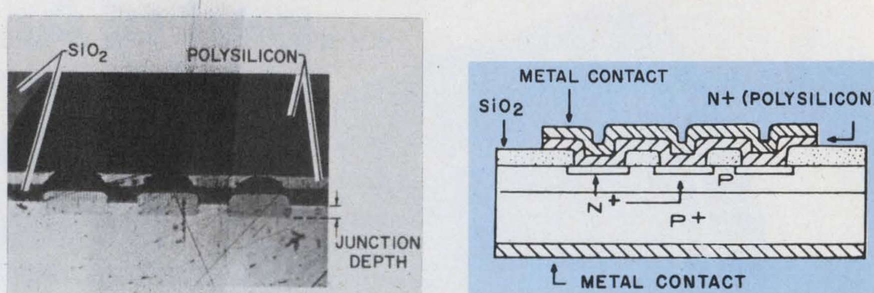
"The 10-GHz MESFET could output 1 to 1.5 W with 4 to 5 dB of gain," Fukuta said.

The kind of GaAs-FET structure to be used was indicated by Fukuta during his delivery of a paper on "GaAs 8-GHz Band High-Power FET."

Edward A. Torrero
Associate Editor



1. **An 8-GHz GaAs power FET yields 0.7 W at unity gain** (left). The FET's cross-section (right) reveals interdigitated sources and drains.



2. **The first planar Trapatt diodes.** A seven-diode array employing standard IC techniques, is arranged in an hexagonal geometry.

The paper reported an X-band device that delivers 0.7 W of saturation power with a drain efficiency (rf output to dc input) of 45%. The 8-GHz device operates from a 6-V drain voltage. With about 3-dB of gain, a similar FET can output 0.4 W at a drain efficiency of 30%. And a parallel structure yields 1.6 W.

The basic FET structure consists of interdigitated source and drain electrodes and an overlaid electrode that connects 52 Schottky gates in parallel (Fig. 1). Gates have a length of 2 μ and an overall width of 2600 μ, and they are 1 and 2 μ away from sources and drains, respectively.

The key to more power at higher frequencies, according to Fukuta, is wider gates. Also heightened gain requires both a shortened gate length and a lowering of ohmic contact resistance and common-source lead inductance.

"If only the common-source load inductance were lowered to one-fifth its present value," Fukuta said of the 8-GHz FET, "the maximum available gain would increase by about 2.5 dB."

Trapatts became ICs

While power FETs are moving up the frequency scale, active diodes are embracing integrated-circuit technology. Through the use of standard IC techniques, the first experimental planar Trapatt diodes have been built at RCA Laborato-

Join 'em... the growing crowd using MOSTEK's 16-pin 4K RAM!

The crowd of MOSTEK's 4K RAM users continues to grow. Why this preference for MOSTEK's 16-pin MK4096 over 22-pin alternates? Let's review a few of the reasons:

MOSTEK saves you memory board space. You can pack over twice the memory in the same board space as the 22-pin designer, without increasing power dissipation. The result is a more compact and efficient system.

MOSTEK leads in 4K performance. Check the comparative performance table for proof!

MOSTEK gives you direct compatibility with TTL, DTL, ECL and CMOS. The MK4096 will interface directly with these popular logic families *without* the special high-voltage clock drivers required by 22-pin RAMs. Fewer address drivers are required also.

COMPARATIVE PERFORMANCE—16-PIN VS 22-PIN RAMs

PARAMETER	MOSTEK	2107	4030
Power Diss.	375 mW	425 mW	690 mW
Input Levels			
Input 0 (Max)	0.8	0.8	0.6
Input I (Min)	2.4	3.0	2.2
Output Levels			
Output 0 (Max)	0.4 at 2 mA	0.45 at 1.8 mA	0.4 at 3.2 mA
Output I (Min)	2.4 at 5 mA	2.4 at 100μA	2.4 at 2 mA
Access Time	300 ns	300 ns	300 ns
Read Cycle Time	425 ns	500 ns	470 ns
Write Cycle Time	425 ns	700 ns	470 ns
Output Data Hold Time	260 ns	40 ns	30 ns
Clock Characteristics	2 TTL Clocks 7 pF	One 12V Clock 21 pF	One 12V Clock 27 pF

MOSTEK's 4K RAM is easy to use. You can use readily available automatic handlers both for incoming test operations and in circuit board assembly. Not so with 22-pin versions!

Want still more reasons to join the MOSTEK 4K RAM team? Then contact MOSTEK at 1215 West Crosby Road, Carrollton, Texas 75006, (214) 242-0444—or your local MOSTEK distributor or representative. In Europe contact MOSTEK GmbH, TALSTR 172, 7024 Bernhausen, West Germany, Tel. (0711) 70 10 96.

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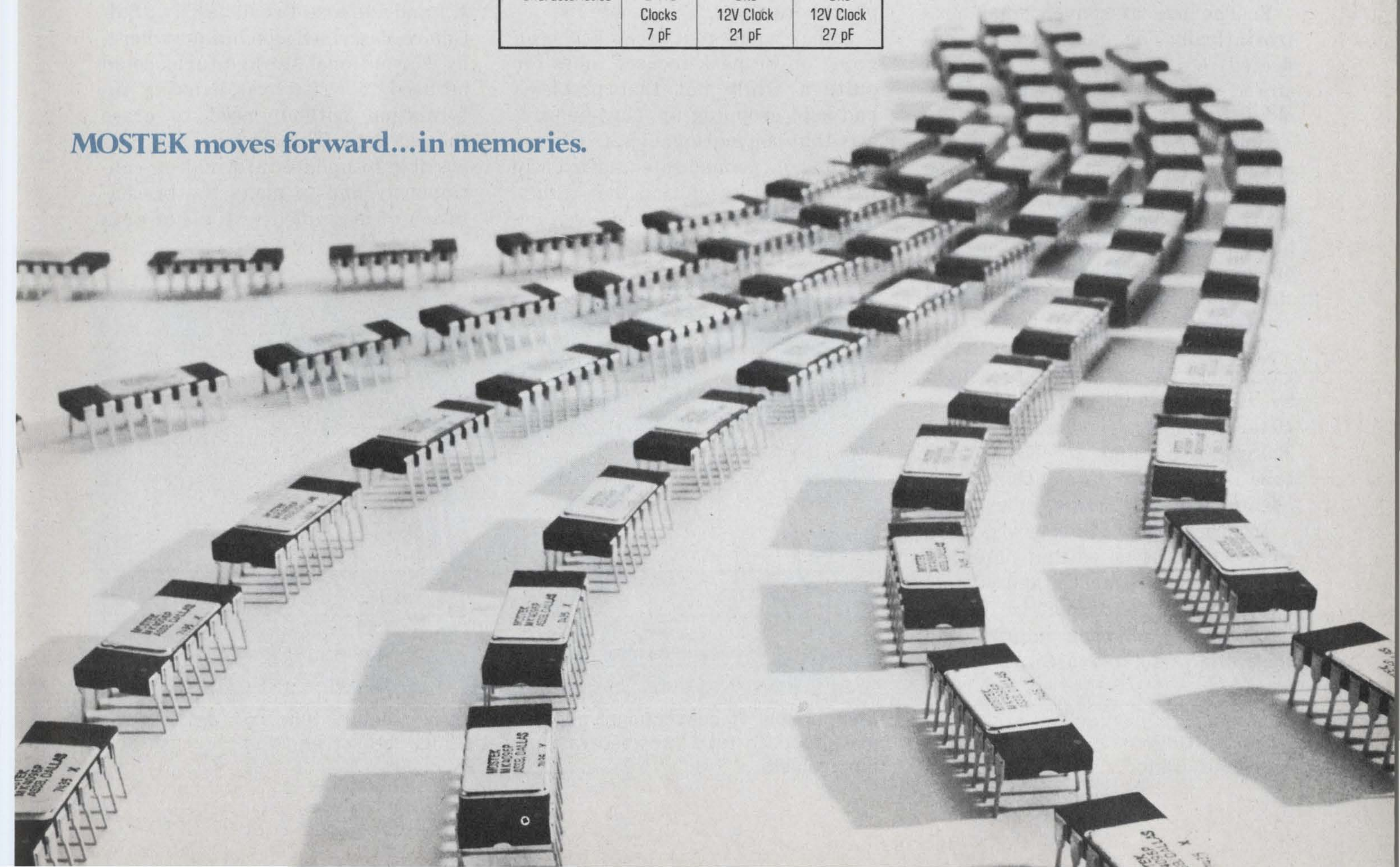


ries, Princeton, NJ.

These planar Trapatts encompass both p and n-type multiple-diode arrays, as well as single diodes. Compared with conventional discrete Trapatts, which employ mesa structures, the new IC versions exhibit several improved characteristics, such as increased ruggedness.

"Diode chips have been run in thermal tests at 500 C for over 800 hours without failure," said Shing-gong Liu, a member of the RCA technical staff. He described the new development in a paper on "Planar Trapatt Diodes."

The new chips' rf performance is also impressive. "A seven-diode array in a compact microstrip circuit has produced a 500-W pulsed-power output at 1.4 GHz with 30% efficiency," Liu said. "And duty cycles of 2% at the 400-W output level have been achieved."

In a p-type seven-diode array (Fig. 2), Trapatts are arranged hexagonally to improve thermal dissipation. These multiple diodes can dissipate higher average power than single diodes of equivalent area. In this respect, according to Liu, the area of the array is equivalent to that of a single diode with less than one-half the array's diameter. ■■

Evolutionary growth helps CRTs keep pace with newer displays

Despite the advance of newer displays, the CRT continues to show vitality. Two significant developments were described at the International Electron Devices Meeting:

1. Fabrication of a new high-performance color picture tube that features a twofold increase in brightness and contrast, 20% smaller beam-spot size and 20 to 30% less deflection power than present tubes.
2. The use of conventional electrostatically or magnetically deflected storage tubes to refresh stored data without need to erase old information.

Solid-state developments unfolded at the meeting included an ac or dc GaP LED array designed as a direct replacement for tungsten-filament lamps and also a silicon-on-sapphire liquid-crystal display that can be used in projection TV systems.

Information on the new cathode-ray color TV tube was presented by Hiromi Kanai, an engineer at Hitachi's Electron Tube Div. in Tokyo. According to Kanai, the tube is a natural development from earlier work in picture tubes.

In describing earlier efforts with color CRTs, he noted that phosphor efficiency, screen voltage, panel transparency and matrix transparency had all been improved to their limits to increase brightness and contrast. The screen's current density was the only parameter that had not been improved.

The new tube increases screen current density with a technique known as mask focusing. Unlike other CRTs, the mask-focused tube has a potential difference between the mask and the screen that creates converging fields for the electron beam. The electrons that pass through the shadow mask are thus condensed onto the screen phosphors.

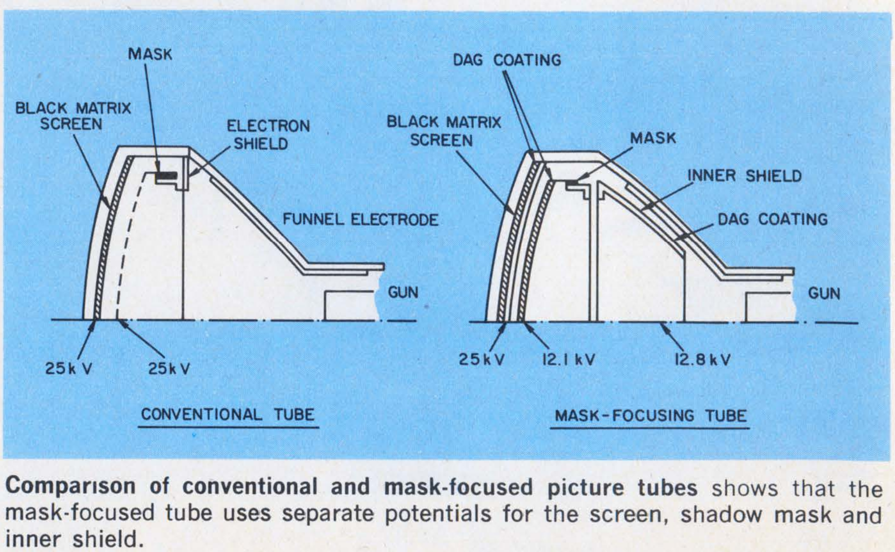
Kanai noted that work had been going on in mask-focused tubes for quite a while but that problems had kept cropping up. One, he said, was that conventional electron guns could not compensate sufficiently for the poor resolution that resulted from the lower anode voltage used with this technique.

To solve that problem, Kanai explained, a new multistage focusing gun was developed. The main lens system consists of two lenses instead of one. The resulting spot size is smaller, and increased resolution results.

Continuous updating of data

In the second major CRT development, Igor Limansky, an engineer for Westinghouse Electric's Industry and Defense Products Div., Baltimore, described a technique whereby conventional storage tubes could be used to write over existing information without need to erase the old data. This means that it is possible to update information continuously and to make the presentation of magnified sections of data easy.

Jules H. Gilder
Associate Editor



Comparison of conventional and mask-focused picture tubes shows that the mask-focused tube uses separate potentials for the screen, shadow mask and inner shield.

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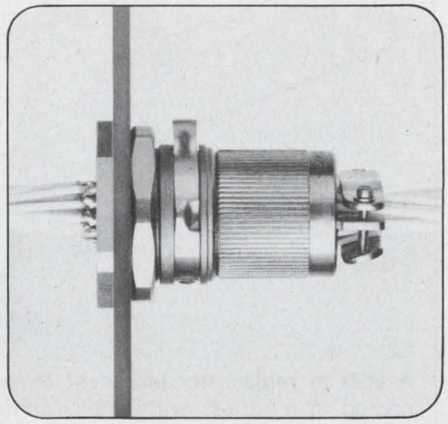

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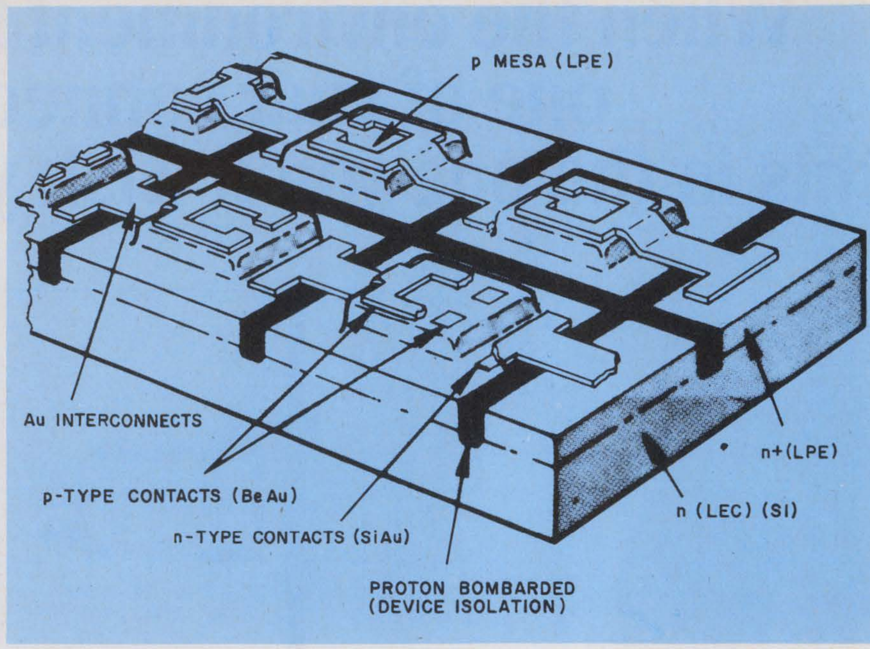

A LED to replace incandescent lamps is made when several devices are connected in a series, anti-parallel configuration. This reduces the power wasted in a series resistor and makes both ac and dc operation possible.

The new technique is known as equilibrium writing.

In the usual storage-tube system, writing is done by a high-voltage writing beam that charges the dielectric surface negatively. The cathode voltage is held constant, and the writing beam is intensity-modulated. Before a new signal can be written, the old one must be erased in a separate operation.

With equilibrium writing, however, Limansky reported, a lower voltage beam is used, so that as the writing-gun cathode is modulated by the signal, the secondary emission ratio is also modulated. The writing-beam current is kept constant. Instead of using −1500 V to write information, the same tube can be used with −25 to −100 V.

LEDs and liquid crystals progress

LEDs, the meeting was told, are finding considerable use in applications that formerly would have been handled by incandescents, but they have generally not replaced them in existing equipment. The main reason for this is that a large voltage drop often is necessary across a series resistor to interface a 1.9-V LED to the higher voltages generally used to power incandescents.

To overcome this problem, S. M. Spitzer, of Bell Laboratories in Murray Hill, NJ, has designed a multijunction GaP LED array chip. He noted that his new illuminator consisted of several LED devices in series, so that most of the applied power drives the LEDs and is not lost in a dropping resistor.

The unit contains two rows of LEDs connected in an antiparallel configuration so it can be used on either ac or dc circuits.

2 new technologies combined

By combining two relatively new technologies—liquid crystals and silicon-on-sapphire—engineers at Hughes Aircraft Co., Carlsbad, CA, have come up with a real-time 100-by-100-element TV display. According to M. A. Meyer, the 1 × 1-in.-square device uses a PMOS silicon-gate process to make the one-transistor, one-capacitor cell matrix, which controls and stores video information at each spot of the display.

Explaining why SOS technology was used, Meyer said that it prevented crosstalk by providing good isolation; that it required simple processing; that it had small address-line overlap areas, which reduce pinhole sensitivity, and that through its transparent substrate, it permitted the use of backlighted liquid-crystal displays. ■■

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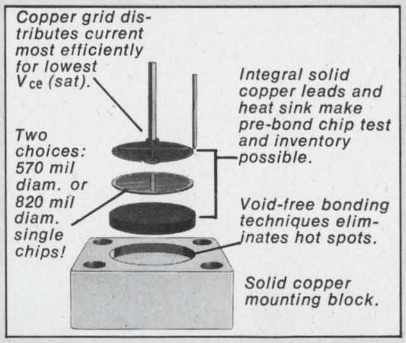
*Voltage ratings to 400 V available.



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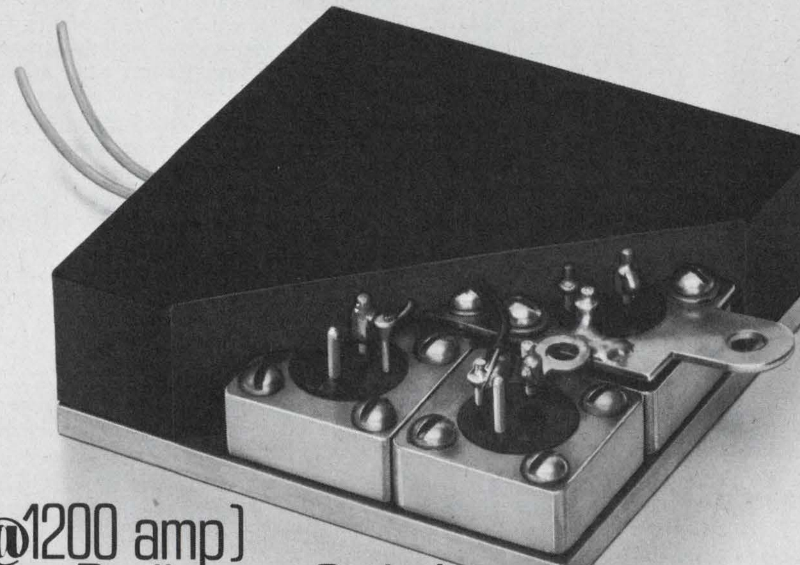

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washington report

Contractors' R&D posing new controversy

Much like a broken record, defense contractors are hearing another assault on the concept of independent research and development as an allowable cost in Government contracts. The General Accounting Office's latest bombshell is an opinion that the Government should have access to the commercial records of contractors to verify whether technical effort is an allowable cost. The Dept. of Defense recognizes independent R&D as a necessary business expense and shares in its cost. This is in anticipation that the R&D will foster technical capabilities that are beneficial to national defense, but the defense agency hasn't insisted on examining company records that pertain to commercial activities.

The GAO, after reviewing a contract with Pratt & Whitney for JT9D jet engines for the Navy, questions the development costs charged to the Government and makes two recommendations that could have a far-reaching impact on defense contractors, if the Defense Dept. goes along. The GAO says the Secretary of Defense should provide specific guidance to review teams and the Defense Contract Audit Agency to ensure that technical effort allowed as independent R&D is not sponsored by, or required in the performance of, commercial contracts. Secondly, the agency has urged the Defense Dept. to "expedite action under consideration to require that independent R&D agreements specifically authorize access to contractors' commercial records" to determine whether the costs are allowable.

AIA sees aerospace decline continuing

Although total sales in the aerospace industry in 1975 are expected to show a dollar increase, constant dollar figures indicate the three-year downturn in the industry will continue. That's the prediction from Karl G. Harr Jr., president of the Aerospace Industries Association, who estimates sales for 1974 at $27-billion, an increase of $2-billion over 1973. For 1975, the estimate is for $29-billion, with the Dept. of Defense still the biggest customer and growing in terms of current dollars. But in constant dollars (1968), there will be a 7 per cent decline this year, Harr says.

Regarding NASA and other government agencies, Harr sees a constant-dollar decline in excess of 12 per cent—and possibly a slight decline in commercial aerospace sales. Employment in the industry, according to the prediction, will drop from 968,000 workers at the end of 1974 to around 959,000 this year.

About the only bright spot Harr sees is in exports. He pegs exports at $6.8-billion for 1974, more than double the 1970 level. For 1975, the prediction is for an increase of 10 per cent more in current dollars to \$7.5-billion. Imports are expected to decline 20 per cent in 1975—to \$650-million—from the \$812-million in 1974.

U.S. role in maritime satellite system weighed

It's a good bet that if the United States joins in the development and operation of an international maritime satellite system that the participant will be a private U.S. company. Prior to an international conference in London from April 23 to May 9, the Federal Communications Commission is asking for opinions from the private sector on the American position. Among the evaluations being sought is an estimate of the willingness of maritime communications carriers to invest in an international system.

The FCC has indicated that it's going to recommend that the U.S. participant be a private concern, but it has raised a lot of unanswered questions, such as the role to be played by Marisat. This is the Maritime Mobile Satellite Communications System, scheduled to go into service in the Atlantic and Pacific this summer. The Navy is slated to use about 80% of the system's capacity, with the remainder available to commercial maritime users.

Congress to overhaul science programs

Look for a determined effort by the 94th Congress to overhaul the structure of Federal science and technology programs this year. High on the list will be the restoration of an Office of Science and Technology in the White House to give the President a full-time adviser.

The Senate passed a bill to do this in mid-October, but the measure got caught in a legislative logjam in the House. Sen. Edward Kennedy (D-MA) and other sponsors will reintroduce it early this session. Similar legislation will emerge from the new House Committee on Science and Technology. This is a new name for the old Science and Astronautics Committee, a result of House reforms that realigned committees. Under the new setup the committee will have jurisdiction over civil-aviation R&D (from the Commerce Committee), environmental R&D (from several committees) and all energy R&D except nuclear.

Capital Capsules: Among its closing efforts for 1974, **Congress passed a bill to change the name of the Patent Office.** In the future it will be the Patent and Trademark Office. . . . Electrical and electronic applications annually consume about 125 tons of gold, and while there are efforts to find substitutes or more efficient use of gold, **the experts believe that demand by the electronics industry will be little affected in the near term by rising gold prices.** The industry, after jewelry, is the second largest consumer of the metal. . . . The Air Force is **contemplating procuring a phased-array radar system** known as PAVE PAWS. Two sites will be involved, each consisting of a dual-faced, phased-array radar capable of detecting a submarine-launched ballistic missile attack on the Continental U.S. and to provide warning and assessment data to NORAD and SAC. . . . Aerospace Corp., under contract to the Law Enforcement Assistance Administration, is **developing a Citizen Alarm System, with which an individual can summon police assistance.** The system will consist of three components: a digitally coded on-person actuator, such as a wristwatch; a location coded receiver relay unit, and a central station. Initial production of the actuators hasn't been defined, but an estimated 5000 to 10,000 will likely be in the first batch.

