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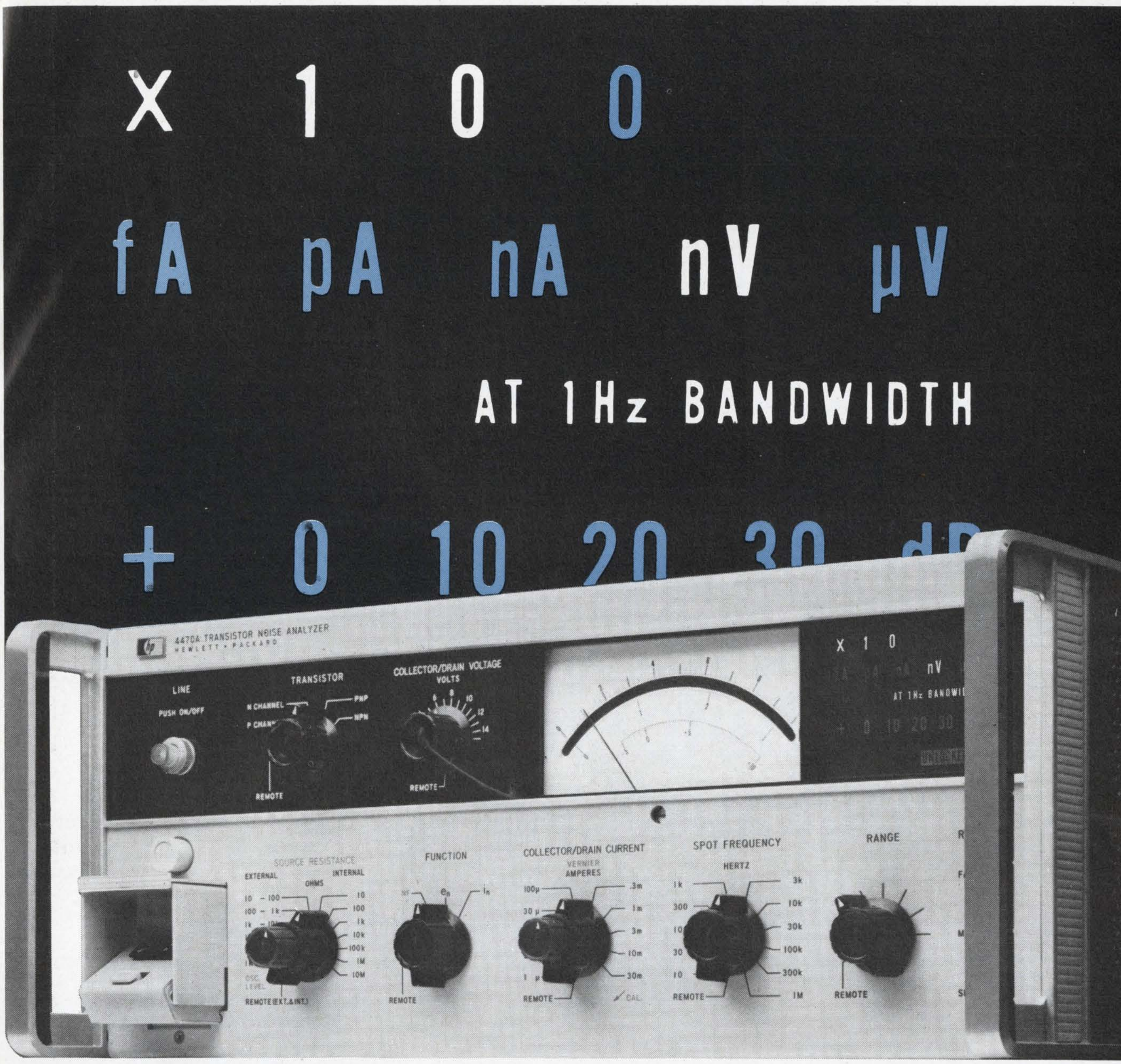
October 27, 1969

Electronics®



Our singularly accurate transistor noise analyzer tells you the whole story

The singular advantage of Hewlett-Packard's new 4470A is its inherent ability to read out transistor noise voltage (e_n), noise current (i_n) and noise figure (NF), accurate to better than ±1 dB. And when you tie these factors into one neat package, you end up with the most complete noise performance story ever told. Unless you want accuracy an order of magnitude greater by calculating your measurements with e_n and i_n.