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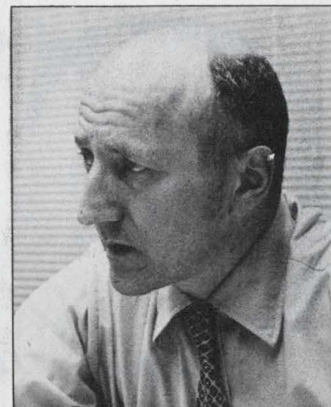
INFORMATION RETRIEVAL NUMBER 30

editorial

Service with a smile



I forget which novelist wrote that service was what he took his father's cow to the neighbor's bull for. I was reminded of such service during my recent stay at the Dukes Hotel in London, an institution that takes pride in "an atmosphere of quiet comfort and gracious living" and a "Staff who are only too happy to attend to your slightest wants."

Well, perhaps my wants weren't slight enough, but on my first morning, a Saturday, I complained that my shower sprayed water in all directions but mine. And since the shower curtain was about a foot too narrow, the bathroom floor got more water than I did. As you might expect, I was courteously informed that the matter would be looked into.

On Sunday, when I complained again, the man at the desk, somewhat chilly now, told me that something had indeed been done; the housekeeper had been informed. And on Monday I learned that the housekeeper had, in fact, looked into the matter. I was also told, somewhat indignantly, that nobody had ever complained about the shower before and, of course, nothing could be done about the curtain since the Dukes had only one width.

When I finally got a new shower head, on Tuesday, I began to feel guilty about making a fuss. Perhaps I had been too demanding. Perhaps I was too rigid. A creature of habit, I had assumed that I should perform my ablutions while standing in the tub; I could easily have received more water by stepping out to the bathroom floor.

Not wishing to fuss further, I simply decided that the Dukes was not my favorite London hotel and that its being "only too happy to attend to your slightest wants" did not apply to weekends.

Then I began to wonder if, in the electronics business, we give our customers any better service. We respond to customer complaints with, "Oh, we'll certainly look into that," then forget the matter and hope the customer will. We answer customer complaints at our convenience, rather than theirs. Or we put down our customers with: "Oh, it's always that way."

We'll do a lot better if we look at service in a different way. It's not a sales gimmick to win customers or to pamper them. We should see it as an intrinsic ingredient in our product. We should see it, too, as a mechanism for customers to teach us how to be better designers.

George Rostky

GEORGE ROSTKY
Editor-in-Chief

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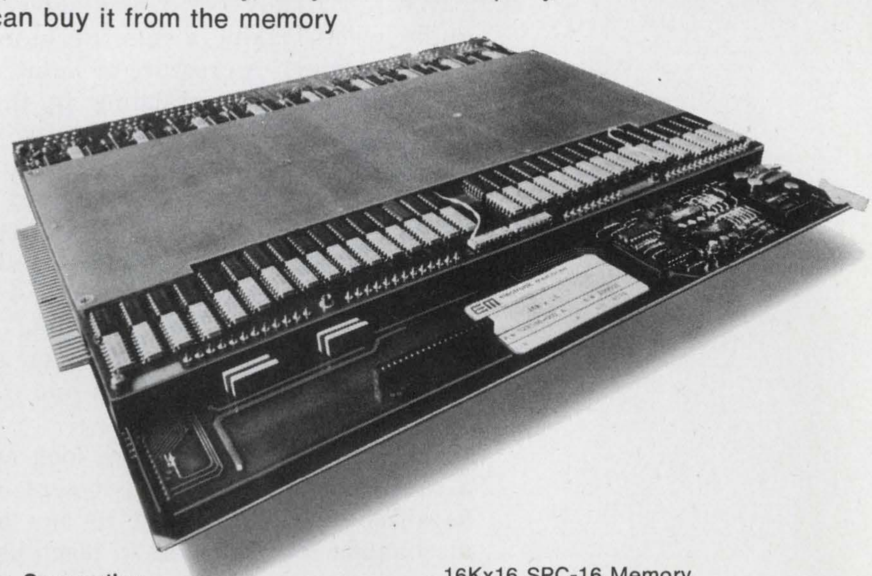

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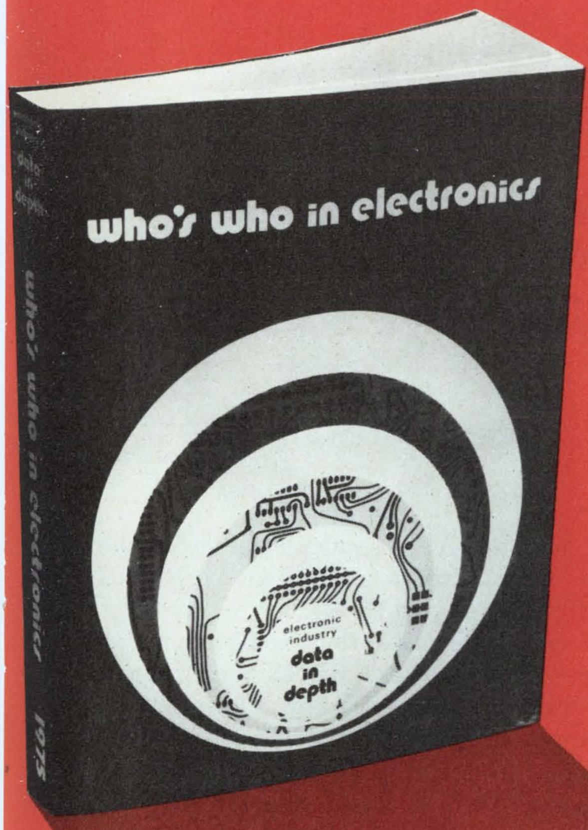

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Reverse-Polish or algebraic entry —which is best? Calculator manufacturers make similar claims for each, but an objective study reveals a winner.

Most modern calculators use either a variant of an algebraic-entry system (AES) or reverse-Polish notation (RPN). "Polish" is easier to pronounce than the name of the notation's inventor, the Polish logician Jan Lukasiewicz.

According to calculator manufacturers, each system is easier to learn, remember and use. But in an objective evaluation, based upon algorithms for all the basic arithmetic operations (+, −, ×, ÷) with four variables, RPN gets the best score (Table 1).

However, though RPN uses fewer keystrokes on the average, which system is easier to use remains a subjective decision. For the author, again RPN won. He made fewer mistakes with RPN, and selected it for his personal use.

Calculators in action

Simple AES calculators have two working registers and perform each operation when the next operation is keyed in. Complex expressions sometimes need to be rewritten to work with this system. For example,

$$a + bc/d - e$$

can be done on a simple AES calculator by rearrangement of the sequence as follows:

$$b \boxed{\times} c \boxed{\div} d \boxed{+} a \boxed{-} e \boxed{=} .$$

Note that $\boxed{=}$ is always needed at the end to denote the last operation.

Another AES method, referred to as AESH, has three working registers and an operational hierarchy so that × and ÷ are done before + and −. People familiar with Fortran or Basic will feel comfortable with this system, which is very similar to ordinary algebra without parentheses. More elaborate AES schemes have parentheses, too.

With AESH, a one-line arithmetic expression without parentheses can be directly keyed in as it stands:

$$a \boxed{+} b \boxed{\times} c \boxed{\div} d \boxed{-} e \boxed{=} .$$

In this problem, the AESH calculator saves the "a" and $\boxed{+}$ and automatically performs this operation after the $\boxed{\times}$ and $\boxed{\div}$.

The RPN calculator uses four working registers in a push-down stack. RPN is characterized by an enter ($\boxed{\uparrow}$), or save key. The numbers are first entered into the push-down stack, then the operation to be performed is pressed, and the answer appears on the stack in place of the operands. Most adding machines use a crude form of RPN: You first key in the number and then the operation. Anyone familiar with such adding machines will feel at home with this system.

The preceding problem done in RPN is

$$a \boxed{\uparrow} b \boxed{\uparrow} c \boxed{\times} d \boxed{\div} \boxed{+} e \boxed{-} .$$

Note that the straightforward RPN algorithm for this problem requires one keystroke more than the AES or AESH algorithms. Also the sequence is not very obvious but must be learned. An alternative RPN sequence is

$$b \boxed{\uparrow} c \boxed{\times} d \boxed{\div} a \boxed{+} e \boxed{-} ,$$

which uses the same number of keystrokes as AES or AESH.

Weighing the methods

Table 1 contains a systematic listing of the shortest algorithms to perform all possible basic arithmetic operational combinations with four variables. To simplify the notation, $\boxed{\pm}$ is used for either $\boxed{+}$ or $\boxed{-}$, $\boxed{*}$ (multiply or divide) for either $\boxed{\times}$ or $\boxed{\div}$ and $\boxed{\cdot}$ for any of these four operations. The problems are categorized to shorten the table whenever this can be done without an advantage being conferred on one of the systems. Some categories allow the use of the $\boxed{\cdot}$ notation to shorten the table further. However, this class of calculation is given zero weighting and thus does not affect the final result.

A number entry and its operator are counted

John A. Ball, Radio Astronomer, Center for Astrophysics, Harvard College and Smithsonian Astrophysical Observatories, Cambridge, MA 02138.

Table 1. Study compares two algebraic systems, AES and AESH, and reverse Polish, RPN

	AES		AESH		RPN		
Case	Algorithm	#Ks	Algorithm	#Ks	Algorithm	#Ks	Weight
a•b	a[•]b[=]	2	a[•]b[=]	2	a[↑]b[•]	2	4
a±b±c	a[±]b[±]c[=]	3	a[±]b[±]c[=]	3	a[↑]b[±]c[±]	3	8
a*b*c	a[*]b[*]c[=]	3	a[*]b[*]c[=]	3	a[↑]b[*]c[*]	3	8
(a•b)•c	a[•]b[•]c[=]	3	a[•]b[=] [•]c[=]	4	a[↑]b[•]c[•]	3	(0)
(a±b)*c	a[±]b[*]c[=]	3	a[±]b[=] [*]c[=]	4	a[↑]b[±]c[*]	3	4
(a*b)±c	a[*]b[±]c[=]	3	a[*]b[±]c[=]	3	a[↑]b[*]c[±]	3	4
a•(b•c)	b[•]c[=] [STO]a[•] [RCL] [=]	6	b[•]c[=] [STO]a[•] [RCL] [=]	6	a[↑]b[↑]c[•] [•]	4	(0)
a+(b*c)	b[*]c[+]a[=]	3	a[+]b[*]c[=]	3	b[↑]c[*]a[+]	3	2
a−(b*c)	b[*]c[+/−] [+]a[=]	4	a[−]b[*]c[=]	3	a[↑]b[↑]c[*] [−]	4	2
a×(b±c)	b[±]c[×]a[=]	3	b[±]c[=] [×]a[=]	4	b[↑]c[±]a[×]	3	2
a÷(b±c)	b[±]c[=] [1/x] [×]a[=]	5	b[±]c[=] [1/x] [×]a[=]	5	a[↑]b[↑]c[±] [÷]	4	2
a±b±c±d	a[±]b[±]c[±]d[=]	4	a[±]b[±]c[±]d[=]	4	a[↑]b[±]c[±]d[±]	4	40
a*b*c*d	a[*]b[*]c[*]d[=]	4	a[*]b[*]c[*]d[=]	4	a[↑]b[*]c[*]d[*]	4	40
(a•b)•(c•d)	c[•]d[=] [STO] a[•]b[•] [RCL] [=]	7	c[•]d[=] [STO] a[•]b[•] [RCL] [=]	7	a[↑]b[•]c[↑]d[•] [•]	5	(0)
(a±b)*c*d	a[±]b[*]c[*]d[=]	4	a[±]b[=] [*]c[*]d[=]	5	a[↑]b[±]c[*]d[*]	4	16
(a*b)±(c*d)	c[*]d[=] [STO]a[*]b[±] [RCL] [=]	7	a[*]b[±]c[*]d[=]	4	a[↑]b[*]c[↑]d[*] [±]	5	8
a*b×(c±d)	c[±]d[×]a[*]b[=]	4	c[±]d[=] [×]a[*]b[=]	5	c[↑]d[±]a[×]b[*]	4	8
a*b÷(c±d)	c[±]d[=] [1/x] [×]a[*]b[=]	6	c[±]d[=] [1/x] [×]a[*]b[=]	6	a[↑]b[*]c[↑]d[±] [÷]	5	8
(a*b)±c±d	a[*]b[±]c[±]d[=]	4	a[*]b[±]c[±]d[=]	4	a[↑]b[*]c[±]d[±]	4	16
(a±b)*(c±d)	c[±]d[=] [STO] a[±]b[*] [RCL] [=]	7	c[±]d[=] [STO] a[±]b[=] [*] [RCL] [=]	8	a[↑]b[±]c[↑]d[±] [*]	5	8
a±b+(c*d)	c[*]d[+]a[±]b[=]	4	a[±]b[+]c[*]d[=]	4	c[↑]d[*]a[+]b[±]	4	8
a±b−(c*d)	c[*]d[+/−] [+]a[±]b[=]	5	a[±]b[−]c[*]d[=]	4	a[↑]b[±]c[↑]d[*] [−]	5	8
a•(b•(c•d))	c[•]d[=] [STO]b[•] [RCL] [=] [STO]a[•] [RCL] [=]	10	c[•]d[=] [STO]b[•] [RCL] [=] [STO]a[•] [RCL] [=]	10	a[↑]b[↑]c[↑]d[•] [•] [•]	6	(0)
a×(b+(c*d))	c[*]d[+]b[×]a[=]	4	b[+]c[*]d[=] [×]a[=]	5	c[↑]d[*]b[+]a[×]	4	2
a÷(b+(c*d))	c[*]d[+]b[=] [1/x] [×]a[=]	6	b[+]c[*]d[=] [1/x] [×]a[=]	6	a[↑]c[↑]d[*]b[+] [÷]	5	2
a×(b−(c*d))	c[*]d[+/−] [+]b[×]a[=]	5	b[−]c[*]d[=] [×]a[=]	5	b[↑]c[↑]d[*] [−]a[×]	5	2
a÷(b−(c*d))	c[*]d[+/−] [+]b[=] [1/x] [×]a[=]	7	b[−]c[*]d[=] [1/x] [×]a[=]	6	a[↑]b[↑]c[↑]d[*] [−] [÷]	6	2
a+(b*c*d)	b[*]c[*]d[+]a[=]	4	a[+]b[*]c[*]d[=]	4	b[↑]c[*]d[*]a[+]	4	8
a−(b*c*d)	b[*]c[*]d[+/−] [+]a[=]	5	a[−]b[*]c[*]d[=]	4	a[↑]b[↑]c[*]d[*] [−]	5	8
a*b*(c±d)	Previously done						
a×(b±c±d)	b[±]c[±]d[×]a[=]	4	b[±]c[±]d[=] [×]a[=]	5	b[↑]c[±]d[±]a[×]	4	8
a÷(b±c±d)	b[±]c[±]d[=] [1/x] [×]a[=]	6	b[±]c[±]d[=] [1/x] [×]a[=]	6	a[↑]b[↑]c[±]d[±] [÷]	5	8
a+(b×(c±d))	c[±]d[×]b[+]a[=]	4	c[±]d[=] [×]b[+]a[=]	5	c[↑]d[±]b[×]a[+]	4	2
a−(b×(c±d))	c[±]d[×]b[+/−] [+]a[=]	5	c[±]d[=] [×]b[+/−] [+]a[=]	6	a[↑]c[↑]d[±]b[×] [−]	5	2
a+(b÷(c±d))	c[±]d[=] [1/x] [×]b[+]a[=]	6	c[±]d[=] [1/x] [×]b[+]a[=]	6	b[↑]c[↑]d[±] [÷]a[+]	5	2
a−(b÷(c±d))	c[±]d[=] [1/x] [×]b[+/−] [+]a[=]	7	c[±]d[=] [1/x] [×]b[+/−] [+]a[=]	7	a[↑]b[↑]c[↑]d[±] [÷] [−]	6	2
a±b±(c*d)	Previously done						
((a•b)•c)•d	a[•]b[•]c[•]d[=]	4	a[•]b[=] [•]c[=] [•]d[=]	6	a[↑]b[•]c[•]d[•]	4	(0)
(a±b)*c*d	Previously done						
((a*b)±c)*d	a[*]b[±]c[*]d[=]	4	a[*]b[±]c[=] [*]d[=]	5	a[↑]b[*]c[±]d[*]	4	8
(a*b*c)±d	a[*]b[*]c[±]d[=]	4	a[*]b[*]c[±]d[=]	4	a[↑]b[*]c[*]d[±]	4	16
(a*b)±c±d	Previously done						
((a±b)*c)±d	a[±]b[*]c[±]d[=]	4	a[±]b[=] [*]c[±]d[=]	5	a[↑]b[±]c[*]d[±]	4	8
(a±b±c)*d	a[±]b[±]c[*]d[=]	4	a[±]b[±]c[=] [*]d[=]	5	a[↑]b[±]c[±]d[*]	4	16
a•((b•c)•d)	b[•]c[•]d[=] [STO]a[•] [RCL] [=]	7	b[•]c[=] [•]d[=] [STO] a[•] [RCL] [=]	8	a[↑]b[↑]c[•]d[•] [•]	5	(0)
a±(b*c*d)	Previously done						
a×((b±c)*d)	b[±]c[*]d[×]a[=]	4	b[±]c[=] [*]d[×]a[=]	5	b[↑]c[±]d[*]a[×]	4	4
a÷((b±c)*d)	b[±]c[*]d[=] [1/x] [×]a[=]	6	b[±]c[=] [*]d[=] [1/x] [×]a[=]	7	a[↑]b[↑]c[±]d[×] [÷]	5	4
a×((b*c)±d)	b[*]c[±]d[×]a[=]	4	b[*]c[±]d[=] [×]a[=]	5	b[↑]c[*]d[±]a[×]	4	4
a÷((b*c)±d)	b[*]c[±]d[=] [1/x] [×]a[=]	6	b[*]c[±]d[=] [1/x] [×]a[=]	6	a[↑]b[↑]c[*]d[±] [÷]	5	4
a*(b±c±d)	Previously done						
a+((b*c)±d)	b[*]c[±]d[+]a[=]	4	b[*]c[±]d[+]a[=]	4	b[↑]c[*]d[±]a[+]	4	4
a−((b*c)±d)	b[*]c[±]d[=] [+/−] [+]a[=]	6	b[*]c[±]d[=] [+/−] [+]a[=]	6	a[↑]b[↑]c[*]d[±] [−]	5	4
a+((b±c)*d)	b[±]c[*]d[+]a[=]	4	b[±]c[=] [*]d[+]a[=]	5	b[↑]c[±]d[*]a[+]	4	4
a−((b±c)*d)	b[±]c[*]d[+/−] [+]a[=]	5	b[±]c[=] [*]d[+/−] [+]a[=]	6	a[↑]b[↑]c[±]d[*] [−]	5	4
(a•(b•c))•d	b[•]c[=] [STO] a[•] [RCL] [•]d[=]	7	b[•]c[=] [STO] a[•] [RCL] [=] [•]d[=]	8	a[↑]b[↑]c[•] [•]d[•]	5	(0)
(a+(b*c))*d	b[*]c[+]a[*]d[=]	4	a[+]b[*]c[=] [*]d[=]	5	b[↑]c[*]a[+]d[*]	4	4
(a−(b*c))*d	b[*]c[+/−] [+]a[*]d[=]	5	a[−]b[*]c[=] [*]d[=]	5	a[↑]b[↑]c[*] [−]d[*]	5	4
(a×(b±c))*d	b[±]c[×]a[*]d[=]	4	b[±]c[=] [×]a[*]d[=]	5	b[↑]c[±]a[×]d[*]	4	4
(a÷(b±c))*d	b[±]c[=] [1/x] [×]a[*]d[=]	6	b[±]c[=] [1/x] [×]a[*]d[=]	6	a[↑]b[↑]c[±] [÷]d[*]	5	4
(a*b*c)±d	Previously done						
(a×(b±c))±d	b[±]c[×]a[±]d[=]	4	b[±]c[=] [×]a[±]d[=]	5	b[↑]c[±]a[×]d[±]	4	4
(a÷(b±c))±d	b[±]c[=] [1/x] [×]a[±]d[=]	6	b[±]c[=] [1/x] [×]a[±]d[=]	6	a[↑]b[↑]c[±] [÷]d[±]	5	4
a+(b*c)±d	b[*]c[+]a[±]d[=]	4	a[+]b[*]c[±]d[=]	4	b[↑]c[*]a[+]d[±]	4	4
a−(b*c)±d	b[*]c[+/−] [+]a[±]d[=]	5	a[−]b[*]c[±]d[=]	4	a[↑]b[↑]c[*]d[±] [−]	5	4
(a±b±c)*d	Previously done						

as one keystroke, and the total needed is noted for each system. Also each category has an associated weight that approximates the frequency of occurrence of such problems. Other scoring methods are possible, but the outcome would probably be the same.

Table 2 contains summary information from Table 1. Clearly, RPN requires fewer keystrokes for this type of problem.

RPN is the winner?

The problems considered here form only a small subset of all the arithmetic problems that can be encountered in engineering. Thus it is difficult to be certain that RPN wins for more complex problems, but it is reasonable to expect that

Table 2. Comparative weighted scores

Sums of number of wins × weights from Table 1

RPN vs AESH:	RPN 156	AESH 30	Ties 170
RPN vs AES:	RPN 62	AES 0	Ties 294
AES vs AESH:	AES 116	AESH 32	Ties 208

Sum of keystrokes × weights

AES:	1562
AESH:	1630
RPN:	1484

RPN does. As additional evidence in favor of RPN, note that AES and AESH calculators must use their $\boxed{\text{STO}}$ register for even some simple problems in Table 1. Then the register is not available for more complex problems. Monadic functions, such as sines and logs, are omitted because AES and AESH calculators, in fact, use RPN for such operations. ■■

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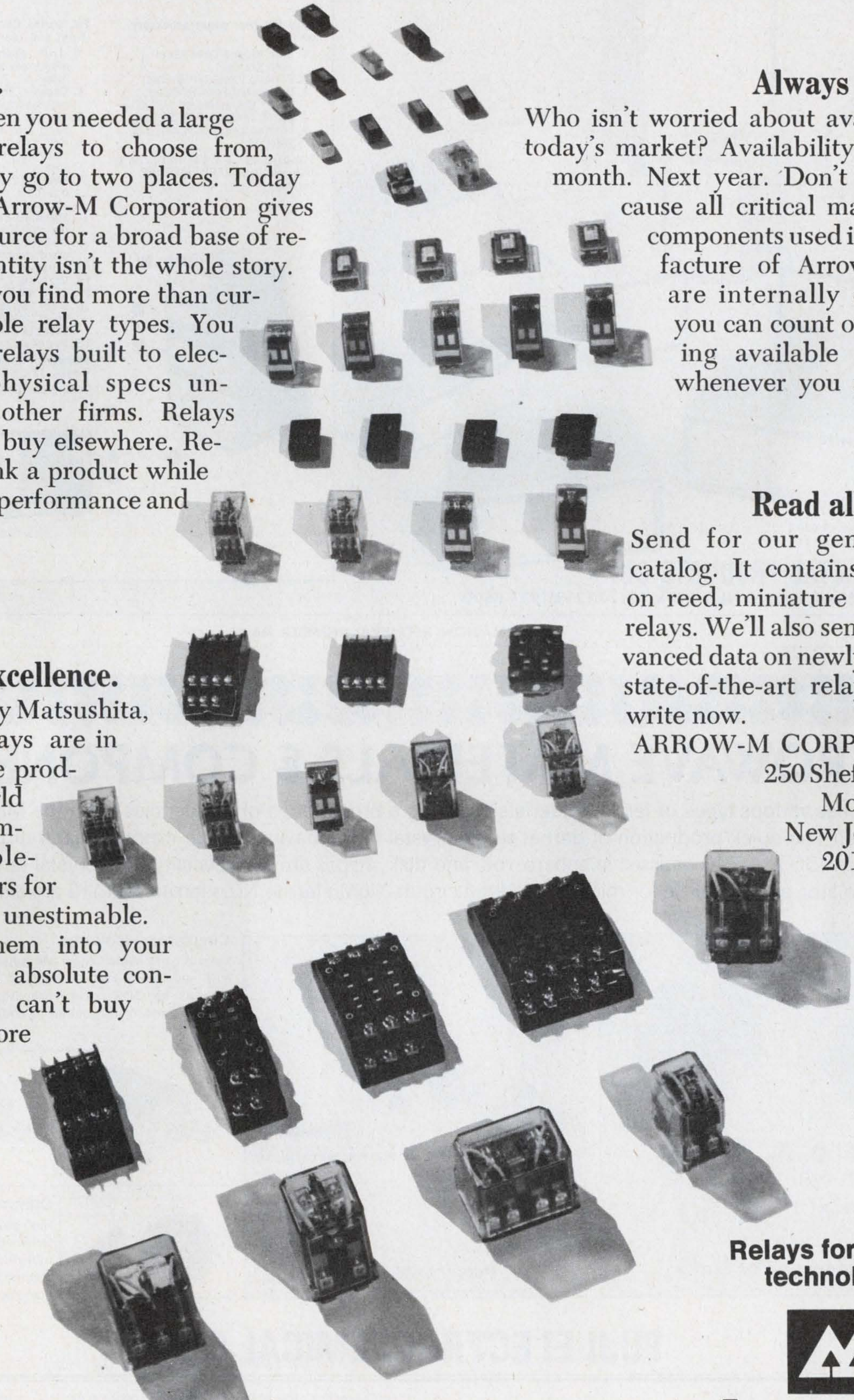

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INFORMATION RETRIEVAL NUMBER 35

INFORMATION RETRIEVAL NUMBER 36

INFORMATION RETRIEVAL NUMBER 37

IR's new glass passivated, high voltage Power Transistors and Darlingtons...

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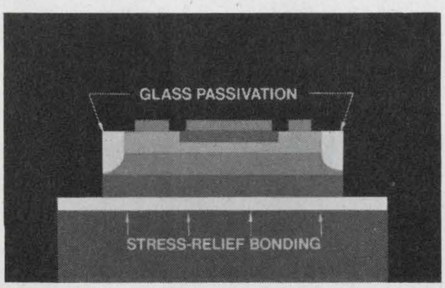
The three other largest selling high voltage power transistor lines of today offer you good characteristics. But while a specific device may excel in specs for one parameter, it may be marginal in other equally important characteristics. Not so with IR's new high voltage power transistors. They easily meet or exceed all established specifications. Now you can design a better, more efficient circuit without compromising.

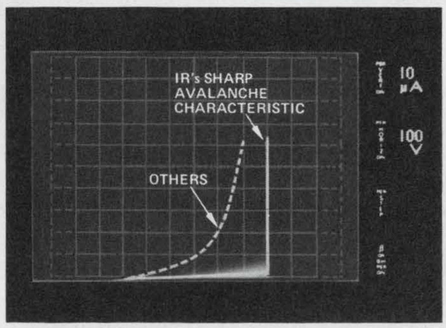
✱ High Voltage and High Gain in the same transistor.

Most others offer you either high voltage or high gain. They can't give you both in the same device. We can. For example: rated to $700V_{CBO}$ with an I_C from 7 to 10 Amps (pulse), we provide a gain of 30 - 90 at 1 Amp.



✱ Glass Passivation for longer life, better stability.

IR triple-diffused, NPN mesa structure, high voltage power transistors have glass passivated junctions. You'll get longer life and a stability unequalled by the other brands. The avalanche curve



pictured shows our "sharp" curve and the "soft" curve of the others. Convincing evidence of better junctions that you can operate at full rated specs without a worry.

✱ Lower Saturation Voltage for better efficiency.

IR saturation voltage is lower than the others. Higher efficiency, less power loss, reduced power consumption and system operation at lower power levels are your new advantages. And you won't have to sacrifice switching speeds or voltage capability.

✱ "Stress-Relief" Bonding for better resistance to temperature cycling.

IR's "Stress-Relief" bonding between the chip and mounting surface gives better protection from thermal cycling, gives you an extra margin of safety in thermal design considerations, with a broad safe-area that is more than adequate for any application.

Competitively Priced and Cross-Referenced to the 3 major lines.

IR high voltage power transistors are available in 12 models rated from 300 to $700V_{CBO}$ with an I_C from 7 to 10 Amps (pulse). Monolithic Darlingtons in 15 models are rated to $600V_{CBO}$ with an I_C from 15 to 25 Amps (pulse). All are in the standard TO-3 package.

Find IR's equivalent to the devices you're now using, then ask your local IR salesman, Rep or Distributor for complete specs and a test evaluation sample. When you've put it to the test, we think you'll agree. It's better – everywhere that counts.

IR P/N	Delco P/N	RCA P/N	Motorola P/N
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IR402	DTS 402 2N3902		MJ3028 MJ3030 2N3788 2N3902
IR403	DTS 403		
IR409	DTS 409		
IR410	DTS 410	RCA410	MJ410
IR411	DTS 411	RCA411 2N5838 2N5839	MJ411 MJ1800 MJ3029 MJ3430
IR413	DTS 413	RCA413 2N5840	MJ413
IR423	DTS 423	RCA423	MJ423
IR424	DTS 424		MJ424
IR425	DTS 425		MJ425
IR430	DTS 430	2N5239 2N5240	MJ430
IR431	DTS 431	RCA431 2N5240	MJ431 2N5241
Monolithic Power Darlingtons			
IR4040	DTS 4040	Ask for data on IR's 11 additional types.	
IR4045	DTS 4045		
IR4060	DTS 4060		
IR4065	DTS 4065		

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INFORMATION RETRIEVAL NUMBER 38

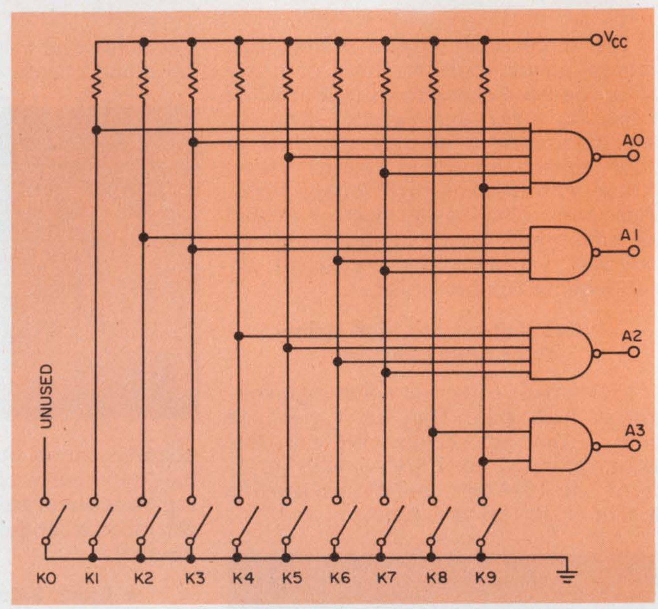
Need a small keyboard? Obtain binary-coded output from a low-cost sequential-scanning circuit that can be easily expanded from 10 to 64 keys.

To use a full ASCII encoder for a small keyboard is expensive overkill. Instead, you can "roll your own" low-cost designs with 10 to 64 keys that provide binary-code outputs for TTL digital systems.

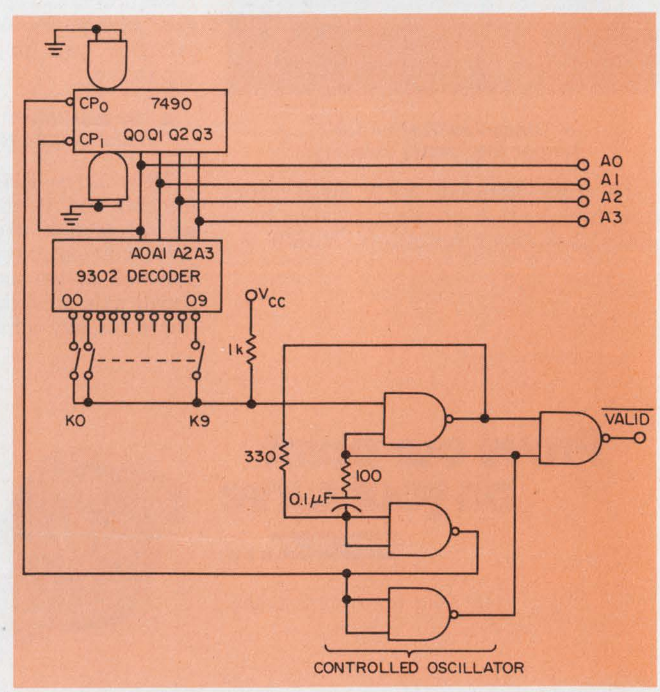
But the simplest, obvious approach to keyboard encoding (Fig. 1) won't work well because:

- It does not distinguish between the "all-keys-up" and "key-zero-down" condition.
- It generates erroneous output codes if more than one key is depressed.
- It is difficult to eliminate the effects of switch bounce.
- It requires many input pull-up resistors.
- Its parts count becomes prohibitive when used for more than 16 contacts.

Use of a 9302 decoder IC in a sequential scanning circuit can solve most of these problems. Though the response time increases to milliseconds, this speed is more than adequate for keyboards, which usually handle less than 10 inputs a second. In addition to the decoder, a 7490 decade counter and a controlled oscillator are needed (Fig. 2). When all keys are up, the oscillator runs free at about 1 kHz. The counter sequences in modulo 10 and activates, one after the other, the open-collector outputs of the 9302, a 1-of-10 decoder. The 10 key contacts are connected to the decoder outputs, and the common of the key-switches is pulled to V_{CC} through a 1-kΩ resistor. Every time the counter number corresponds to the selected key, the common is pulled to ground. This causes the oscillator to stop and provide LOW level on the clock input to the 7490 decade counter.



1. **The most obvious approach to a keyboard-circuit design** doesn't work very well, and in addition, the circuit requires a large number of parts.

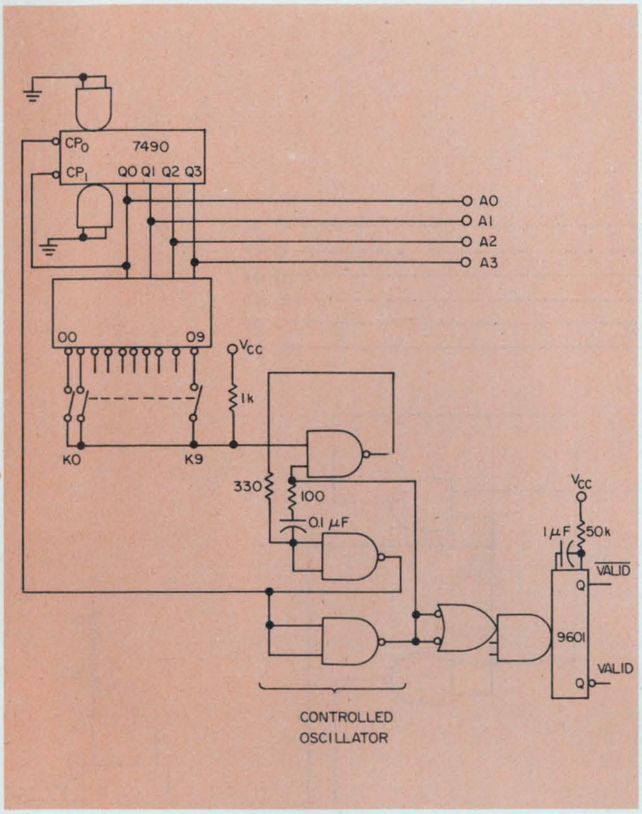


2. **A sequential-scanning circuit** has a low parts count and solves most of the problems presented by the gate encoding approach of Fig. 1.

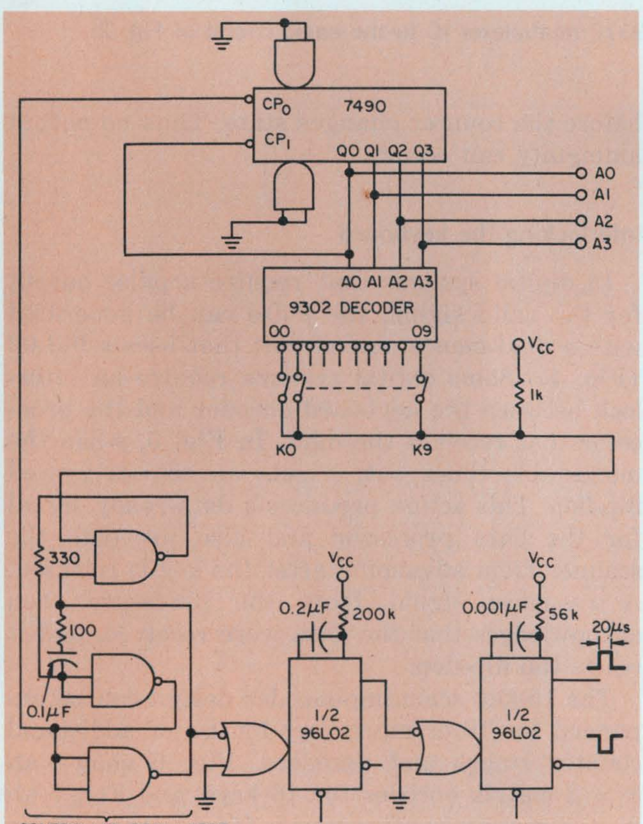
Bounce protection is provided

The oscillator time constant provides some bounce protection; however, under unfavorable circumstances the counter might make one additional complete scan before settling. A LOW output signal on the valid-code line indicates that the counter output corresponds to the number of

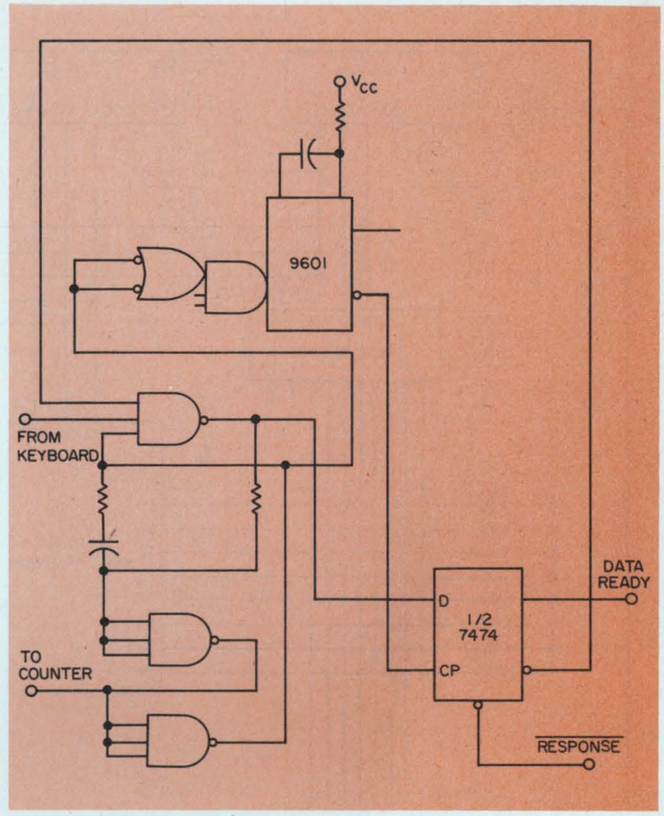
Peter Alfke, Fairchild Camera and Instrument Corp., 464 Ellis St., Mountain View, CA 94042.



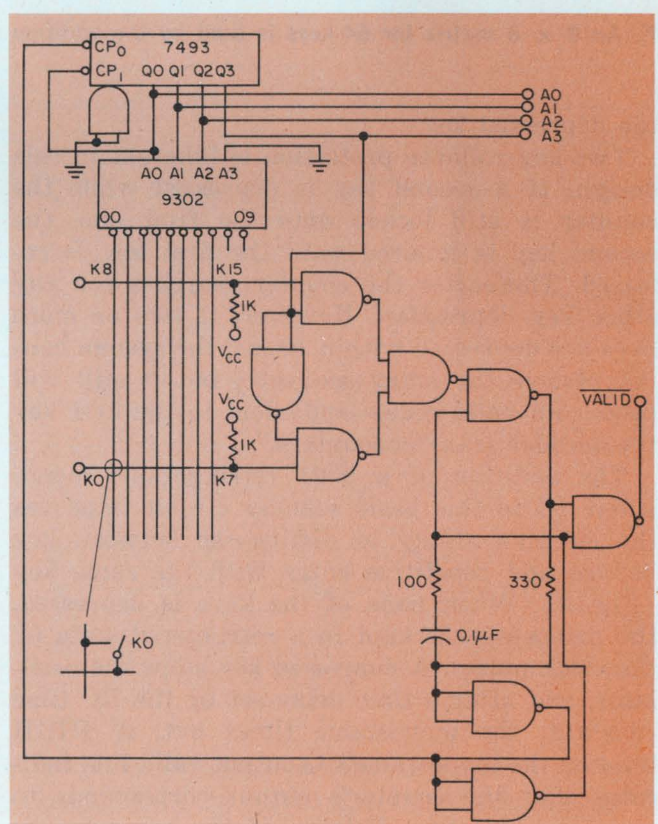
3. **A retriggerable one-shot added to the sequential-scanning** circuit helps eliminate the undesirable multiple-input effects of key-switch bounce.



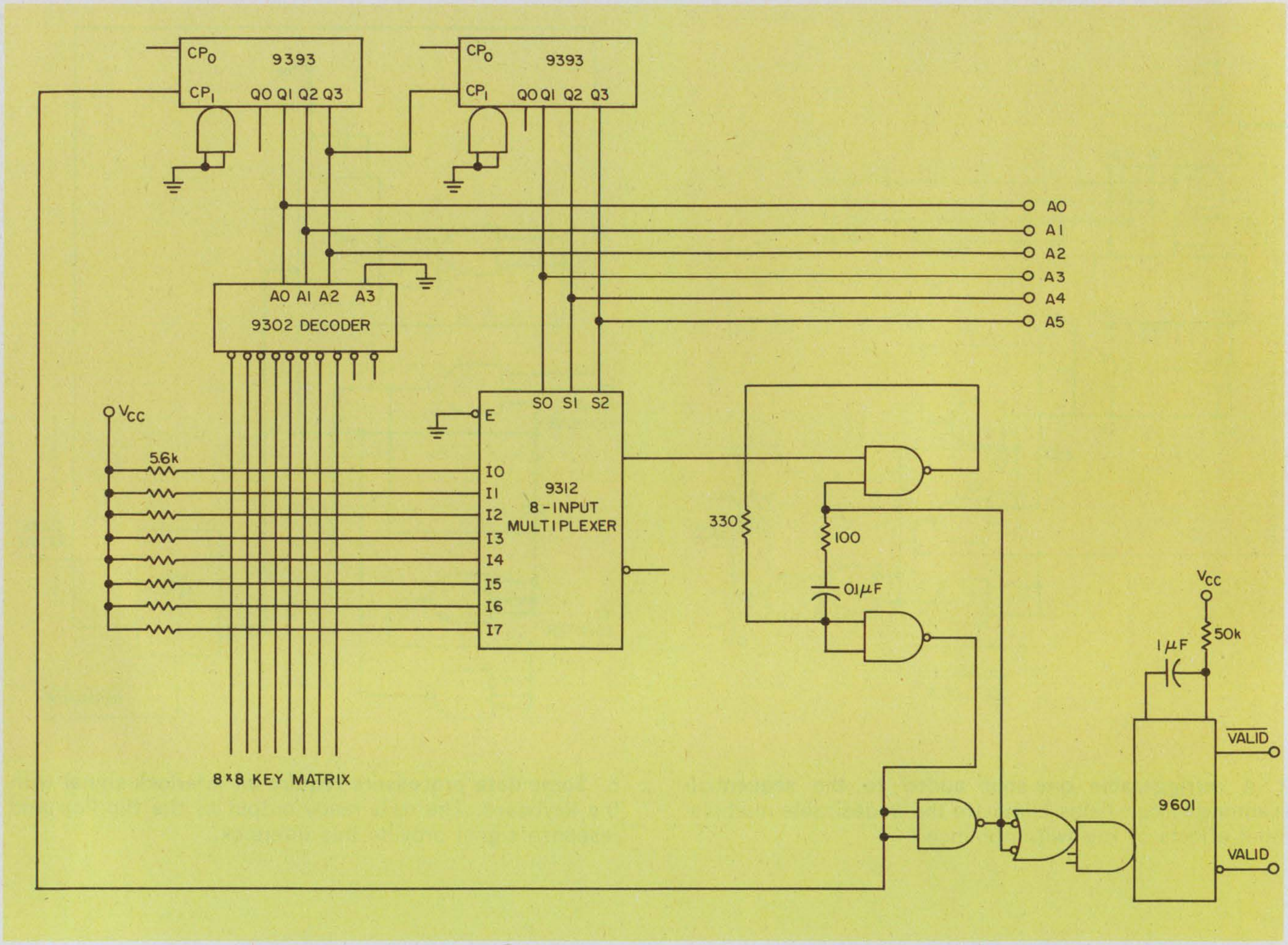
4. **For data systems that need a valid-signal output in pulse form,** a dual-monostable IC is used.



5. **Some data processors require an interlock-signal** with the keyboard. The data-ready output of the flip-flop and response signal provide this interlock.



6. **Only small changes convert the basic sequential circuit to an 8 × 2 matrix or 16-key,** data entry system.



7. **An 8 × 8 matrix for 64-keys is built** by the addition of a 9312 multiplexer IC to the basic circuit of Fig. 2.

the depressed key.

Two-key rollover protection is inherent in this design. If a second key is depressed while the counter is still locked onto the first one, the second key is ignored until the first key is released. Thereafter the counter searches for any other key depression. However, if two or more keys are depressed within 10 ms, the system cannot resolve the entry sequence, but it still will produce a valid code—equivalent to the first key the decoder scan "encounters."

The addition of a 9601 retriggerable monostable IC to this basic scanner circuit improves the circuit's ability to distinguish between key bounce and repetitive entry with the same key (Fig. 3). When none of the keys is depressed, the monostable is kept in a retriggered state by the clock pulses. A depressed key stops the oscillator, and after a time delay set by the RC time constant, the monostable times out. A HIGH level on the monostable's $\overline{Q}$-output valid line indicates that the counter's output corresponds to the depressed key. Release of the key triggers the monostable on the first rising clock edge and terminates the valid signal one-half clock period before the counter changes state. Thus no output ambiguity can occur.

Interlocking the keyboard

In digital systems that require a pulse output for the valid signal, the pulse can be generated with a dual-monostable circuit that uses a 96L02 (Fig. 4). Some digital systems require an interlock between the keyboard encoder and the processor that receives the data. In Fig. 5, when the monostable times out, it sets an edge-triggered flip-flop. This action produces a data-ready signal for the data processor and also prevents the scanner from advancing after the key is released. A response signal from the processor then acknowledges that the data were received, and it resets the flip-flop.

The 10-key scanning-encoder design can be expanded for 16 or more keys by use of additional counter stages and decoders. Fig. 6 shows an 8 × 2 matrix encoder for 16 keys, and Fig. 7 an 8 × 8 matrix configuration for 64 keys. These circuits need no diodes at the matrix intersections. ■■

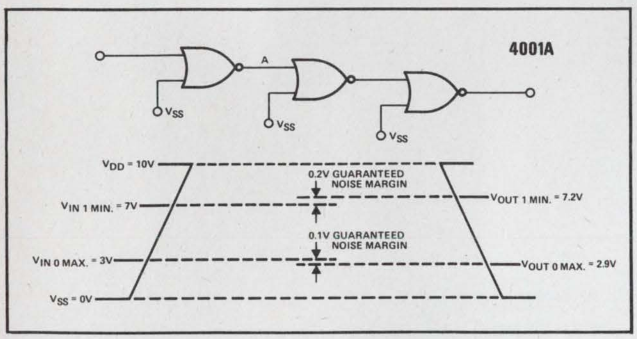
Now! A guaranteed cure for worst case design noise.