The 4470A was designed for accuracy and convenience in laboratory, for incoming device inspection and for QC testing applications on FET and bipolar transistors. Yet the analyzer is simple enough to be used by production personnel.

Measurements are made at 4 Hz bandwidths, for precise checks at 11 spot frequencies between 10 Hz and 1 MHz. Noise figure is read directly in dB, using conveniently applied external or internal source resistances.

Since transistor gain varies between devices, an automatic gain control normalizes overall system gain to a fixed value independent of the transistor being used. And the 4470A is completely flexible for biasing transistors under test. The price is just $4450.

Find out more about the simplicity of measuring transistor noise from your HP field engineer, or write to Hewlett-Packard, Palo Alto, Calif. 94304; Europe: 1217 Meyrin-Geneva, Switzerland.

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Electronics

Volume No. 42, Number 22 October 27, 1969

News Features

Probing the News

U.S. Reports

Electronics International

New Products

Technical Articles

Departments

Electronics: October 27, 1969, Vol. 42, No. 22

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Readers Comment

Schottky transistor

To the Editor:

Your article, "Schottky diodes make the IC scene [July 21, p. 74], shows a lateral Schottky-barrier collector (pnp) transistor. Yet, no reference is made to the paper, "The Schottky-Barrier Collector Transistor," given at the October 1966 International Electron Devices Meeting or to a paper of the same title published in "Solid State Electronics," Pergamon Press, June 1968. These are, as far as I know, the only papers published for this type of transistor.

G.A. May
University of British Columbia
Vancouver, Canada

▪ Authors R.N. Noyce, R.E. Bohn, and H.T. Chua apologize to reader May for not referencing his paper in their article. Their investigations did include one Schottky-barrier collector transistor in the form most easily included in npn transistor circuits. Other forms were not investigated because of incompatibility with the other processing. The goal of their work was to develop low-cost, high-yield processing for complex circuits.

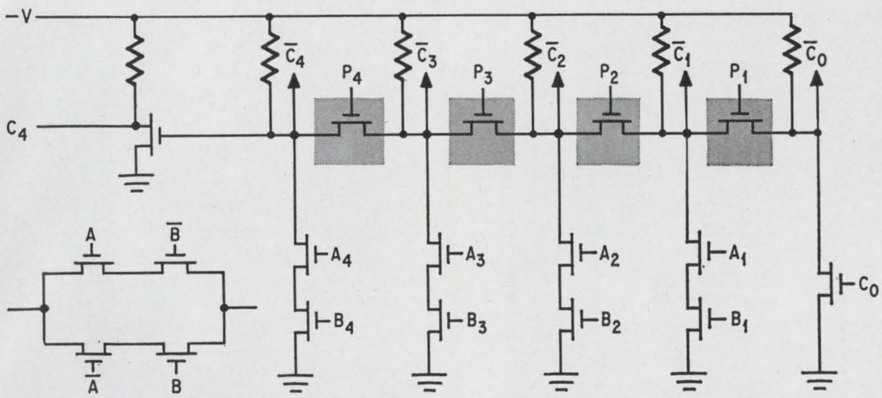
Slightly better

To the Editor:

Regarding Lee L. Boysel's article on a fast, parallel adder [March 18, 1968, p. 119], he could have avoided using a separate carry circuit for each stage in the group by changing the propagation function to $P = \overline{A}B + A\overline{B}$, the exclusive OR of A and B rather than the inclusive OR. With this function, the carry-propagation signals for a stage are never both 1 at the same time. Thus, a carry signal can propagate only in the forward direction.

The diagram shows one way to realize the carry circuitry, using the exclusive-OR function and forming the complement of each carry. Alternatively, the transistors enclosed in the gray areas can be replaced by the circuit shown in

Readers Comment



the inset. In that case, the propagation signal P would not be available separately, but it would open the channel after only a one-gate delay, instead of the two-gate delay required when P is formed first.

Likewise, the propagation function for the borrow in subtraction should be $P_s = \overline{AB} + AB$, the complement of the exclusive OR function.