Designing with CMOS? Got a worst case design requirement? Then look to 54C/74C. It's the only CMOS logic family that guarantees noise immunity in a way that is meaningful to the designer.

Take a for instance. Say you are designing a small CMOS process control system with a 10 volt power supply. You determine that worst case noise is 2 volts—1 volt due to power distribution and 1 volt due to AC coupling on a signal line. Compare what happens when you use 54C/74C as opposed to 4000A. With a 2-volt degradation of input voltage 54C/74C still has typically three times the drive capability of the 4000A series. End result: 54C/74C allows use of worst case design with far greater noise margins than 4000A series.

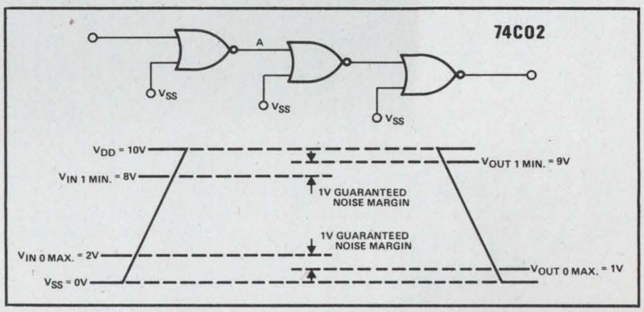
	$V_{IN\,0\,MAX}$	$V_{IN\,1\,MIN}$	$V_{OUT\,0\,MAX}$	$V_{OUT\,1\,MIN}$	I_{OUT}
74C	+2V	+8V	1.0V	9V	10μa Source or Sink
4000A	+3V	+7V	2.9V	7.2V	0.0μa Source or Sink

V_{DD}=10V

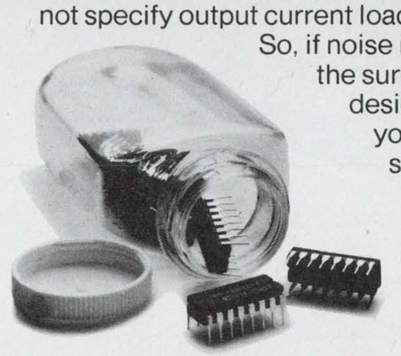


With a seven volt input the 4000A specifies a 2.9 volt maximum output. From this you can guarantee only that the output from the first gate will be ≤2.9 volts, with the worst case 7 volt "1" level in the system. If any more than 0.1 volts of additional noise is injected at A, the outputs of the second and third gates will be undefined.

In the same system 54C/74C specifies an output of 1 volt maximum with the input at 8 volts or a 9 volt minimum output with the input at 2 volts. With 2 volts of noise at the input of the first gate the result will be a 1 volt degradation at the gate's output. Up to one volt of additional noise can be coupled onto the input of the second gate, and the gate will continue to maintain its output within 1 volt of supply. The same holds true for succeeding stages.



In addition, a 54C/74C output terminates signal lines with typically 1/3 the impedance of 4000A, giving you higher immunity to coupled noise. The 54C/74C series also specifies output source and sink current of 10μa minimum as part of its noise immunity specification, while the 4000A series does not specify output current loading.



So, if noise is your problem, take the sure cure: a worst case design using 54C/74C. If you don't need such strong medicine, try our 4000 series. We've got a whole family—more than 30 devices. For details see your Harris distributor or representative.

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INFORMATION RETRIEVAL NUMBER 39

IT'S **CLEARLY THE CHOICE** *OF*
ELECTRONICS ENGINEERS — WORLDWIDE

Use digital counting logic to generate precise waveforms. You can control the waveforms by digitally changing the amplitudes and the starting and stopping points.

To generate and control all the characteristics of ramp waveforms, just use digital counting logic to drive a digital-to-analog converter.

This digital synthesis method—instead of the conventional constant-current source that charges a capacitor—permits complete control of the ramp's starting and stopping voltages, ramp rate and ramp linearity (convex, concave or linear). You can also stop and hold indefinitely the ramp with zero droop at any point on the waveform—a feat difficult to achieve with standard analog sample-and-hold circuitry.

The availability of good 6, 8 and 10-bit d/a converters that cost less than $30 makes these d/a generated waveforms economical in many applications. Some applications include filter testing, analog computing, CRT sweep generation, motor-servo systems and programmable power supplies.

You can also generate waveforms other than the ramp—sawtooth, square, rectangular, sine, or any other waveform desired. Just write a bit pattern and let the converter decode it.

Select the right converter

The accuracy of the waveform you want to generate is limited by the d/a converter resolution. For example, an 8-bit d/a has an available resolution of one part in 2^8, or about 0.39% (Table 1). Thus for a 10-V full-scale range, this translates into an output-voltage resolution of 39 mV.

The actual resolution of the converter is usually less than the theoretical value because of internal component tolerances, drift and noise. Remember that the lower the converter resolution, the more the waveform looks like a staircase instead of a ramp. In fact, a very low resolution d/a converter (2 or 3 bits) is a convenient way to generate a four or eight-level staircase to use with a semiconductor curve tracer, for example.

Michael S. McNatt, Senior Engineer, King Radio, 400 N. Rogers Rd., Olathe, KS 66061.

The analog output span voltage between the minimum and maximum input digital words is usually called the full-scale range. On many converters, this range can be selected if you place wire jumpers between specified terminals. The jumpers change the internal feedback resistor on the output operational amplifier. Some of the popular output ranges include 0 to −10, 0 to +10, ±10, and ±5 V.

In addition to selecting the resolution you need, you must also evaluate the converter settling time. The settling time can range from about 30 μs in the low-cost converters to about 1 μs in the higher-speed models. Basically the settling time can be defined as the total time necessary for the output to fall within a specified error band after a step change at the input.

Table 1. Maximum d/a resolution

N (binary bits)	2^N	Available resolution (%)
4	16	6.25
6	64	1.56
8	256	0.39
10	1,024	0.098
12	4,096	0.024
14	16,384	0.0061
16	65,536	0.0015*

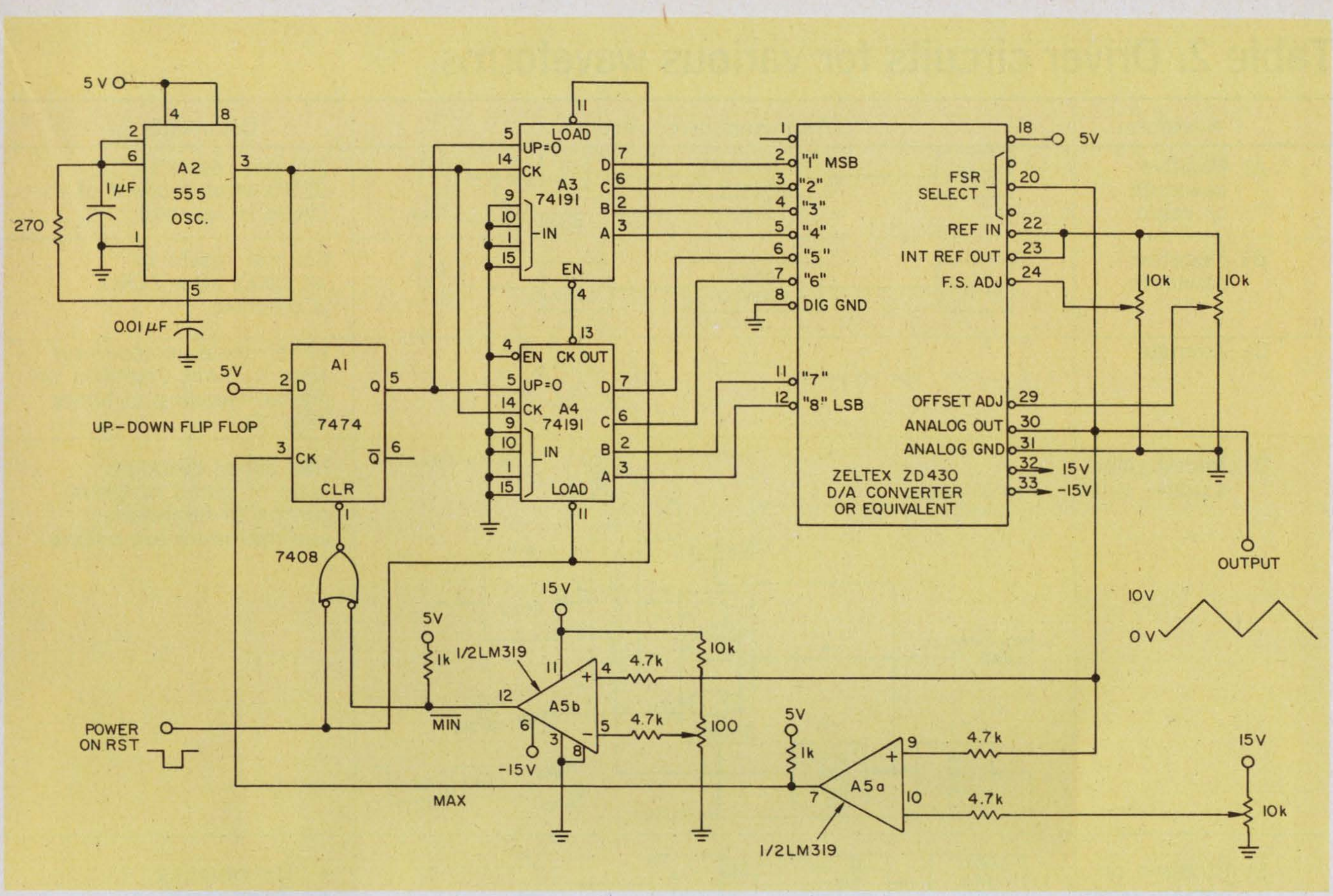
* or 15 ppm.

The maximum slew rate of the converter output can be determined once the settling time is known:

$$\text{Max slew rate} = \frac{\text{Full-scale range}}{\text{settling time} \times 2^n} \text{ V/s},$$

where 2^n is the maximum number of converter input states.

Depending on the converter's settling characteristics, you can increase its slew rate to more than the calculated value. For example, if an 8-bit d/a has a 5-μs settling time and is set for a 0 to +10 V output swing, the calculated circuit slew rate is 7.8 V/ms. This assumes that you have waited for the converter to settle to within its specified limit—usually 0.05 or 0.1% at each



1. **Generate triangular waveforms** with a ramp generator to provide positive and negative-going slopes. An 8-bit d/a converter and some control circuitry are all that are needed.

step in the ramp. If you don't need such accuracy, you can increase the slew rate by speeding up the conversion.

Generate triangular waves

To show the ramp-generation technique, let's generate a triangular waveform by use of the circuit shown in Fig. 1. The two 74191s form a 256-bit up/down counter that drives an 8-bit binary d/a converter. A 555-type timer is used as a free-running clock for the counters. Two comparators (LM319 dual) control the 7474 up/down flip-flop. These comparators provide analog control of the minimum and maximum triangle excursions.

When the circuit is activated, the counters and flip-flop are cleared and up-counting proceeds until the max limit is reached. The flip-flop is then clocked into the down mode. Now the counters count down until the min limit is reached, the flip-flop is cleared again, and the process starts over.

If the ramp's excursions are limited to between preset points, a different method of up/down control can be used. You can digitally decode the output of the counters at each limit (Fig. 2). Thus you eliminate the need for analog comparators and can generate a triangle waveform of any size just by a change of the decoding network at the converter.

If you require different ramp-up and ramp-down times, the up/down flip-flop can be used also to control the clock frequency (Fig. 3). One popular method is to use logically controlled pnp transistors that select between two timing resistors in a 555 oscillator. The following equation can be used to calculate the required clock frequencies:

$$f_{clock} = \frac{C_{max} - C_{min}}{\text{ramp time}},$$

when C_{max} and C_{min} are bit counts that represent the maximum and minimum desired excursions of the ramp. For example, if a 0.1-s ramp-up time is desired for a ramp that varies between 0.39 and 7.995 V, then the clock frequency becomes

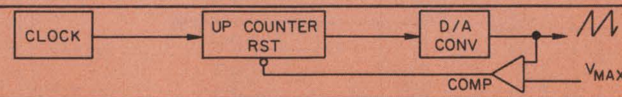
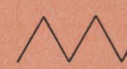
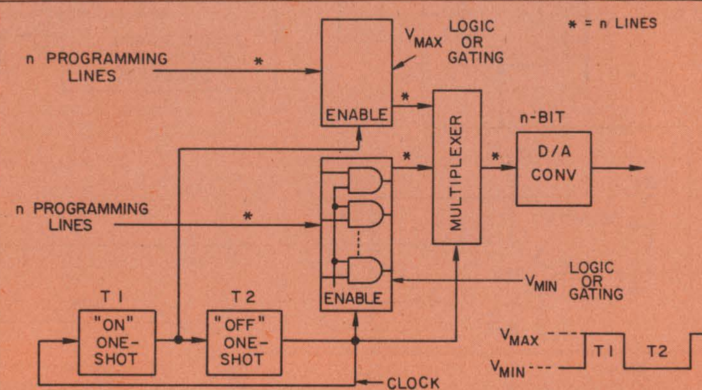
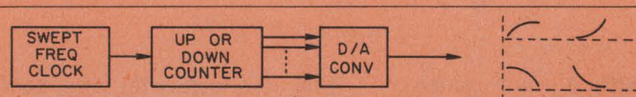
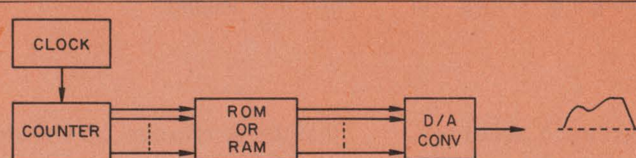
$$f_c = \frac{205 - 10}{0.1} = 7.95 \text{ kHz}.$$

In this example, 205 is actually the max bit count that represents 7.995 V (7.995/0.039); and 10, the min count (10 times 1 LSB).

Generate nonramp waveforms

Practically any type of analog waveform can be generated by a d/a converter with the appro-

Table 2. Driver circuits for various waveforms

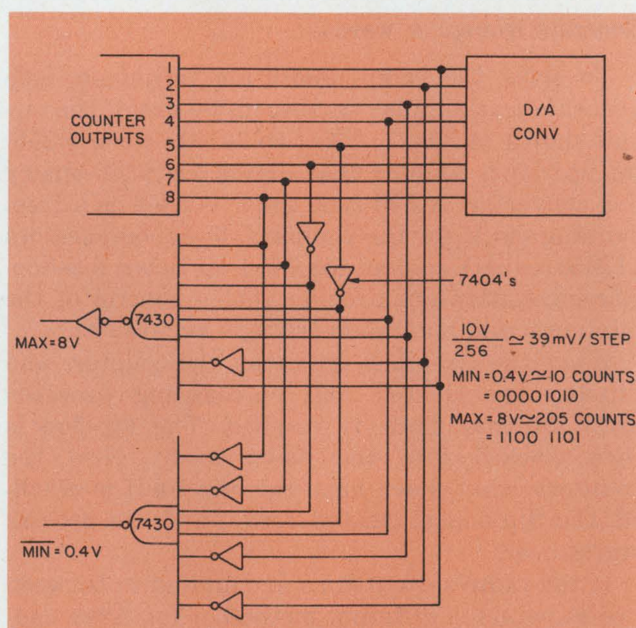
Waveform	Representative circuit	Comments
A) Positive sawtooth or ramp		Counter resets to ZERO after a count of ONEs is reached.
B) Negative sawtooth		Counter resets to all ONEs after ZERO is reached.
C) Triangle	SEE FIGURE I 	Either analog comparator (Fig. 1) limit detection or digital decoding of limits (Fig. 2).
D) Rectangular, square, pulse		Use either decoding logic or gated program control of minimum and maximum excursions.
E) Concave or convex ramp		← Up counting ← Down counting
F) Complex waveforms		Sin x, e^x, etc.

priate input patterns and control logic. Several representative logic input schemes and their output waveforms are listed in Table 2. Of these, sawtooth waveforms are probably the easiest to generate. For a positive sawtooth that ranges from zero to full scale and then resets, all you need is a clock, up-counter and converter. If you add a comparator, the maximum output excursion can be programmed by the V_{max} input. The V_{max} input could be the output of still another converter that is under computer control.

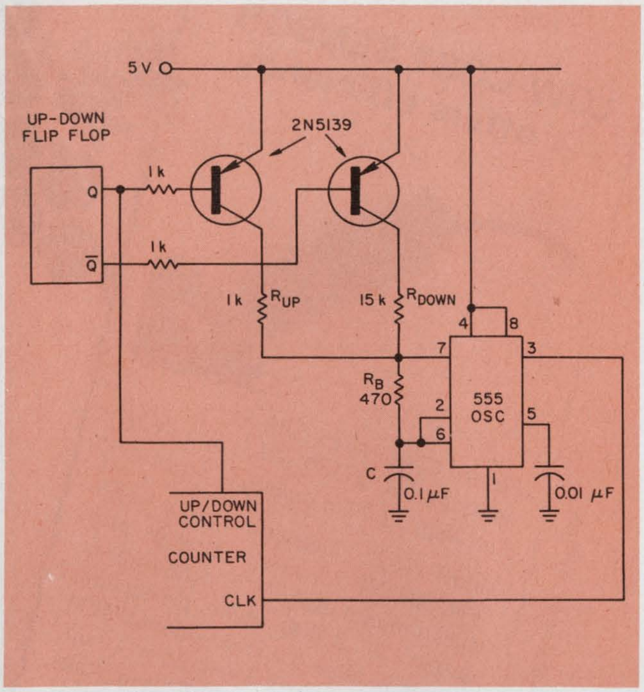
If the counter is switched to the down-counting mode, a negative-going sawtooth results. Various methods such as resistive dividers, controlled-gain amplifiers or analog digital decoding of the limits can be used to get different output excursions.

You can also generate long or short-duration square waves or pulses with a pair of one-shots to form an oscillator that alternately enables two logic decoding networks (Table 2d). These circuits set the waveform's max and min voltage excursions.

Even more complex waveforms can be gener-



2. **You can build a decoding network** that can change and control the starting and stopping points of the ramp. The circuit can also set the ramp excursion limits to vary the waveform amplitude.



3. **Two pnp transistors,** controlled by a flip-flop, can be used to switch resistors in the 555 clock circuit. This, in turn, changes the clock frequency and thus the ramp-up and ramp-down times.

ated if you use random logic, frequency-swept clocks or programmed memories. For instance, a ramp's linearity can be controlled if you sweep the clock driver and change the frequency. Also, multiplexers can be used to produce a number of different waveforms with the same d/a converter, as in a function generator. ■■

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Job ratings hinge on mutual commitment

between engineers and their managers in this method of evaluation. It's designed to align personal goals with those of the company.

Someone once said that although we all live under the same sky, we don't all share the same horizon. Perhaps that's one reason why our company uses an evaluation program called "Key Responsibilities and Work Objectives." It's a method by which our engineers make a mutual commitment with their managers to align their goals and objectives with those of the company.

Any work-measurement approach has subjectivity problems, but these are far outweighed by the benefits of our program, which does the following:

- Forces the engineer and his manager to plan his work at least a year ahead.
- Helps recruit top engineering talent.
- Helps develop supervisors and managers.
- Enables management to administer compensation more fairly.

We all like to know what's expected of us. A more congenial environment is created if the engineer knows what his task is, how he fits into the over-all picture and how he's going to be evaluated.

Applying weights and measures

As we develop the evaluation program for each engineer, we assign percentage weights to each of his responsibilities and work objectives, so he fully realizes the importance of each and knows which one to spend most of his time on.

The weighting can vary greatly. For example, some engineers are outstanding technically; they can finish a design in three months. Often, however, they want to improve on the design for another three months. So we would give a technically superior man a 10% weight factor in technical development and a 40% weight factor in meeting schedules.

If the man is an experienced manager, the weights of his responsibilities may break down something like this: 25% in assisting marketing and booking new business in his technical area; 5% in profitability of that business (because, let's say, he's already profit-oriented); 25% in recruiting and training technical people for production work in his technical area; 15% in supporting other engineering people, and 30% in meeting deadlines.

The weight factors are based on the importance of the responsibility, not on the man's need to improve. If there are areas where the man has to improve, we identify them separately. The manager who's evaluating that engineer or supervisor places high importance on whether his subordinate accomplishes those tasks with the highest percentage of responsibility. It's extremely important that they agree at the first of the year on what is important, so the man being rated won't be shocked at salary and promotion time.

We've adopted job descriptions for certain tasks, and they don't change as long as the job doesn't change. For example, the chief draftsman has to supervise the draftsmen, increase efficiency and work toward fewer design changes. Key responsibilities and work objectives are in addition to this job description.

After the key responsibilities and work objectives are agreed on between the engineer and his manager, a year later the engineer writes his own accomplishment report against that agreement. The manager also writes an accomplishment report and weighs the engineer's accomplishments against each work objective on a scale of one to eight—from unacceptable to outstanding performance. At top management we multiply that scale factor of accomplishment against its weight factor and total all the weights. That total gives us a figure that we can convert to a per-cent increase in salary.

Our engineers are aware of this process. We discuss it openly with them and show it to them. If they disagree with our ratings or with our performance appraisal when we compare accomplishment reports, we like to know why. Usually the engineer is harder on himself in his report than we are.

Realistic goals encouraged

One nice thing about our evaluation program is that we can tailor the work objectives of the

Leslie W. Chapin, Vice President, Beckman Instruments, and Manager, Helipot Div., Fullerton, CA 92634.

engineer for the next 12 months. If he's a junior engineer and would like more practical experience, we can put more weight on lab programs, environmental testing programs and suitable course work. As he progresses in the organization, we can broaden his objectives to include scheduling and budgeting a project; conducting design reviews with the manufacturing people; interfacing with customers in the field, and training with some of the technical specialists in the marketing organizations.

Another benefit of the program is that it forces the engineer to think of his own long-range goals. We ask each man where he'd like to work—as a technical man or in general management some day. Those are hard questions to grapple with, and we try to help the engineer decide. Sometimes we take two weeks to develop a man's main goals. When that's done, we try to put him in an area that will be a stepping stone to that objective.

If he's unrealistic and sets a target that we feel he won't reach, we try to straighten him out. For example, a talented, clear-thinking man who wants to be a general manager may have personality problems and may be unsuitable for managing people. But he may be a super manager of information systems, where he can develop disorganized inputs into flow charts for a computer.

A good recruiting tool

The system also has been a good recruiting tool. We often shoot for the bright engineer who is five or six years out of school, who's decided what part of engineering he's interested in and

Leslie W. Chapin and Beckman Instruments, Inc.

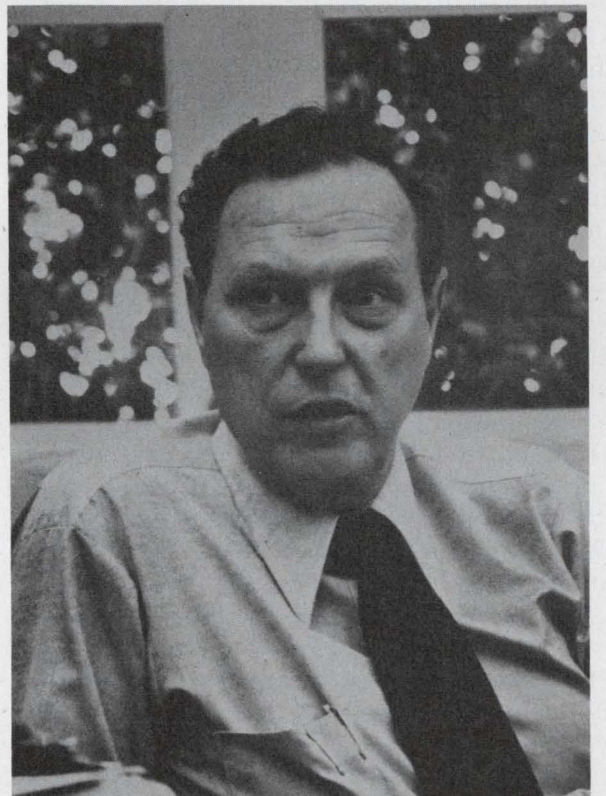
In a little over a score of years, Leslie Chapin worked his way up to his present position—vice president of Beckman Instruments and manager of the Helipot Division. He had served as assistant division manager since 1972. Earlier he held a series of engineering and technical management positions in the company.

The division Chapin is responsible for develops and manufactures a variety of electroproducts, including precision and trimming potentiometers, microcircuits and digital electronic displays. Established in 1934 by its chairman, Dr. Arnold O. Beckman, the company also makes components and related products for medical, industrial, environmental and scientific applications. It employs over 7400 people in the U.S. and abroad.

Chapin is a member of IEEE and the Instrument Society of America. He's a former regional director of the International Society of Hybrid Microcircuits.

He majored in Electrical Engineering at Iowa State College and served as an electronics instructor in the U.S. Navy and at Fullerton College. Chapin is a graduate of the U.C.L.A. Executive Program.

He resides in Fullerton with his wife and two daughters.



who's usually working for his second company.

This engineer is happily surprised when we tell him that we have a formal rating system that tells him what we want him to do in the next year. Invariably the man says something like this: "That's the first time any one ever told me 12 months in advance how I was going to be measured. I feel so much better coming into your organization, because the last three years I was never sure how I was doing. My employers paid me well, but I never knew why."

We also develop managers and supervisors with this program. A supervisor can have one technician reporting to him or, if he's a project engineer, three other engineers, a draftsman and a technician. The first time I get a set of "key responsibilities and work objectives" from a fledgling supervisor, they're all the same—short in length. They're also similar. I refuse to accept these reports. I tell this new supervisor that since no two men are the same, their goals and objectives cannot be the same. I ask him to tell me the strengths and weaknesses of those he is supervising and what are the most important things he wants each to do.

Sometimes the supervisor will write a very brief evaluation on each of his men, saying nothing that is positive or negative. He'll say his men need more experience. I won't accept that report primarily because it doesn't offer constructive evaluation of a man's performance.

I insist that there's something that each man can improve on in each appraisal. The supervisor will say, "I don't know anything that won't make him mad." I tell the supervisor that if he's holding a man back for any reason, he owes it to him to tell him what it is. That's what we're paid for as managers, and whether we're right or wrong, if we're influencing the man's compensation and development, we owe it to him to tell him how we feel. If the supervisor disagrees, then he should tell me why I'm wrong. If he agrees, we'll work together to improve the evaluation.

Our rating system is a fair way to administer raises and promotions. When the engineer writes his own appraisal, he knows if he did a good job or a bad one. He knows that his boss' appraisal of him is based on measures they have mutually agreed on, rather than some measure the boss picked arbitrarily. Because of this, the engineer can accept a lower raise than he'd like if he sees he didn't quite measure up. He's also more receptive to learning how to improve.

If the economy forces reductions in staff, our rating system allows a manager to do a more objective job of cutting back. He can more easily sort the performers from the laggards. Before we had this program, a manager would identify a certain engineer as outstanding and he had no objective basis for his judgment—it was merely his opinion. Often when that manager moved to another job, his replacement would identify the same "outstanding" engineer as a dumb-dumb. Our evaluation system has helped to minimize subjective appraisals, because we now agree on how to measure each man.

Every program has its problems

There are three major problems with the program that we must guard against:

1. It takes extra managerial effort to operate properly.

2. There is a tendency toward similarity in evaluation reports in larger groups because of a common review date.

3. The weights can cause disagreement if both parties to the agreement are not totally frank.

Every man must be reviewed once a year. Busy managers may not evaluate their subordinates' work as often as they should during the year. A frequent complaint of the engineers is: "If you'd just told me that I wasn't working toward my work objective at the three or six-month point, maybe I could have done something to improve. Now it's too late. I'll get half the raise I should have because you didn't monitor me."

We've found that managers should tell their people at least once each quarter how they think they're progressing.

The day on which we write all of the responsibilities and objectives for our total engineering staff is Nov. 1, and the problem here is that all of the reviews may start to sound alike. What sometimes happens is that the manager will make a few changes in last year's review, and it reads like the one he turned in the previous year. We have to take pains to ensure that each review is a fresh one.

Finally, the manager and his subordinate sometimes have trouble agreeing on the weights at the end of the year. I may want one of my managers, or he may want one of his engineers, to accomplish certain work objectives that secretly the subordinate doesn't think he can accomplish in a year. The only cure for that is to encourage full frankness on the day of commitment.

I like the program. We can accommodate change as long as it isn't totally undisciplined and without direction. Our program gives us direction and organization. A technology-based company has to capitalize on its innovations, which are developed by people—the best people it can find. If we don't have a good program to make those creative people comfortable, we're not going to keep them. ■■

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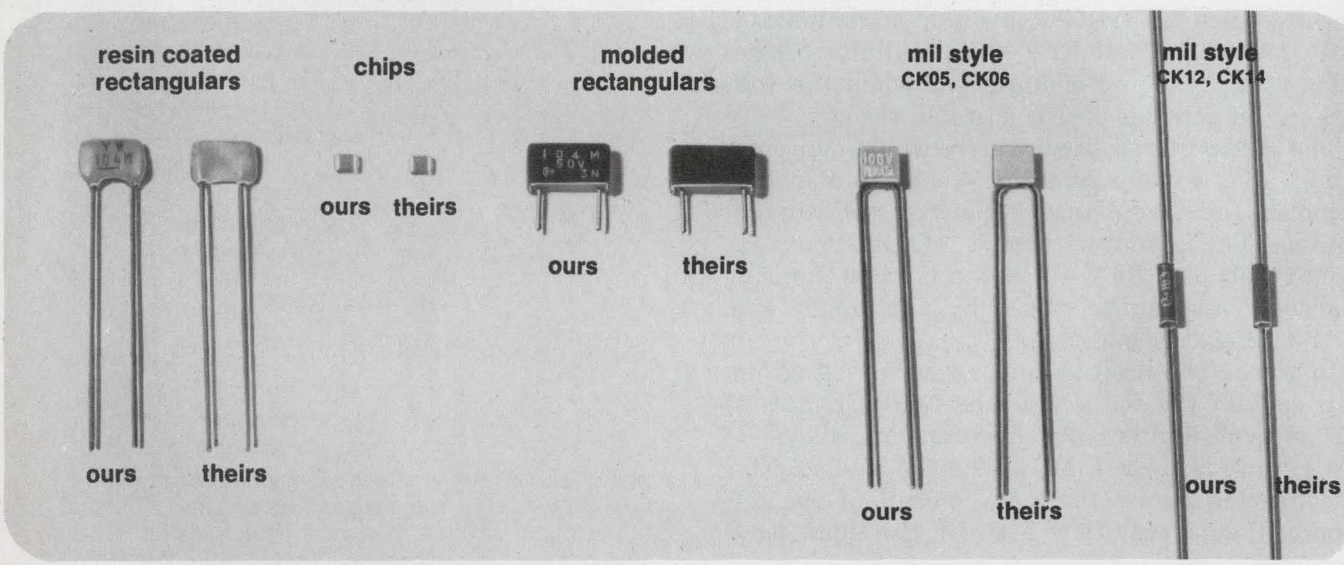

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INFORMATION RETRIEVAL NUMBER 45

ideas for design

Precision voltage reference easily converts to a current limiter

A single resistor added to an IC voltage-reference source can form a simple, two-terminal current limiter. It can be set to a precise current limit. The temperature performance of the circuit, when an AD580 is used, is comparable with that of the best FET current-limiter diodes (about ±0.1%) and is improved when the voltage output is loaded with a stable resistor.

The AD580 low-voltage reference has an operating input voltage range of 4.5 to 40 V, which becomes the compliance range of the current limiter. The standby current of the reference circuit—about 1 mA—is the minimum limiting current. This can be raised by applying a load to the reference output.

In Fig. 1 the positive and negative voltage input leads of the IC become the two terminals of the current limiter. The dynamic impedance of the circuit is over 1 MΩ. When a load resistor is connected across the 2.5-V output of the reference, the current flow between the input leads increases.

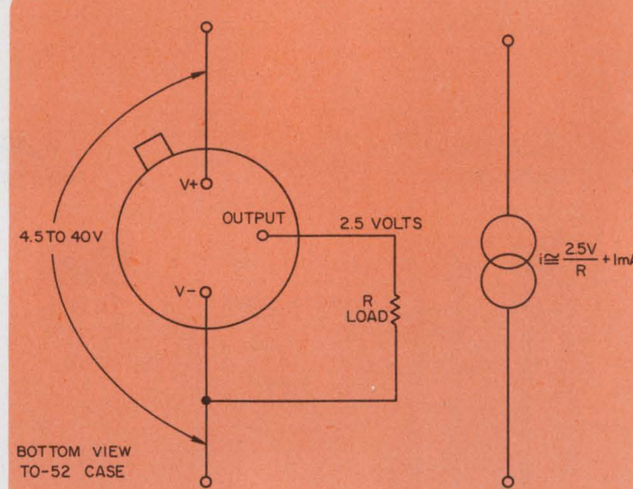
The IC stabilizes the voltage across the load by drawing current from the input. For example, a 1-kΩ resistor connected across the 2.5-V reference output draws 2.5 mA. This current comes from the input leads and adds to the standby current. The total resulting limit current is then 3.5 mA.

A variable load resistor can adjust this current. This is an important advantage over FET limiter diodes, which cannot be adjusted.

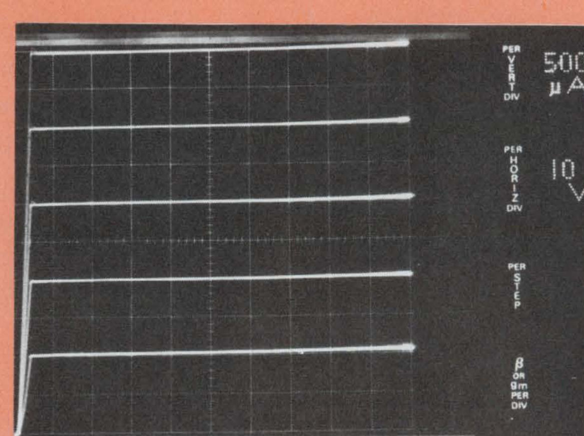
The standby current of the IC has a temperature characteristic of about +1.3 μA/°C, or 0.13%/°C of 1 mA. With a 200-Ω load, the total current is over 13 mA and the temperature coefficient reduces to 0.01%/°C. When both high current and high voltage are applied, temperature rise may reduce the current limiter's dynamic impedance slightly.

A. Paul Brokaw, Director of Advanced Product Development, Analog Devices, Semiconductor Div., Route 1 Industrial Park, P.O. Box 280, Norwood, MA 02062.

CIRCLE NO. 311



1. **The current in the two-terminal current limiter** is adjusted by the resistor across the 2.5-V output of the voltage reference. This resistor also reduces the circuit's relative temperature coefficient.



2. **Curve-tracer photograph** shows the circuit's current-limiting action for currents of 1, 2, 3, 4 and 5 mA. Note that this unit operates properly well beyond the AD580's rated 40-V maximum.

High-speed switch handles ±400-V peak and is controlled by logic levels

The high-voltage switching circuit shown can switch up to 400 V of either polarity at a rate in excess of 100 kHz. The photographs show output-voltage waveforms obtained across a 10-kΩ load for switching rates of 1 kHz and 100 kHz. The signal source was a 60-Hz, 340-V-peak sine wave.

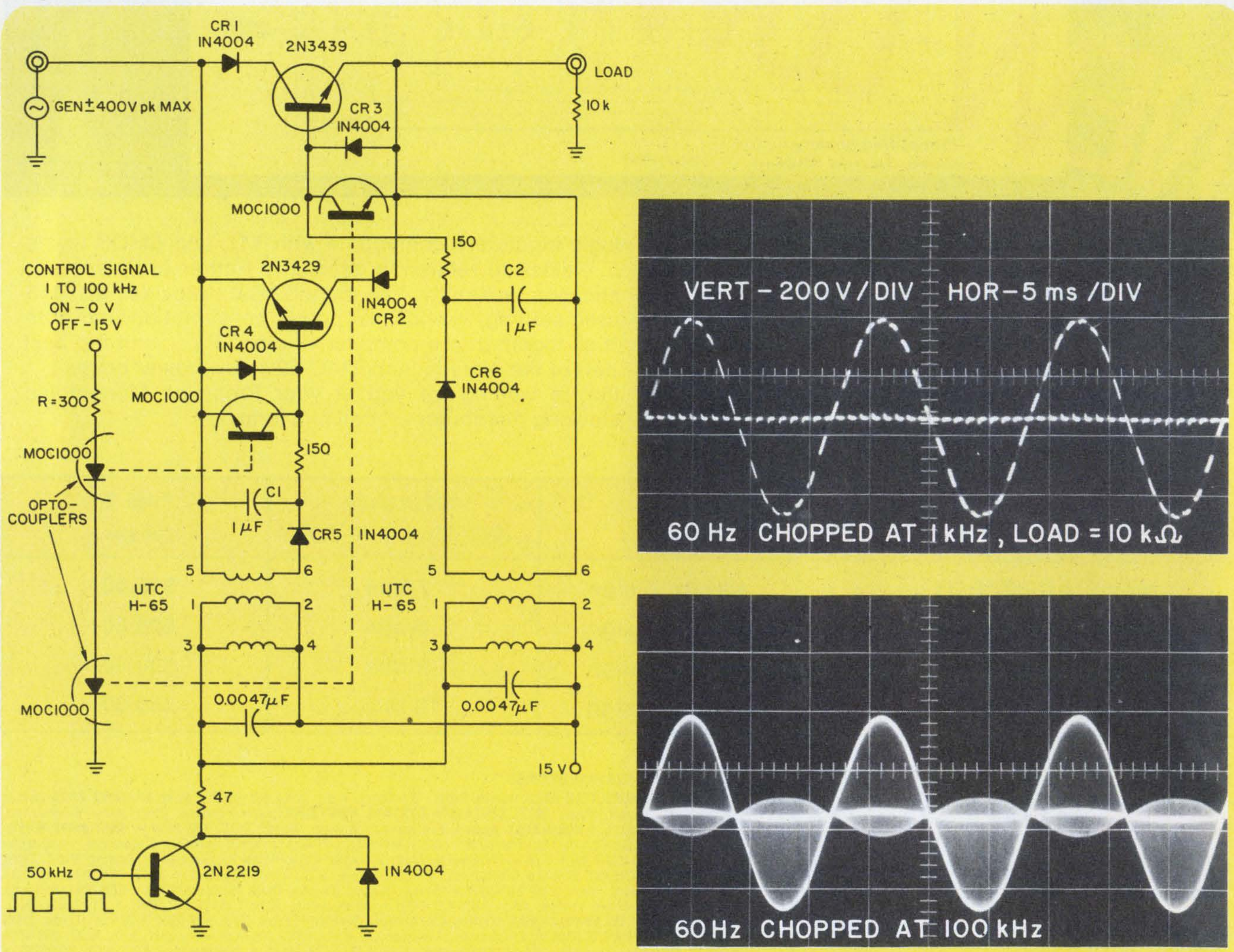
If the ground side of a high-voltage load is inaccessible, or if switching at this point is undesirable, then the switch must be floated on the high side of the load, as shown.

Optical couplers and pulse transformers provide the needed isolation. Diodes CR_3 and CR_4 prevent breakdown of the 2N3439 switching transistors' base-emitter junctions when the switch is off. Diodes CR_1 and CR_2 prevent reverse conduction through the transistors' forward-biased collector-base junctions. The 2N-2219 transistor with its 50-kHz input provides bias for the switching transistors via the transformers, rectifiers CR_5 and CR_6 and filter capacitors C_1 and C_2.

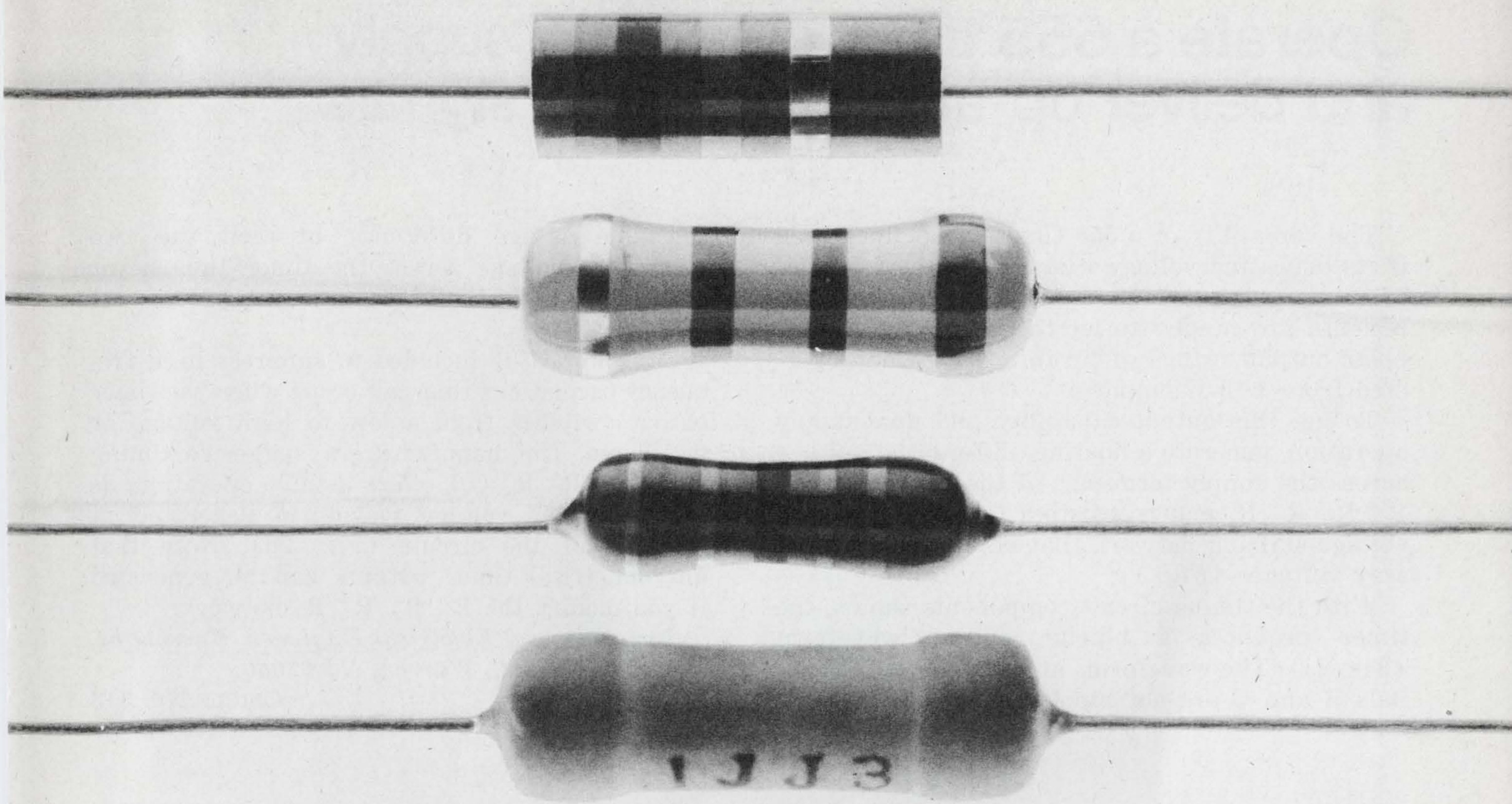
The circuit was originally developed to disconnect a sensitive measuring device from high voltage ac in the event that the instantaneous value of the ac exceeded a preset limit. Shunt protection could not be used. This high-voltage, high-switch-rate, isolated switch should find many other applications. One could be in high-voltage power-supply regulators.

Stephen D. Anderson, 5761 33rd Ave. S., Minneapolis, MN 55417.

CIRCLE NO. 312



Isolation in this high-voltage switch is provided by optical couplers and pulse transformers.



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Operate a 555 timer on a ±15-V supply and deliver op-amp compatible signals

The versatility of a 555 timer can be increased if its operating voltage range is widened to that of most op amps—±15 V. Only a few extra components are needed to let the timer provide bipolar output swings of up to ±11 V when operated from ±15-V supplies.

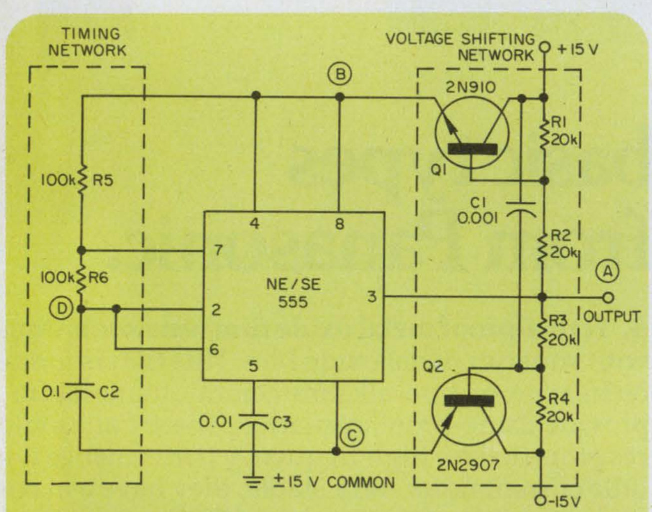
To get this output capability and dual-supply operation, generate a floating, differential voltage across the supply terminals of the 555. Resistors R_1, R_2, R_3, R_4 and transistors Q_1 and Q_2 form a voltage-shifting network that develops the necessary voltages (Fig. 1).

With the timing-circuit components shown, the timer produces a bipolar output waveform (Fig. 2a). The waveforms at power-supply terminals B and C are not bipolar but do maintain a constant voltage difference between the two terminals. Voltage across the timer thus never exceeds 12 V, but the output can swing from −11 to +11 V.

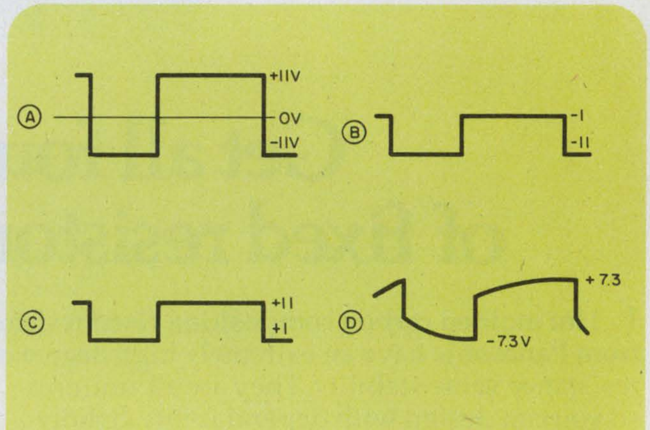
Capacitor C_1 is included to suppress high frequency oscillations that can occur when the timer output switches from a low to high voltage or vice versa. The manufacturers' suggested timing network (R_5, R_6, C_2) offers astable operation, as shown by the voltage waveform generated at point D of the circuit (Fig. 2d). Note that unsymmetrical timer outputs can be generated if you modify the R_1, R_2, R_3, R_4 network.

Surjan Dogra, Electrical Engineer, Burroughs, Mount Bethel Rd., Warren, NJ 07060.

CIRCLE NO. 313



1. **The 555 timer** can be given expanded output capability by an increase in the operating voltage span.



2. **The output signal from the 555** can swing from −11 to +11 V (a) when the timer is powered from dual 15-V supplies. Voltages at the power supply pins of the timer show that a maximum difference of 12 V exists between pins (b and c). The timing circuit waveform (d) varies between ±7.3 V.