Ronald C. DeVries
University of New Mexico
Albuquerque

▪ Author Boysel says reader DeVries overlooks one important point. If all four pull-up resistors are supplying current at the same time, the transistor C_o, serving as a current sink, would have to be very large and thus take up a lot of room on the chip. Furthermore, C_o's extra capacitance slows the circuit's operation. For d-c operation, the approach taken saves space and speeds up operation, even though on paper it looks more complicated. On the other hand, in four-phase circuits, DeVries' approach is unquestionably better. In fact, Boysel, who is now with Four-Phase Systems Inc., is now working with this approach.

Vested interest

To the Editor:

Your story on AGA [Oct. 13, p. 210] stated that the company has "acquired control" of Consolidated Airborne Systems Inc. Actually, AGA's interest in Consolidated is limited to 200,000 shares—about one-third of the outstanding shares—purchased last month.

However, at the time of acquiring its stock interest in Consolidated, AGA entered into a shareholders' agreement with John I. Nestel, chairman of Consolidated. Under this agreement, Mr. Nestel is given the right to nominate 70% of Consolidated's board for a 10-year period, thus eliminating any thought that AGA seeks to obtain control of Consolidated.

William A. Washburn
AGA Corp.
Secaucus, N.J.

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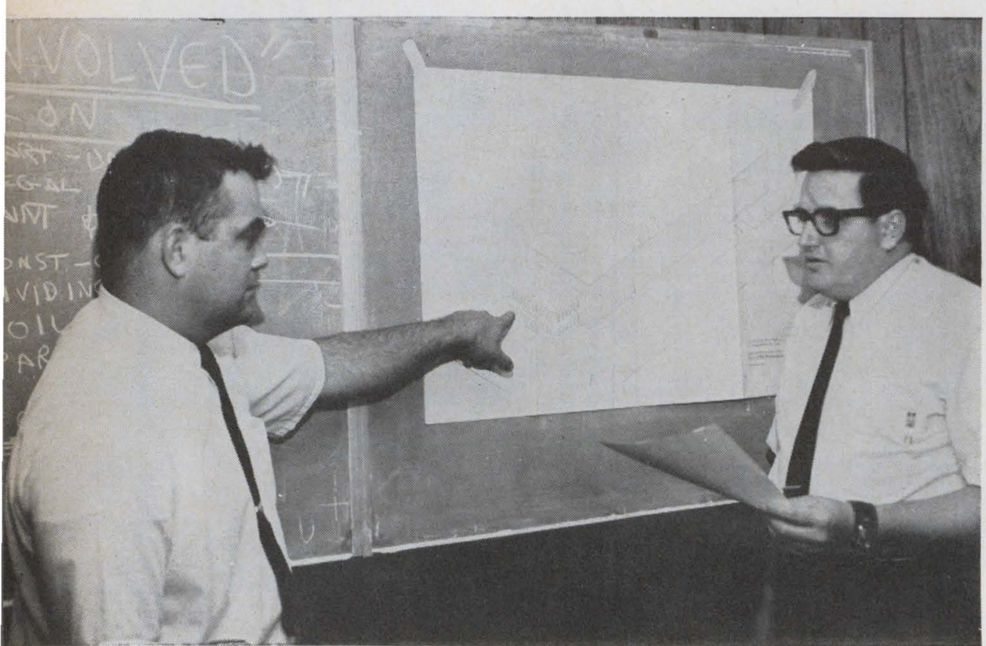
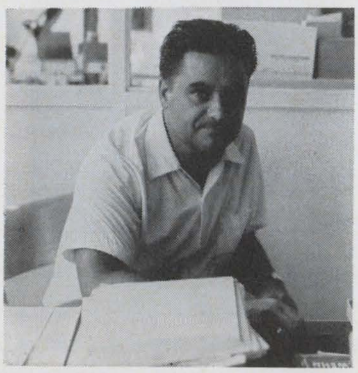


Lambert Boisvert

Founding fathers of the Digital Information Storage Corp., Roland Boisvert and Stephen A. Lambert, authors of the article starting on page 88, came from the Digital Equipment Corp., where Boisvert was magnetic tape systems manager and Lambert was a special project engineer for disk memories. Boisvert is a graduate of the University of New Hampshire; Lambert attended Wentworth Institute.