IFD Winner of September 13, 1974

Marvin J. Moss, PhD., M.J. Moss and Associates, Box 28601, Atlanta, GA 30328. His idea "Voltage Monitor Uses LED Indicators to Show Out-of-Tolerance Voltage" has been voted the Most Valuable of Issue Award.

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international technology

Higher efficiency for avalanche diodes

Unusually high efficiency of gallium-arsenide avalanche diodes has been observed in experiments at the University College in London, England. The efficiency, above that predicted by the Read sharp-pulse approximation, is due to wide variations in the depletion-region width during r-f cycles, particularly at large signal levels, according to University College researchers.

The variation in depletion-region width is termed "depletion-width modulation." X-band diodes with this effect have been found to give output powers of 8 W at efficiencies of about 40%.

In silicon diodes power losses due to undepleted material swamp the advantages of width modulation of the depletion region. Also the voltage under oscillating conditions is very near the punch-through level, in silicon units whereas gallium-arsenide devices operate at well below punch-through voltages. As a result, losses in the arsenide devices are reduced.

Bipolar transistor arithmetic array

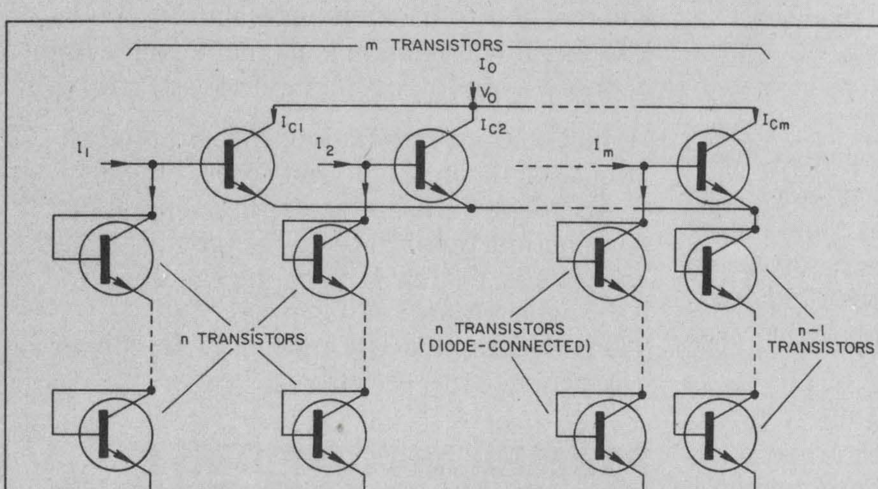
A low-cost and simple alternative to the usual method of using multiplier and summer circuits for solving mathematical expressions has been developed at the University of Sheffield in England. Designers there have produced a bipolar transistor circuit that can perform the following operation:

$$\sum_{1}^{m} \left\{ (X_r)^2 \right\}^{1/2}$$

Solution to this expression is often required in instrumentation, where X_r represents a current or voltage proportional to a variable.

The Sheffield design, which can be fabricated on a single monolithic chip, requires transistors with the Beta parameters matched to within ±5%. The number of transistors needed to perform the mathematical operation is given by

$$2(m + L) + (m - 1).$$



For the Sheffield circuit in which m = 3, 10 transistors were needed.

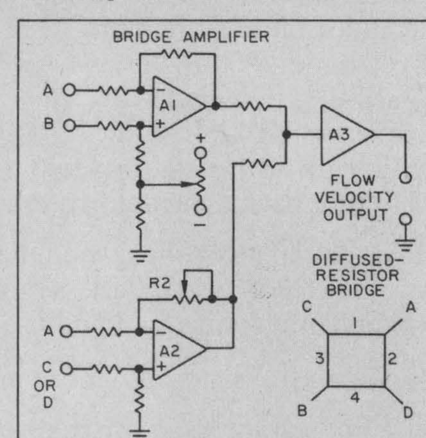
The circuit shown in the figure can handle arithmetic of the general form:

$$I_o = \left\{ \sum_{1}^{m} (I_r)\, n \right\}^{1/2}$$

In this circuit, if n = 2 the number of transistors is 10. Typical problems for which these circuits would be used include: (1) determining the total harmonic distortion from component harmonic amplitudes; and (2) finding the magnitude of a vector from its separate coordinates in two or three dimensions—vector addition.

Sensor and processor on one chip

A flow-measuring sensor small enough to be incorporated with an integrated signal-processing circuit on the same chip has been designed in the Electrical Materials Laboratory at the University of Delft, in the Netherlands. The sensor is a Wheatstone bridge comprising four resistors diffused on a 50-μm-thick, n-type, silicon chip. The resistors lie close to the edges of the chip which is 1.5 mm². The bridge circuitry is in the center of the chip.



When the sensor is placed in moving air with the chip parallel to the flow, the two bridge resistors lying across the flow are cooled more than those parallel with it. The bridge senses the resistance change of the diffused resistors. Bridge-unbalance current is amplified to indicate airflow velocity. The bridge circuit is designed to compensate for ambient-temperature changes.

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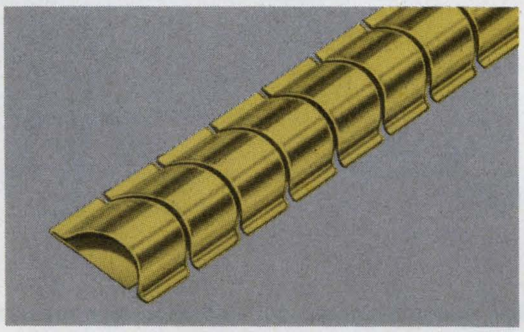

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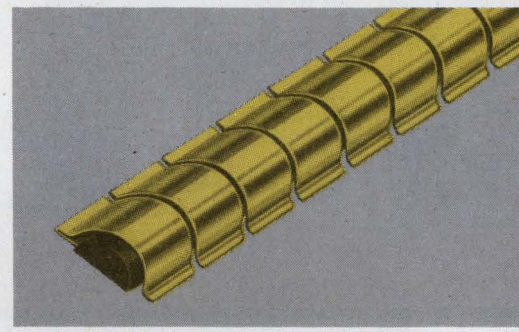

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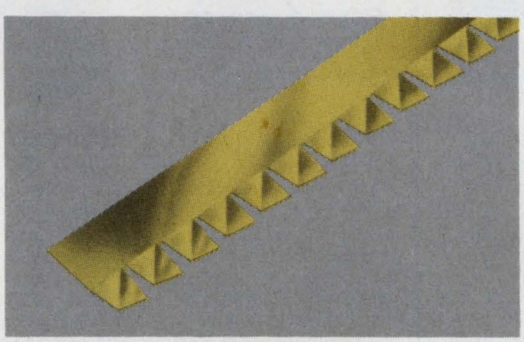

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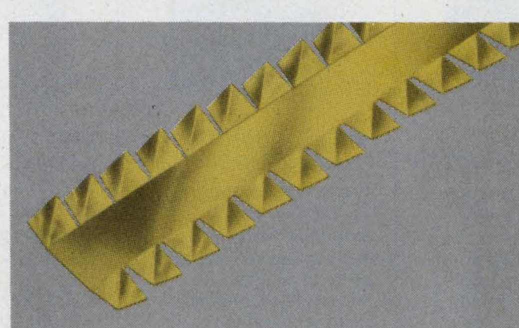

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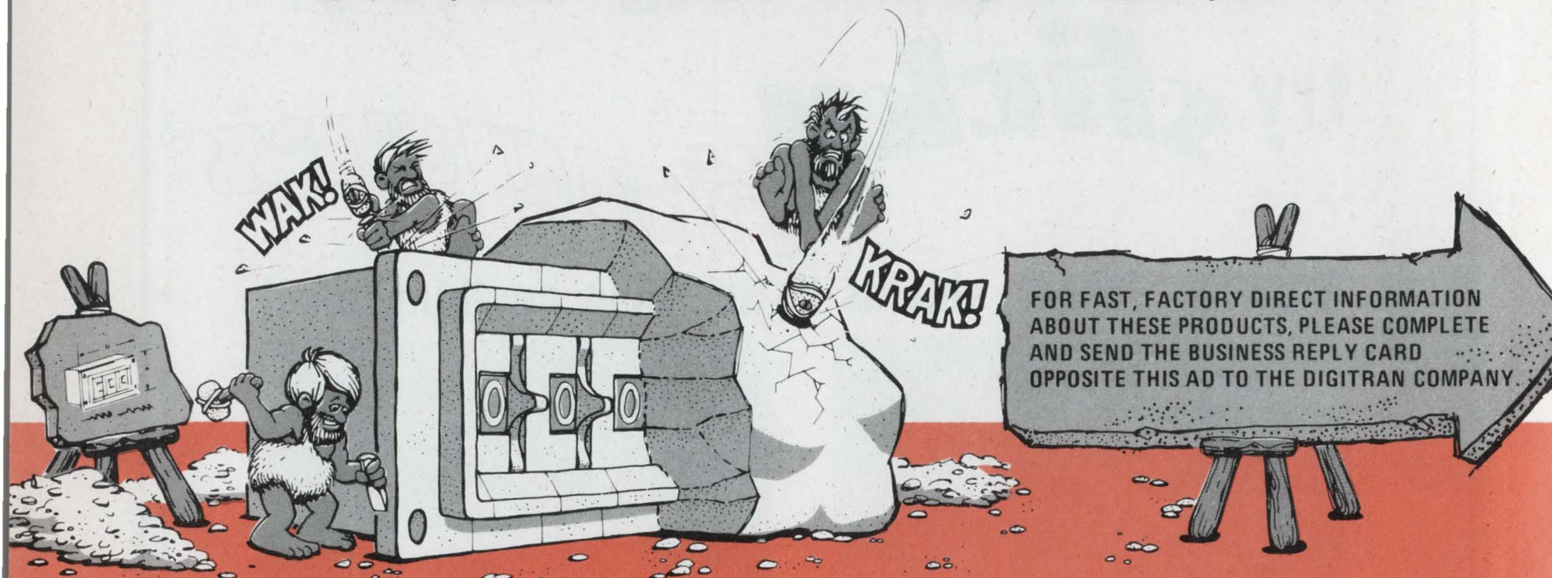

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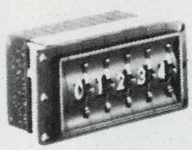

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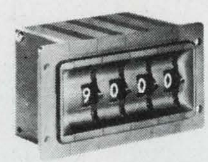

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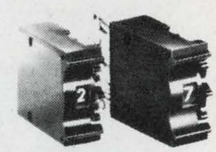

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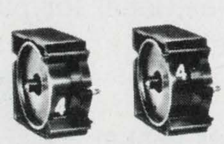

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- Best for positive, quick set/reset uses

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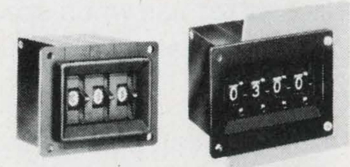

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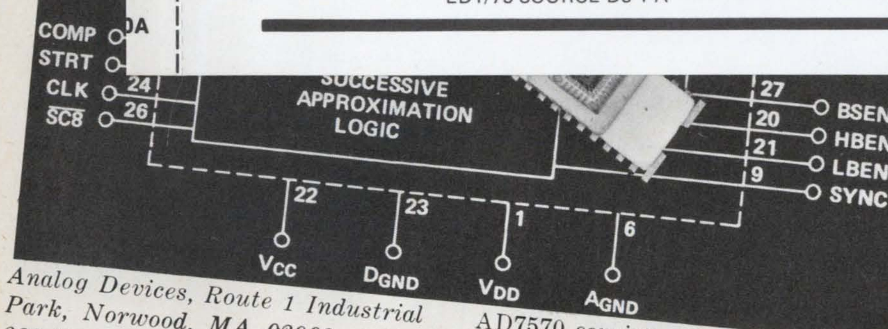


Analog Devices, Route 1 Industrial Park, Norwood, MA 02062. (617) 329-4700. P&A: See text.

Though not the first analog-to-digital (a/d) converter to have 10-bit resolution, CMOS low-power dissipation or fast data-acquisition capability, Analog Devices' AD7570 is the first to offer these features on a single chip.

And the thin-film IC, which performs successive-approximation conversion, permits direct interfacing with commercially available LSI microprocessors that require an 8-bit byte.

Previously, only hybrid-IC or discrete-component converters have offered this combination of features. Competing IC versions employ an integrating-type of a/d conversion to provide digital display of relatively slow-changing analog values.

Other monolithic a/d converters that have preceded Analog Devices' AD7570 consist of these three: the single-chip MC904 from Integrated Photomatrix (1101 Bristol Rd., Mountainside, NJ 07092); the MC1505 analog subsystem from Motorola Semiconductor (5005 E. McDowell Rd., Phoenix, AZ 85036); and the two-chip LD110/111 or LD111/114 (just announced) from Siliconix (2201 Laurelwood Rd., Santa Clara, CA 95054).

These models are primarily BCD converters, though the Motorola analog unit specifies up to 13 bits of binary data. Monolithic converters offer the advantage of reduced package count in DVM applications that call for typical display resolutions of 3-1/2 digits.

The new Analog Devices converter requires a comparator—such as the standard LM311—a reference voltage and a 15-V power supply. A 5-V supply is also needed if the CMOS-compatible circuit must be made TTL-compatible on its digital

Three-state control logic on the chip provides up to 10 bits of data directly onto an eight-line microprocessor bus. This control also can be used to multiplex one converter with other AD7570s or I/O peripheral devices. Successive-approximation techniques achieve throughput rates of 50 kHz for the 10-bit output.

Through control and status lines, the converter supervises interface operations. One strobe line controls the two most-significant bits, while a second controls the remaining eight least-significant bits. A status, or ready, line keeps track of the conversion process, and it responds to inputs from a ready-enable line.

In addition to 10 parallel output lines, the AD7570 has a serial output line. Serial data are synchronized to the 10 positive edges of the clock signal. Both serial and parallel outputs—all are three-state lines—can be bussed with similar lines on other AD7570s.

A multiplying digital-to-analog converter in the chip's feedback loop permits ratiometric operation. The reference voltages may be switched for different full-scale ranges without the need for external amplifiers that would boost low-level analog inputs.

(continued on page 82)

INTEGRATED CIRCUITS

(continued from page 81)

The chip's low differential nonlinearity allows the manufacturer to guarantee no missing codes. Over the 0-to-75-C temperature range, all 1024 digital outputs will appear when the analog input is varied from minimum to maximum values. The AD7570 has a gain temperature coefficient of less than 10 ppm of full scale/°C.

The AD7570 (suffix L) comes in a 28-pin ceramic DIP and costs $69 in quantities of 1 to 49. For $52 an 8-bit version (suffix J) is offered in the same-size ceramic package and the same quantities. Both models cover a commercial-temperature range, and they are expected to be available in production quantities by April. Sample quantities are available from stock.

Analog Devices **CIRCLE NO. 304**

Integrated Photomatrix **CIRCLE NO. 305**

Motorola Semiconductor **CIRCLE NO. 306**

Siliconix **CIRCLE NO. 307**

Low-power S-TTL ICs provide replacements

Raytheon Semiconductor, 350 Ellis St., Mountain View, CA 94042. (415) 968-9211. $2.20 to $11.00 (100-999).

Two families of low-power Schottky-TTL ICs are direct plug-in replacements for the 54LS/74LS and 9LS TTL families. Devices in production now include eight gates, two multiplexers and four shift registers. Introductions in 1975 will begin with flip-flops, counters and inverters plus additional gate and multiplexer types. The company plans to have 62 low-power Schottky devices in production by the end of 1975. The LS series features typical gate delays of 5 ns and typical power consumption per gate of 2 mW. Hence, the speed-power product is only 10 pJ. Initial availability is in the ceramic dual in-line package. Flat packages will be available by special order only. Most types will also be available in beam-lead chip form in 1975.

CIRCLE NO. 308

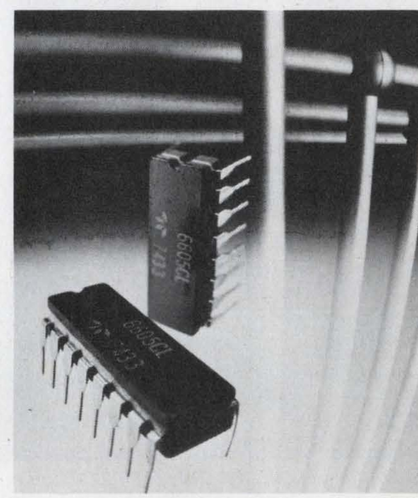
Bipolar RAM dissipates low power

Fairchild Integrated Circuits Group, 464 Ellis St., Mountain View, CA 94042. (415) 962-3541. $22 (100-999).

The 93L415, a 1024-bit Isoplanar static RAM, typically dissipates 200 mW with a maximum of 250 mW at 75 C. The new RAM has a typical access time of 80 ns in addition to standard TTL-output characteristics. The new unit achieves the same power dissipation as existing MOS static RAMs while maintaining a five-times speed advantage.

CIRCLE NO. 309

Bus driver/receiver simplifies interfaces

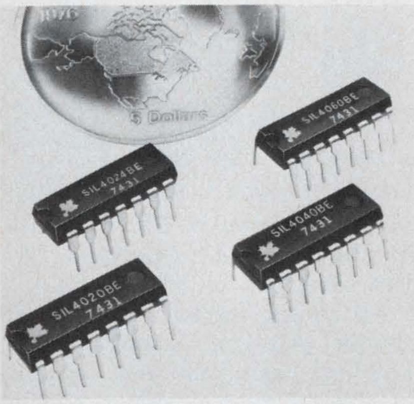


Teledyne Semiconductor, 1300 Terra Bella Ave., Mountain View, CA 94043. (415) 968-9241. $2.16 to $2.81 (1000).

The 6605 TTL quad bus driver/receiver allows subsystems to communicate over a common bus with increased speed and noise immunity. It also protects the system during subsystem power interruptions, and permits simplified bus and logic design. Drivers can sink 100 mA continuously and the receiver inputs are fully buffered. Absolute maximum currents are 150-mA bus current and 30-mA receiver output current. Receiver logic thresholds are 1.4 and 3.0 V, assuring noise margins 1.0 V greater than TTL margins (400 mV). Output nodal capacitance is a low 8 pF. Typical propagation delays range from 20 to 40 ns with a load of 450 pF and 50 Ω.

CIRCLE NO. 310

Four CMOS ICs count and divide



Siltek International Ltd., Airport Industrial Park, Bromont, Quebec JOE 1LO, Canada. (514) 534-2255. $1.75 to $3.00 (1000); stock.

CMOS multistage ripple-carry binary counters/dividers are offered in four circuits that have input-pulse shaping circuitry, reset capability and buffered outputs. The counters/dividers operate with a maximum clock frequency of 10 MHz at $V_{DD} = 10$ V and $C_L = 50$ pF. The SIL4024B consists of seven ripple-carry stages with buffered outputs. The SIL4040B consists of 12 ripple-carry stages with buffered outputs from each stage. The SIL4020B and SIL4060B have 14 ripple-carry stages with 12 and 10 buffered outputs, respectively. The SIL4060B has multiple-inverter and flip-flop circuitry for RC or crystal-oscillator configurations. Both MIL and commercial temperature-range versions are available.

CIRCLE NO. 320

IC drives stepper motors

N.V. Philips' Gloeilampenfabrieken, Elcoma Div., P.O. Box 523, Eindhoven, the Netherlands.

The SAA1027 monolithic stepper-motor driver performs all the necessary functions between data-information pulses and motor windings. The IC replaces discrete circuitry, and it yields up to 500 mA of direct unipolar drive to each phase of a 12 V, four-phase, two-stator stepper motor. Outputs are protected against transient spikes. The SAA1027 operates from supplies in the range of 9.5 to 18 V dc. Current consumption is 4.5 mA, excluding load current.

CIRCLE NO. 321

Video converter delivers 8 bits at 17 MHz

ILC Data Device Corp., 105 Wilbur Pl., Bohemia, NY 11716. (156) 567-5600. $3500 (1 to 9).

The Model VADC-8/17 video digitizer can accommodate full-scale changes from one 8-bit binary word to the next at rates up to 17 MHz. The unit is a complete analog-to-digital converter that contains its own integral sample-and-hold. The s/h circuit has an aperture jitter of less than 60 ps and aperture delay of 37 ns. The high impedance input (FET) accepts ±2.5-V signals (other ranges available) and the output delivers parallel positive true offset binary logic compatible with ECL/TTL. A 50-Ω line driver option is available. The high spurious harmonics signal-to-noise ratio (better than 45 dB from 0 to 5 MHz) results in minimum signal degradation due to the digitizing process. Offset temperature coefficient is ±400 μV/°C and gain tempco is ±100 ppm/°C over the operating temperature range of 0 to 70 C. Operation with moderately degraded specs is possible from −55 to +85 C. Power requirements are +15 V at 180 mA, ±1%; −15 V at 150 mA, ±1%; +5 V at 600 mA, ±3%; and −5 V at 1.8 A, ±3%. The converter is mounted on four repairable printed circuit cards in a wraparound card file and measures only 4.5 × 8.5 × 3 in.

CIRCLE NO. 322

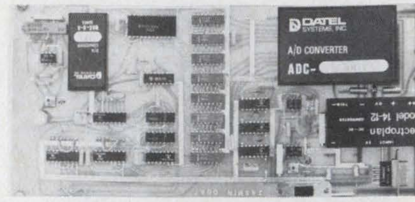
Temperature controller handles 7-A loads

Sys-Tec, 877 Third St., SW, New Brighton, MN 55112. (612) 636-6373. $52 (qty).

Model TC-118 temperature controller provides on-off switching within 5% of the dialed temperature. It uses a zero-voltage cross-over solid-state circuit capable of handling up to 7 A. Dial accuracy is ±2%; repeatability of switching point is ±1%. The input circuit accepts a 676 Ω NiFe resistance temperature detector, which may be field interchanged without recalibration.

CIRCLE NO. 323

Analog signal time delay handles 5 kHz inputs



Jasmin Electronics, Boston House, Abbey Park Rd., Leicester, LE4 5AN, England. £ 420.

An analog memory module can provide delay on analog signals. The unit has a minimum capability of handling one channel, storing 256 4-bit words and passing data at 5 kHz. The board can be expanded in both word length or storage capability. The minimal size board is 8 × 4 in., requires +5 V at 900 mA and can accept and deliver 0-to-10-V analog signals. The unit has an on board power switch to allow removal and replacement without disturbing main equipment.

CIRCLE NO. 324

F/v converter delivers 1 mV to 10 V

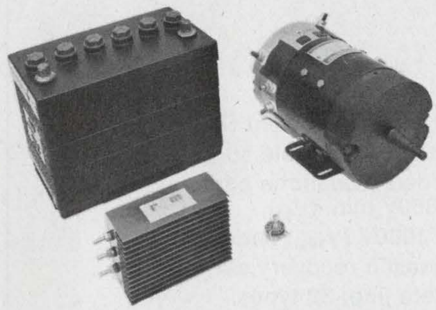
Teledyne Philbrick, Allied Dr. at Rte. 128, Dedham, MA 02026. (617) 329-1600. $39.50 (unit qty.); stock.

A 10-kHz frequency-to-voltage converter, the 4714, delivers a 1 mV to +10 V output voltage. The output is a direct linear function of the 1 Hz to 10 kHz input frequency. With four decades of dynamic range and linearity of 0.08% of F.S., the 4714 is designed for use in FM demodulation equipment as well as wide range frequency monitors.

CIRCLE NO. 325

200-A motor controller provides high power in a small package

RPM Industries, 6371 Arizona Circle, Los Angeles, CA 90045. (213) 670-4127. $269.10 (1 to 9); 2 wk.



One quarter the size and one third the price of a comparable SCR motor controller, the RPMC-200 illustrates the advantages of using power Darlington transistors instead of SCRs. Made by RPM Industries, this 200-A motor controller is claimed to be the smallest, lightest and cheapest in its class.

The controller uses new 200-A, 120-V monolithic power Darlington transistors, made by RPM, as the power output devices. It is reportedly the most powerful monolithic Darlington on the market.

Since it uses switching transistors instead of SCRs, this dc controller also avoids the problems of runaway that sometimes occur in SCR controllers. Runaway is when commutation circuitry fails and the SCRs don't turn off.

The controller uses a chopper circuit to control the speed of dc wound field or permanent-magnet traction motors.

Current multiplication at low motor speeds increases the torque and efficiency of the motor at start-up and during acceleration. You can control the output power from the RPMC-200 by varying a potentiometer.

The efficiency far surpasses SCR controllers. While SCR controllers are rarely better than 90% efficient, the RPMC-200 has a 96% or better efficiency over its entire output current range.

Voltage can be varied from 6 to 60 V, and the chop rate is 400 Hz.

The case dimensions for the aluminum, finned casting are approximately 6 × 4 × 2 in., and the unit weighs 2 lb.

CIRCLE NO. 303

High resolution DACs handle up to 16 bits

Function Modules, 711 W. Seventeenth St., Costa Mesa, CA 92626. (714) 645-6001. From $149; stock.

The 414/416/418 family of d/a converters can be connected for either current or voltage outputs. The 414 is available in a 14-bit version with a linearity of 0.003% and a tempco of ±3 ppm/°C. The 416 is available in a 16-bit or 4-digit BCD version with linearities of 0.002% and 0.005%, and tempcos of ±2 or ±3 ppm/°C, respectively. The 418 is a 4-1/2 digit BCD converter with a linearity of 0.003% and a tempco of ±3 ppm/°C. All converters require only ±15 V at 25 mA.

CIRCLE NO. 326

A/d converter series has 10 and 12-bit units

Datel Systems, Inc., 1020 Turnpike St., Canton, MA 02021. (617) 828-8000. From $99 (unit qty); stock to 4 wk.

The ADC-MA series of a/d converters uses successive approximation conversion techniques and gives 10 or 12-bit resolution. The units have conversion times of 20 or 40 μs. Four different models are available and offer a choice of resolution and conversion time. All models have four voltage input ranges and an optional internal buffer amplifier, which provides a 1000 MΩ input impedance. The single-ended input voltage ranges are 0 to +5, 0 to +10, ±5, and ±10 V and are pin selectable by the user. The digital output data for unipolar operation are straight binary in either serial or parallel format. For bipolar operation the output data are offset binary in serial format and offset binary or two's complement in parallel format. The temperature coefficients for units in the ADC-MA series is 30 ppm/°C for gain and 5 ppm/°C for offset. The converters are encapsulated in a 4 × 2 × 0.4 in. module with DIP compatible 0.1 pin spacing. Input power requirements are ±15 V dc at 40 mA and +5 V dc at 200 mA. Operating temperature range is 0 to +70 C.

CIRCLE NO. 327

Ac/dc voltage source offers programmability & precision

Optimation, 9259 Independence Ave., Chatsworth, CA 91311. (213) 882-6490. See text: 6 to 8 wk.

Engineers in calibration and standards labs have long sought a high-precision voltage calibrator that provides both ac and dc in a single box. And for automated calibration systems and production-line test systems for precision instruments, programmability is desirable. Both of these features are incorporated in a pair of instruments from Optimation.

The AC-126 is the basic calibrator; for the programmable version, the model number changes to AC-130. The voltage accuracy for both units is ±0.002% of setting for all ranges on dc. Accuracy on ac is not as tight, but it ranges from ±0.01% over 50 Hz to 20 kHz, to ±0.2% over 0.1 MHz to 1.1 MHz. No other frequency range is worse than ±0.05%.

Voltage ranges on both ac and bipolar dc extend from 10 nV to 100 V in six decade ranges with six-place settability and 20% overranging. Frequency extends from 10 Hz to 1.1 MHz through the 10 V range and to 110 kHz through 100 V.

With the PA-226 high-voltage amplifier (an option at $2995), the ac and dc ranges can be extended to 1200 V. Other companies offer similar high-voltage options on ac calibrators.

Some additional features of the calibration instruments from Optimation include:

- Short-circuit-proof circuitry that reverts to standby mode under overcurrent or short-circuit conditions and cannot be reprogrammed until the fault is removed.
- Floating or grounded output that allows operation at 120 V ac or 500 V dc above ground.
- Flexible programming format in the AC-130 that provides a choice of positive or negative true logic, BCD or individual lines and choice of strobing.

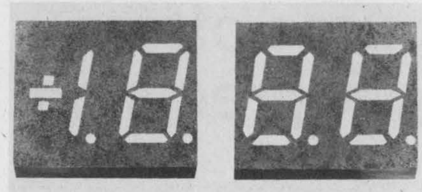
For ac dc error measurement, a calibrated offset error can be introduced using a 10-turn potentiometer. Three ranges are available: 0% (calibrated output); ±0.5%; and ±5%.

The price of the AC-126 is $5495. The AC-130 (with programming) costs $6995.

CIRCLE NO. 301

DISCRETE SEMICONDUCTORS

0.5 in. high displays come two in a package



Litronix, 19000 Homestead Rd., Cupertino, CA 95014. (408) 257-7910. $4.70/2 digits (1000-up); stock.

Two 0.5 in. high LED displays, in a single DIP-type package, include the DL-727, which has two 7-segment digits plus decimal points, and the DL-721, which has a plus-or-minus sign and a "1" preceding one 7-segment digit. All modules are end-stackable to produce any combination of 0.5-in. digits on 0.5-in. centers. Luminous intensity is 5 mcd at 20 mA per segment. Light pipes spread illumination evenly over broad segments. Both modules have the same drive requirements. Power required is only 30 to 40 mW per segment from standard logic voltage supplies.

CIRCLE NO. 328

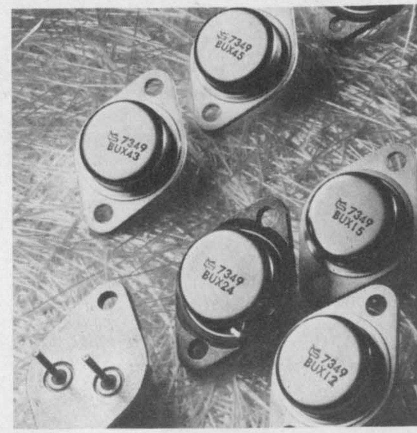
Npn/pnp power devices handle up to 200 W

Power Physics, Industrial Park West, Eatontown, NJ 07724. (201) 542-1393. From $2.40 (100-up); 2 wk.

A family of epitaxial base npn-pnp power transistors is designed for high power switching applications, and perform well in amplifiers rated for a 50-kHz bandwidth. The following JEDEC types are available: 2N5301, 2N5302, 2N-5303, 2N6326 through 2N6331 and 2N5683 through 2N5686. These families feature h_{FE} ranges from 15 to 50, V_{CEO}'s from 40 to 140 V and f_{ts} of 4 MHz. Power dissipation ranges from 117 to 200 W for the TO-3 packaged transistors.

CIRCLE NO. 329

High-voltage transistors handle up to 500 V

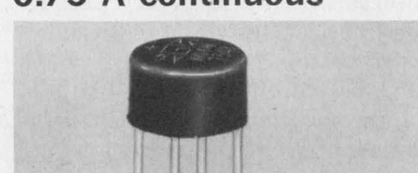


Thomson-CSF, Sescosem, 101 Boulevard Murat, 75781 Paris Cedex 16.

Three series of power transistors, the BUX39 to BUX45, BUX10 to BUX15 and BUX20 to BUX-25, are specially designed for use as fast switching transistors in high voltage inverters (25 kHz), ultrasonic generators and choppers. Their performance with voltages up to 500 V ($V_{CEO(sus)}$) allows them to be connected to 220-V power lines without a transformer. Some of the main characteristics include $V_{CEO(sus)}$ from 90 to 500 V, $I_{C\ max}$ from 15 to 30 A, $I_{C\ effective}$ from 8 to 20 A, $V_{CE\ sat}$ from 1 to 1.6 V and t_f from 0.3 to 1.6 μs.

CIRCLE NO. 330

Bridge rectifiers handle 0.75 A continuous



General Instrument, Semiconductor Components Div., 600 W. John St., Hicksville, NY 11802. (800) 645-1247. Model 75 W02M: $0.20 (25,-000-up); 3 to 4 wk.

The 75 WOM series of miniature 0.75 A single-phase, silicon bridge rectifiers has PRVs from 50 to 1000 V. Depending on PRV rating, the units have a maximum rms input voltage of 35 to 700 V and a maximum dc blocking voltage of 50 to 1000 V. All minibridges in the 75 WOM series have a peak surge overload rating of 30 A and an operating temperature range of -55 to $+125$ C.

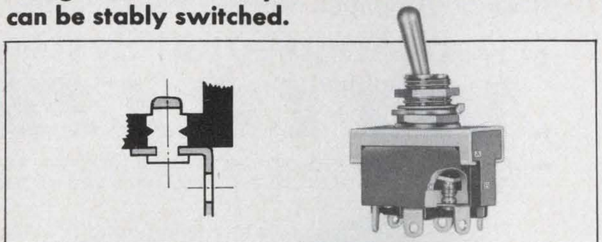
CIRCLE NO. 331

MOLDED IN SERIES

STABLE SWITCHING FROM MINUTE CURRENT TO HEAVY CURRENT

Series A | **Series B**

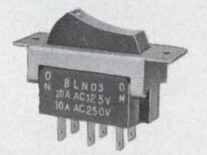
Designed to extremely low noise contact construction related value, from minute current to heavy current can be stably switched.



7 types, 100 models
Ratings: 25, 20, 15 & 10A 125V 250VAC
Contact resistance: DC 2～4V, 0.1A 10mΩ maximum
Types: Toggle, rocker, slide, pushbutton, double pushbutton, rotary, molded lever.

Ⓐ Short caulking frame
- Frame and conductor are perfectly separated for perfect isolation and safety.

Ⓑ UL Standards 94V-0 approved material
- Superior arc resistance, heat resistance, cold resistance, moisture resistance, and shock resistance.



8 types, 200 models
Rating: 10 & 6A 125V 250VAC
Contact resistance: DC 2～4V, 0.1A 10mΩ maximum

(1) All models are highly reliable, trustworthy products which satisfy 10A specifications. The 10A type are small, low-cost popular type.
(2) Perfectly sealed terminals prevent the entry of flux 'nto the case.
(3) Unit type terminal contacts prevent electrical accide. ts even if the case should be deformed by soldering heat, etc.

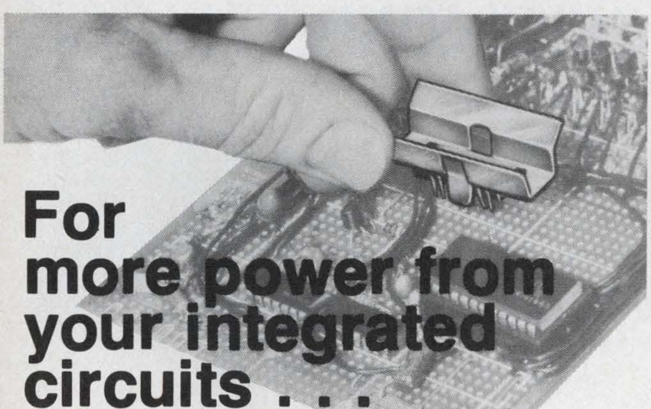
Ⓒ Buried fixed contacts system
- This system eliminates entry of flux into the case.
- Electrical performances are not effected by loosening of the terminals or deformation of the case due to heat.

OHTO CO., LTD.

Meeting your design needs......

18-1, MINAMIOHI 5-CHOME, SHINAGAWA-KU, TOKYO, 140 JAPAN
PHONE: 03 (765) 7216～7

INFORMATION RETRIEVAL NUMBER 62

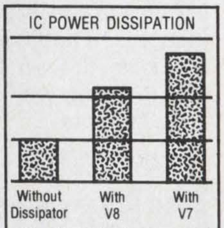


For more power from your integrated circuits . . .

Specify Staver heat sinks of silver-bearing copper.

Our specialized metal alloy does the trick. The silver-bearing copper in Staver Thermovane® V7 and V8 heat sinks conducts more heat from IC packages. And as heat dissipation increases, so does power output. Staver Thermovanes also mean longer life and greater reliability for your power-type circuits.

The V7 and V8 were designed for 14- and 16-pin dual in-line packages with side tabs, like the Sprague A, P and Q and National Semiconductor LM 377, 378 and 380. Other Staver Thermovane heat sinks are available in a wide variety of designs and configurations. Write us for full details.



The chart tells the story. IC power dissipation more than triples with Staver's V7, more than doubles with the V8.

THE Staver COMPANY INC. 41-51 N. Saxon Ave., Bay Shore, N.Y. 11706 (516) 666-8000

INFORMATION RETRIEVAL NUMBER 63

If **Better Cooling** is what you need, *Better Cooling* is what you get! **astrodyne's**

New!

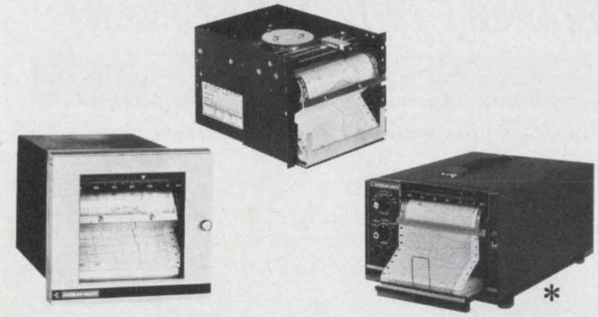
Forced Convection Catalog offers the widest selection of high performance and economical cooling packages available. Easy to use performance charts simplifies selection of the most suitable assembly.

for your free Forced Convection Assembly catalog FC-730 see your Astrodyne representative or write:

astrodyne, inc.
SUBSIDIARY OF ROANWELL CORPORATION
353 MIDDLESEX AVENUE / WILMINGTON, MASSACHUSETTS 01887
(617) 272-3850 TWX 710-347-0704

INFORMATION RETRIEVAL NUMBER 64

Miniservo® recorders shipped in 72 hours*



Three basic models, hundreds of combinations—bench, panel, and OEM (stripped)—offer accurate, dependable performance at an average price of $400. Miniservo basic full scale sensitivity is 100 MV (0 to 1, 10, 50, 100, 500 MV, 1 V ranges available) with a response speed of 0.5 sec, accuracy within 0.5% of span, and 8 chart speeds from 1.25 to 300 cm/hr or faster. 10 cm active width chart is Z-fold or roll. Disposable fiber pen/ink writing. Full scale zero adjust. *And for $525, you can get a stock S-22087 multi-speed, multi-range bench-mount unit **shipped in 72 hours.** Request Bulletins F 610, 611 and 612 from Esterline Angus Instrument Corporation, Indianapolis, IN. 46224. 317/244-7611.

ESTERLINE ANGUS
A UNIT OF ESTERLINE CORPORATION

INFORMATION RETRIEVAL NUMBER 65

0.01% linearity 0∽5V level Isolation Amplifier!

200μsec rise-time, 60dB more S/N of this Isolation Amplifier meet all the requirements of **Data Acquisition System**

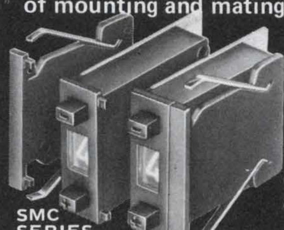
MTT CO., LTD.

SUGIURA BLDG. 10-2, DAIKYO-CHO, SHINJUKU-KU, TOKYO 160, JAPAN
PHONE: (03) 341-8330 TELEX: J26779 CABLE: PORTEDROITE TOKYO

INFORMATION RETRIEVAL NUMBER 67

ALCOSWITCH®

The World's smallest BI-DIRECTIONAL, CODE PUSHBUTTON switch with large easy-to-read numerals. Available in a variety of coded outputs (includes decimal) and lots of mounting and mating accessories.



Call (617) 686-0126 today for detailed information and ask us for a "dummy" switch to study and compare on your own panel design.

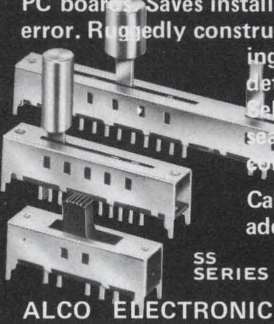
SMC SERIES

ALCO ELECTRONIC PRODUCTS, INC.
1551 Osgood St., No. Andover, Mass. 01845

INFORMATION RETRIEVAL NUMBER 102

ALCOSWITCH®

High density multiple position SLIDE SWITCHES designed specifically for PC boards. Saves installation time and wiring error. Ruggedly constructed with metal housing. All models have ball detent for positive feel. Self-cleaning contacts & sealed terminals prevent contamination.



Call (617) 686-0126 for additional information.

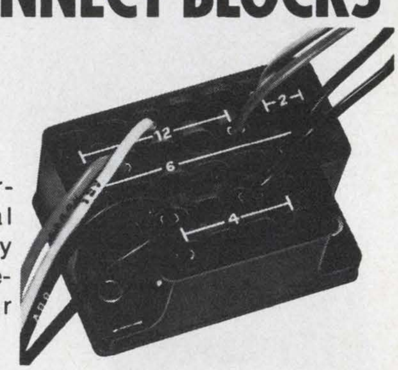
SS SERIES

ALCO ELECTRONIC PRODUCTS, INC.
1551 Osgood St., No. Andover, Mass. 01845

INFORMATION RETRIEVAL NUMBER 103

QUICK-CONNECT BLOCKS

With Infinite Design Possibilities



There's an Underwriters Terminal Block for virtually any design requirement you have or can conceive.

No other line offers a wider selection of blocks and variations of in-block circuitry. Any number of terminations. Wide choice of configurations. Most are UL recognized and CSA certified. Blocks in kit form, too. Also special designs and hot-stamped coded blocks.

Request bulletin.

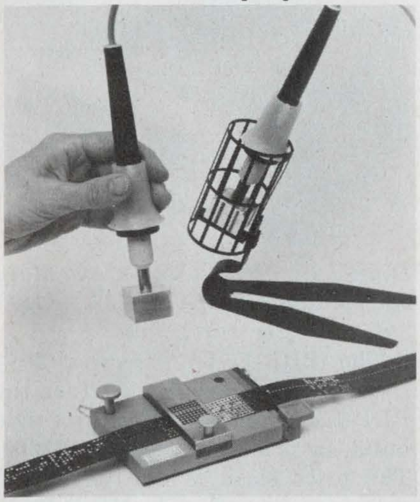
Underwriters Safety Device Company

7300 W. Wilson Ave., Chicago, Ill. 60656 • 312-867-4600

INFORMATION RETRIEVAL NUMBER 68

PACKAGING & MATERIALS

Heat-sealed splices hold on oiled paper



Computer Accessories Corp., 211 New York Ave., Huntington, NY 11743. (516) 421-0929. $23: Iron, $5.79 per 50 ft roll tape.

Now you can convert your perforator tape patch splicer into a heat-seal splicer, inexpensively, with the CAC 503 heat-sealing iron and 900 series heat-seal splicing tapes. Gum adhesives on conventional pressure-sensitive patches run from humidity or melt from temperatures produced by photocell lamps. And oiled perforator tapes pose an adhesion problem. The 900 series tapes, made of metalized Mylar, produce a permanent bond at 350 F, which endures extreme storage and operating conditions. The tapes can be used with any level oil or unoiled paper, or Mylar tapes.

CIRCLE NO. 332

Fuzz buttons useful for probe contacts

Technical Wire Products, Inc., 129 Dermody St., Cranford, NJ 07016. (201) 272-5500.

Fuzz buttons are resilient, multipath contact elements produced by the die compression of a charge of fine knitted wire mesh to a desired shape and density. The buttons provide low resistance, redundancy of contacts and mechanical compliance. They make reliable test connections and probe contacts in earphones, switches and field radios. Any wire that can be knitted can be used to produce the buttons.

CIRCLE NO. 333

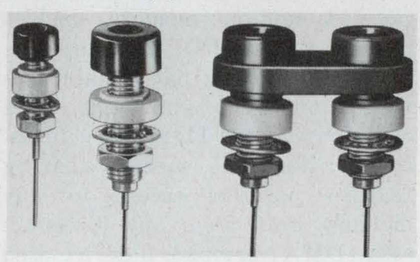
Rectangular connector mates with zero force

International Telephone & Telegraph Corp., 666 E. Dyer Rd., P.O. Box 929, Santa Ana, CA 92702. (714) 557-4700. 4 wks.

Instamate rectangular connector, DL3-60, features zero mating force with cam-actuated contacts. Hermaphroditic contacts, removable crimp snap-in contacts, 10,000 mating-unmating cycles and machine wire wrapping are some of the other features. The connector is intermountable with the ELCO 56-pin Varicon, 50-pin AMP "M," 50-pin Burndy "HYFEN" and the Winchester "MRA" connectors. The body is made of glass-filled Noryl insulator material with copper-alloy contacts. There are 36 polarizing positions and the ambient operating temperature is −65 to 100 C.

CIRCLE NO. 334

Banana jack features wire-wrappable terminal



ITT Pomona Electronics, 1500 E. Ninth St., Pomona, CA 91766. (714) 623-6463.

Three new banana jacks fitted with 0.025-in., square wrapped-wire terminals are offered in three configurations: standard single jack, Model 4005; standard double jack, Model 4069; and a miniature single jack, model 4022. All are molded of polycarbonate thermoplastic per Federal Spec L-P-394A to a nickel-plated brass body for low insertion loss, low power factor and high insulation resistance. The wrap pins are gold plated.

CIRCLE NO. 335

INFORMATION RETRIEVAL NUMBER 69

DATA PROCESSING

Versatile test panel interfaces to card files

Mupac Corp., 646 Summer St., Brockton, MA 02402. (617) 588-6110. $25 (qty 10); 3 wks.

A family of panels is designed for card file interfacing and diagnostic testing. These panels may be used for input-output expansion, for active test stimuli and measurement or for mounting discrete components not able to be mounted within the card file. These panels offer a practical way of disconnecting stranded wire signal leads and power leads from card files with Gardner Denver's wrapped-wire back planes. The panels communicate to the card file by means of a 36/54 pin connector mounted at the top of each card. The two piece connector arrangement permits multiple insertions as well as strain relief for the stranded wire.

CIRCLE NO. 336

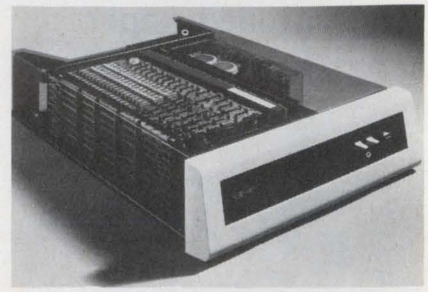
Dual-port memory lets minis do multiprocessing

Cambridge Memories, 12 Crosby Dr., Bedford, MA 01730. (617) 271-6300. $1875.

An extension of Cambridge's Dual-Port option on its ExpandaCore-11 add-on memory enables more than two PDP-11 computers to be linked in a daisy-chain configuration while sharing a series of ExpandaCore-11 memory units. In addition, the memory-sharing feature permits access to any memory unit from any direct-access (DMA) peripheral device used with PDP-11 processors. Access to the Dual Port memory by one of the processors allows independent operation of the alternate processor in the multiprocessor link, with its resident memory and associated peripherals. ExpandaCore-11 memory systems are plug-compatible with all models of Digital Equipment Corporation's PDP-11 minicomputers. The Dual Port memory systems are expandable up to 120k words (with or without parity) in increments of 8k or 16k. A 14-in. enclosure (17-in. deep) houses each memory.

CIRCLE NO. 337

Mini price slashed; console is virtual



Digital Equipment Corp., 146 Main St., Maynard, MA 01754. (617) 897-5111. See text; July.

The PDP-11/04 offers a 20% speed increase over its partner the PDP-11/05 yet costs $2495 in single units—a price reduction of $1300. The price slash is due to several factors: use of 4 k MOS RAM rather than core; a software replacement of the 11/05 control console (in ROM); and omission of the real-time clock, auto restart and serial line controller. The latter three are optional. The machine offers a 750-ns cycle time and total compatibility with the 11/05, including vectored automatic interrupt. If you add a serial interface all console functions can be commanded from a terminal or even another machine. Hence a host computer can do remote diagnostics or even transmit programs for execution by the 11/04. The other ROM programs include a bootstrap loader and extensive diagnostics. The console has only two controls; power and bootstrap load. Memory is available in 4 k or 8 k word units to a maximum of 28 k. In quantities of 50 the price of a 4-k (word) machine drops to $1647.

CIRCLE NO. 338

Card-to-tape converter digests 150 card/min

Datatex Corp., 10935 S. Wilcrest Dr., Houston, TX 77072. (713) 495-3100. $7000; 60 to 90 days.

The Model card-to-tape converter can punch up to 75 card/s and read 60 to 150 cards/min., depending on the amount of data. Important capabilities include multiple code operation, programmable formats with up to 65 Hollerith characters and verification of data after punching.

CIRCLE NO. 339

INFORMATION RETRIEVAL NUMBER 71

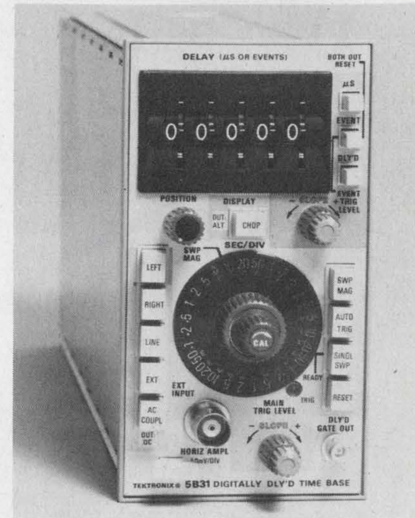
INFORMATION RETRIEVAL NUMBER 73

INFORMATION RETRIEVAL NUMBER 72

INFORMATION RETRIEVAL NUMBER 74

INSTRUMENTATION

Digital unit boosts time-base accuracy



Tektronix, P. O. Box 500, Beaverton, OR 97005. (503) 644-0161. $600; Feb. 15.

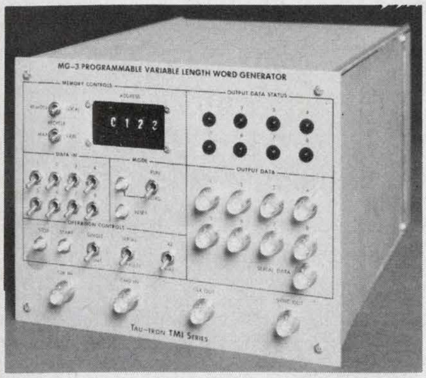
Model 5B31 digitally-delayed time base, a new plug-in in the 5400-Series scope line, overcomes many of the problems of the analog time base. The unit's digital pushbuttons and thumbwheels eliminate the ambiguity of dials and multipliers, and make it easy to set the number of delaying events or time periods. The delay system—a crystal-controlled clock, digital counter, and a unique circuit that eliminates one-count ambiguity in the counter—replaces the usual delaying time base.

In the delay-by-events mode, the 5-digit thumbwheel switch displays the number of events following the main triggering event before the sweep starts. This mode provides a diagnostic tool in the analysis of high-jitter digital data streams, like those from disc memories or tape recorders. There is an independent trigger level and a slope control for the event input from the left vertical plug-in. The event trigger operates to 20 MHz.

The delay time can be incremented in 1-μs steps from 0 to 99,999 μs and read directly from the 5-digit thumbwheel switch (no multiplication is necessary). The calibrated sweep and no-parallax internal CRT graticule in the scope mainframe can be used to interpolate between 1-μs steps for greater resolution. Delay jitter is less than 10 ns plus 1 part in 10^7.

CIRCLE NO. 302

Word generator outputs variable data stream

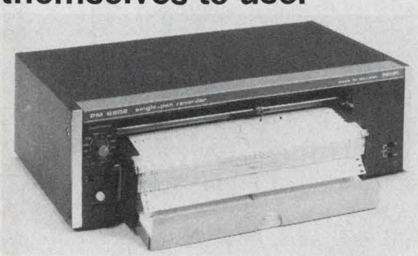


Tau-Tron, 11 Esquire Rd., North Billerica, MA 01862. (617) 667-3874. $4000; 6-8 wks.

MG-3 word-generator module operates at bit rates up to 50 MHz. The unit contains 1024 bits of random-access semiconductor memory programmable from front-panel controls and via a remote bus. The 1024 bits are arranged into a matrix of 8 bits by 128 words. An 8-bit LED display shows the contents of any word in the matrix. Data output may be either in 8-bit parallel, or in serial format. The output word or bit length is controllable in integer steps: in the parallel mode, from 1 to 128 parallel words; in the serial mode, from 1 to 1024 serial bits.

CIRCLE NO. 340

Chart recorders tailor themselves to user

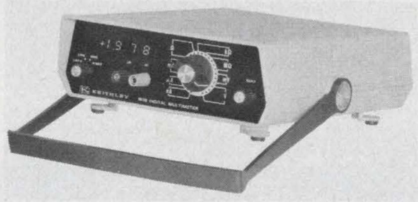


Philips, PO Box 523, Eindhoven, the Netherlands. See text.

Two new, low-profile, compact chart recorders can be tailored to an individual user's requirements. The recorders—PM 8202, single line and the PM 8222, double line—have a response time of 0.25 s for full chart width of 250 mm. Both are basically single span with a sensitivity of 10 mV, although there is a preamp available to increase this to 1 mV when required. The accuracy of both instruments is 0.5% and dead band is 0.1%. No price available at press time.

CIRCLE NO. 341

DMM spans extra wide measurement ranges

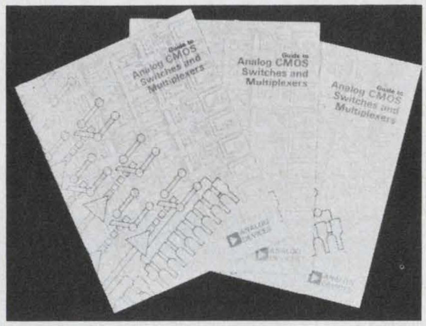


Keithley Instruments, 28775 Aurora Rd., Cleveland, OH 44139. (216) 248-0400. $525.

The voltage sensitivity of the Model 160B DMM ranges from microvolts (1 μV/digit) to kilovolts (1200-V full-range). And a current measuring capability of 10 pA per digit to 2 A enables this new unit to handle many low-level measurements. Wide resistance capability of 1 mΩ per digit to 2000 MΩ completes the all-around performance capability of the 160B. Zero stability is 0.2 μV/°C.

CIRCLE NO. 342

new literature



CMOS switches

A 44-page guide to monolithic analog CMOS switches and multiplexers describes five multiplexer families and six series of dual and quad switches. Specifications include prices, schematics, package configurations, test conditions and performance characteristics. An eight-page applications section discusses CMOS protection schemes, switch and multiplexer terminology, and applications in sample-and-hold amplifiers, data-acquisition systems, commutating bandpass filters, digitally controlled timing circuits, d/a converters and ramp generators. Analog Devices, Norwood, MA

CIRCLE NO. 343

Wire, cable and cord sets

Power cable, portable power cable, Selectrocrown portable cords, control cable and cord sets are described in a six-page catalog. ITT Royal Electric, Pawtucket, RI

CIRCLE NO. 344

Marvin's marvelous mini

If you're facing the decision of whether to build or buy a minicomputer for the system you're planning to take to market, then you might follow the tale of corporate disaster which unfolds in "The Story of Marvin's Marvelous Mini." Marvin's documentary serves up some fascinating guidelines for avoiding such pitfalls as "Paddling the Corporate Canoe up the Creek" or "Getting Caught in Your Own Mousetrap." Computer Automation, Irvine, CA

CIRCLE NO. 345

Instruments and systems

Trim but not slim describes Hewlett-Packard's 572-page menu of instruments and systems for 1975. Wrapped in a new format this year, the coated pages of the HP catalog go down easily as big photos, graphs, technical info and clear descriptions give vent to the company's huge line of appetizing equipment. For your copy, write to 1501 Page Mill Rd., Palo Alto, CA 94304

INQUIRE DIRECT

Data communications

A 12-page catalog describes data communication products. The full-color catalog includes high-speed modems for end-users as well as OEM. International Communications Corp, Miami, FL

CIRCLE NO. 346

Power instrumentation

A systems handbook details real-time event recording for on-line monitoring of faults that are recorded on magnetic tape, oscillographs, printers and frequency and phase angle control for use in economic phase angle power load distribution. Also covered are programmable controllers for use in peak standby generating plants, environmental control applications and automatic demand load controller for economic electric power er demand control. Datametrics, Wilmington, MA

CIRCLE NO. 347

YIG devices

An introduction to YIG devices, a section of definitions of YIG-device parameters as well as five product sections covering YIG-tuned oscillators, YIG-tuned filters, integrated YIG filter/oscillator sets, YIG drivers and YIG-tuned harmonic generators are given in a 24-page catalog. The catalog is illustrated with photographs and outline drawings. Watkins-Johnson, Palo Alto, CA

CIRCLE NO. 348

Transducer control system

The multichannel modular transducer control system is described in a 12-page brochure. Validyne Engineering, Northridge, CA

CIRCLE NO. 349

Desktop index

Now in its second year of publication, The AMT Desktop Index, a guide to design articles in eight top electronic periodicals, is an invaluable reference for the engineer. The 1974 edition spans the last 3-1/2 years and features over 5000 entries in some 250 categories. The index and a six-month update cost $9. AMT Desktop Index, P.O. Box 11275, Kansas City, KS 66111

INQUIRE DIRECT

Circuit breakers

The booklet "UL, CSA and Circuit Breakers: What they mean to you" provides data about the Underwriters Laboratories and the Canadian Standards Association. It discusses the testing standards and procedures for products and explains the specific approvals UL and CSA grant to particular circuit breakers. The booklet lists and describes the company's products under their UL and CSA approval classification. Heinemann Electric, Trenton, NJ

CIRCLE NO. 350

Process control systems

"How a Foxboro Integrated Computer Control System Can Save You Time and Money" details the company's approach to systems integration, using subsystems called SPEC 200, INTER-SPEC, FOX 1 and FOX 2. The Foxboro Co., Foxboro, MA

CIRCLE NO. 351

Submerged arc welding

All the essential ingredients for making a good submerged arc weld plus formulas for determining the cost of the job are included in "The Submerged Arc Welding Handbook." The 68-page handbook presents step-by-step instructions on setting up for welding, preparing the workpiece and making the weld. The handbook is available at $3.50 per copy. Union Carbide, Linde Div., 270 Park Ave., New York, NY 10017

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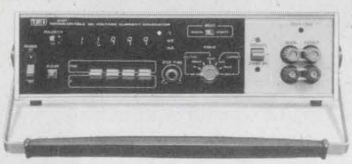

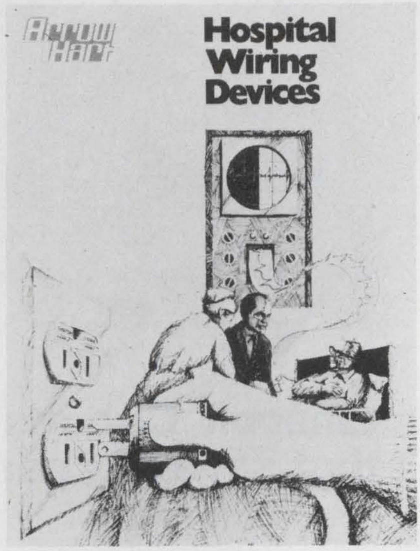

Hospital wiring devices

Ordering information, description and photos of the hospital-grade UL-listed wiring devices are highlighted in a folder. Arrow-Hart, Stamford, CT

CIRCLE NO. 352

Lighted PB switches

Information on the company's Series 01-669 lighted pushbutton switches is colorfully illustrated in a two-page bulletin. Licon, Chicago, IL

CIRCLE NO. 353

Power supplies

Encapsulated power supplies that include thermal barrier, chassis-mount and low profile models, are covered in an eight-page catalog. Specifications, prices, derating information, package configurations and applications are provided for the logic and dual supplies. Analog Devices, Norwood, MA

CIRCLE NO. 354

Financial fact book

"Electronic News Financial Fact Book & Directory 1974" contains a wealth of financial statistics on over 750 electronics companies. The 769-page book lists parent companies alphabetically in the table of contents and an index at the back of the book cross-references divisions. The book costs $60. Fairchild Publications, Book Div., 7 E. 12th St., New York, NY 10003

INQUIRE DIRECT

Knobs

Literally hundreds of different choices of knob styles, sizes and types for every conceivable use are listed in a 17-page catalog. Kurz-Kasch, Dayton, OH

CIRCLE NO. 355

Control/gauges

A 100-page catalog describes low differential pressure air and gas gauges, differential pressure switches, flowmeters, manometers, air filter and air velocity gauges and combustion testing instruments. The catalog includes technical data, OEM and plant applications and prices. Dwyer Instruments, Michigan City, IN

CIRCLE NO. 356

Rack/panel connectors

A DPD/DPDMA rectangular rack/panel connector catalog lists nonenvironmental single and two-gang configurations. The 16-page catalog includes 10 photographs and discusses model differences, rear release contact retention assembly, contact arrangements and variations, polarization, shell dimensions, accessories, contact data and engaging devices. ITT Cannon Electric, Santa Ana, CA

CIRCLE NO. 357

Tachometry systems

An 18-page catalog covers tachometry equipment. The catalog contains descriptions and specifications for frequency-to-dc converters, dc voltage level detectors, over/underspeed controls and indicating or indicating/control tachometry systems. Application, dimensional and how-to-order data are included. Electro Corp., Sarasota, FL

CIRCLE NO. 358

Consumer ICs

A quick guide to standard consumer entertainment integrated circuits lists 36 ICs for such applications as chroma oscillators, demodulators, amplifiers and signal processors, as well as video-fine-tuning systems, detector limiters, gain blocks, stereo decoders, rf/i-f amplifiers, dual audio preamplifiers and audio amplifiers. Sprague Electric, North Adams, MA

CIRCLE NO. 359

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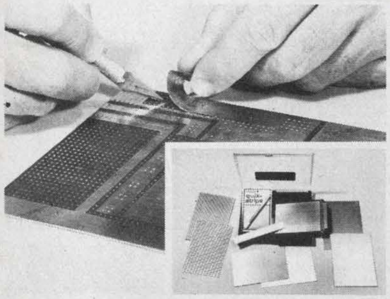

Cut & Peel Circuit Board Kit. Cut prototype boards or ground planes. Assortment of 7 includes one and two sided Cut & Peel Boards on .100" grid drilled and plain epoxy-glass, "X" and "X-Y" Board, a plug-in Cut & Peel GP Board with etched gold/nickel edge connector, and a special knife. Kit #8964 is $37.00. Circuit-Stik, Inc. Box 3396, Torr., CA 90510.

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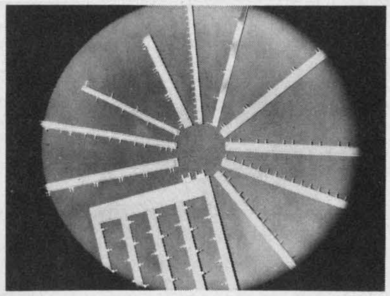

Mini/Bus® Evaluation Kit, $25, in stock. Lets you try Rogers' low-cost, noise attenuating, high packaging density power distribution system for PC boards. Millions in use. Standard parts on 2 weeks delivery, or less! Customer parts 4 to 6 weeks delivery. Rogers Corporation, Chandler, Ariz. 85224. Phone (602) 963-4584

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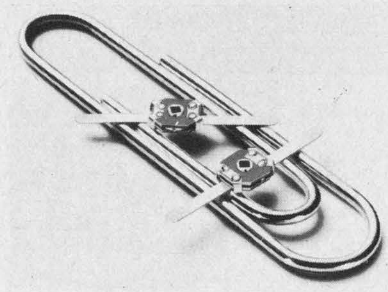
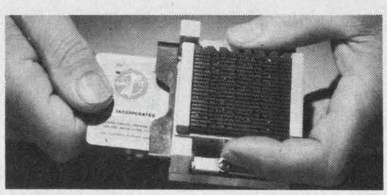


Thin-Trim variable capacitors provide a reliable means of adjusting capacitance without abrasive trimming or interchange of fixed capacitors. Series 9401 has high Q's and a range of capacitance values from 0.2-0.6 pf to 3.0-12.0 pf and 250 WVDC working voltage. Johanson Manufacturing Corporation, Boonton, New Jersey (201) 334-2676.

INFORMATION RETRIEVAL NUMBER 607

Free Applications Booklet—"Group Delay Equalization In Communications Systems". This comprehensive manual, prepared by SEG's Equalizer Design Dept., features useful applications information as well as a tutroial look at the design of equalizers and their functions. SEG Electronics Corp. 120-30 Jamaica Ave., Richmond Hill, N.Y. 11418 (212) 441-3200.

INFORMATION RETRIEVAL NUMBER 602



Where new high security starts, at low, lock-and-key prices. We introduce the AMP 130 Security Card Reader—a high reliability, low-cost first. It could revolutionize your thinking in large-volume access-control applications—hotels, motels, offices, computer peripherals. Or in timekeeping, personnel identification, factory-control equipment, etc. No external power, no complex mechanisms—operates with the insertion of a standard 2⅛ x 3⅜" punched card. Has a maximum capacity of 80 bits. Never needs adjustment or preventive maintenance. Compact, rugged, built to withstand a lot of user abuse. AMP Capitron Division, Elizabethtown, Pa. 17022. (717) 367-1105.

INFORMATION RETRIEVAL NUMBER 605

Free catalog of 34,500 power supplies from the worlds largest manufacturer of quality Power Supplies. New '74 catalog covers over 34,500 D.C. Power Supplies for every application. All units are UL approved, and meet most military and commercial specs for industrial and computer uses. Power Mate Corp. (201) 343-6294.

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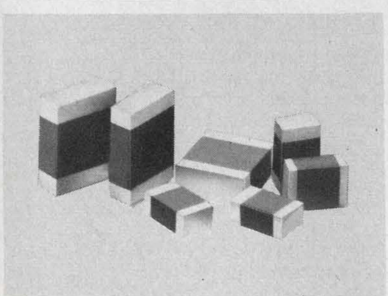
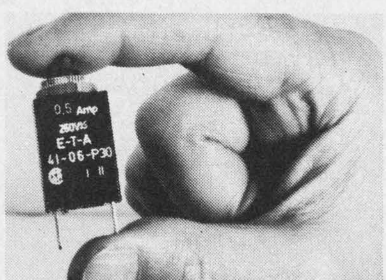


HIGH Q MULTILAYER CAPACITORS feature very high quality factors at microwave frequencies. Offered in three standard sizes: .050 x .040, .080 x .050, .125 x .095. Capacitance values from 0.1 pf to 1000 pf with close tolerance and voltages to 1000 VDCW. Johanson/Monolithic Dielectrics Div., Box 6456, Burbank, Ca. 91510, (213) 848-4465.

INFORMATION RETRIEVAL NUMBER 603



Overcurrent Protector, manual reset eliminates fuse replacement. Convenient panel mounting. 15 fractional ratings from 0.1 to 3 amp. Other models up to 400 amp. Tripfree and fool-proof, UL and CSA approved. High quality, low cost $1.29 ea. in 1000 lots. E-T-A Products Co. of America, 7400 N. Croname Rd., Chicago, Ill. 60648. Tel: (312) 647-8303. Telex: 253780.

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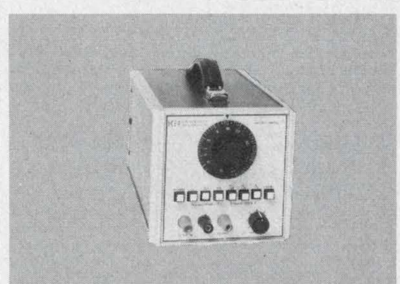

Low Cost Function Generator, Model 5800; sine, square and triangle waveforms from 0.2Hz to 2MHz. 15 volts p-p outputs, 50 ohm output. Distortion typically less than .3%. 1000:1 tuning dial covers audio range on one band. Aux. output square wave. Hite Corp. 580 Mass. Ave., Cambridge, MA 02139 (617) 491-3211.
MA 02139 (617) 491-3211.

INFORMATION RETRIEVAL NUMBER 609

advertiser's index

**Advertisers in non-U.S. Edition.*

product index

Information Retrieval Service. New Products, Evaluation Samples (ES), Design Aids (DA), Application Notes (AN), and New Literature (NL) in this issue are listed here with page and Information Retrieval numbers. Reader requests will be promptly processed by computer and mailed to the manufacturer within three days.

new literature

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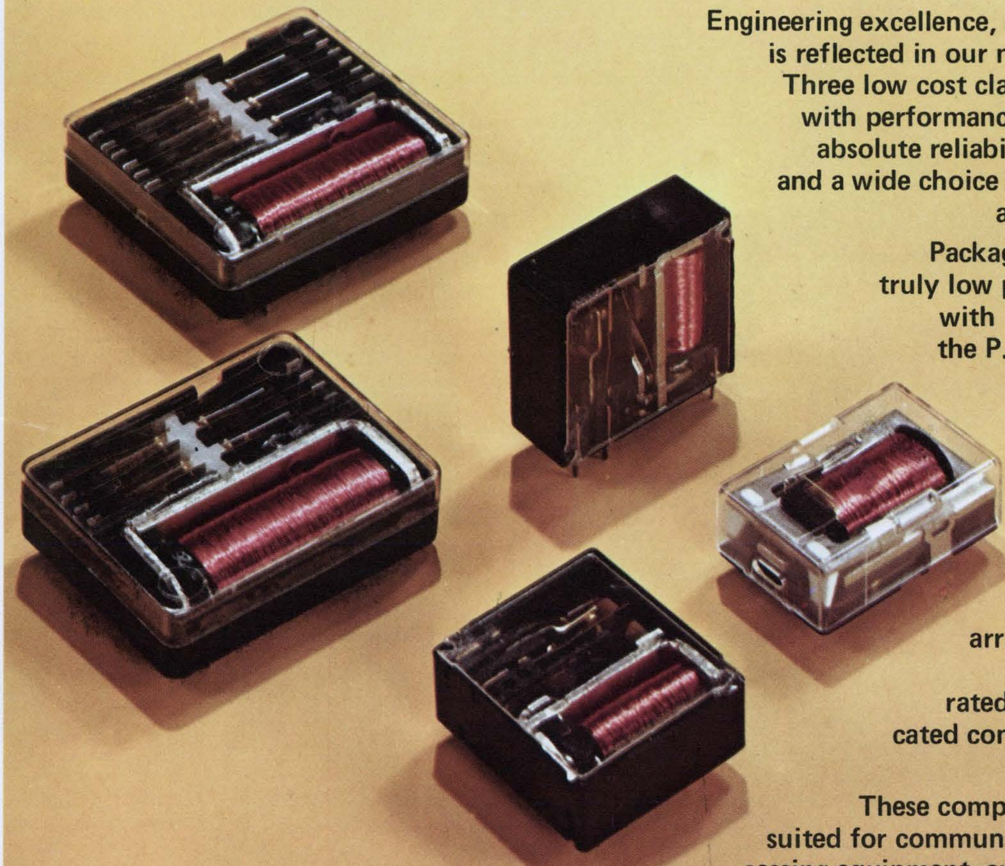

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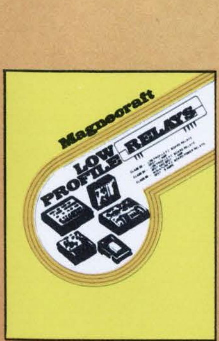
These compact relays are particularly suited for communication systems, data processing equipment, automatic control systems, process control, automotive and consumer electronics.

*Family of Relays



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