Bertram Neuhaus Hoffman

Unconventional may be the word that best describes the techniques used by this trio of German engineers who authored the article starting on page 116, another in *Electronics'* series on German IC's. Their article describes an unconventional, but nevertheless significant, approach to designing customized digital IC's to meet specific, high-volume applications. Hans Hoffman is group leader for digital electronics at Philips Zentrallaboratorium GmbH in Hamburg—a subsidiary of the giant Dutch electronics company, Philips Gloeilampenfabrieken. Uwe Bertram and Hans-Wilhelm Neuhaus are members of Hoffman's staff.



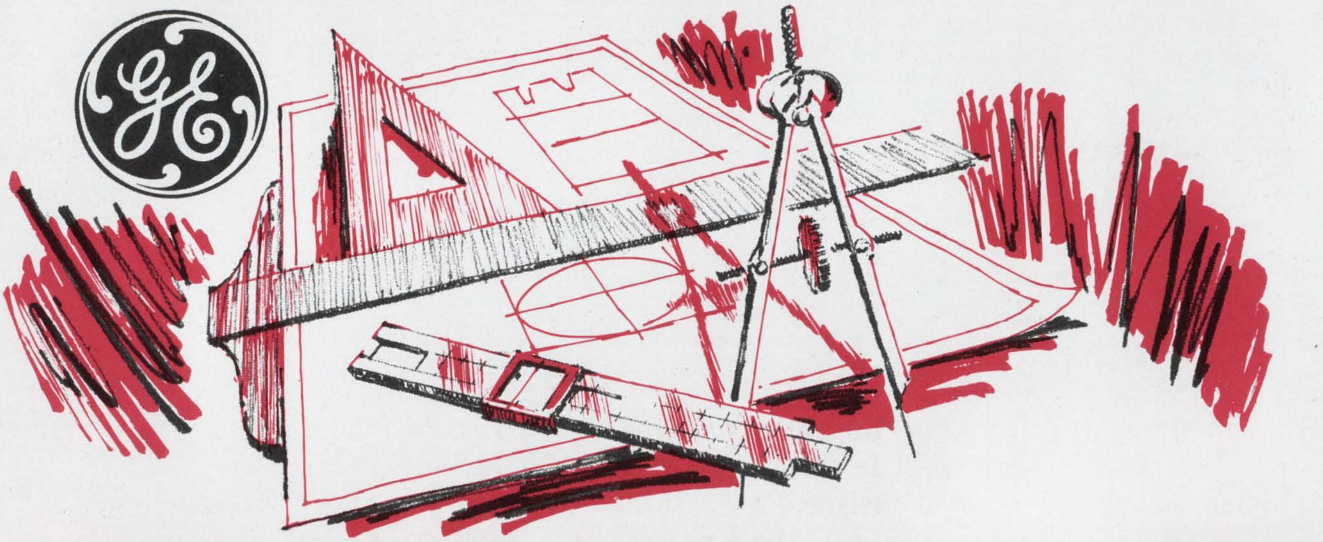
Schlotterer

A new technique for achieving high isolation and fast switching time in MOS IC's by growing silicon crystals on a spinel substrate is described by Heinrich Schlötterer, in the article beginning on page 113. Schlötterer has been with Siemens AG in Munich since 1965. Schlötterer is no newcomer to this subject. Before, he worked on electron-optical methods for studying crystal growth and thin-film structures.

Anderson

"Join the Navy and see a future in electronics" could be the motto of James L. Anderson, author of the article starting on page 100. A Fairchild employee for the past three years, Anderson was introduced to electronics while serving in the Navy. Anderson, an assistant engineer at Fairchild, has worked on applications for bipolar MSI circuitry and now is concerned with LSI MOS mosaic arrays. He majored in history at San Fernando Valley State College.

Michael Hills, author of the article starting on page 106, is a lecturer on telecommunication systems at Britain's University of Essex. Hills, whose article compares five different designs for active filters, first became interested in this subject while working on his doctoral dissertation. His topic was based on a technique for the design of several bandpass filters to be used in telephone tone-dialing systems. Since that time he has been awarded a grant to develop a telecommunications programing language.



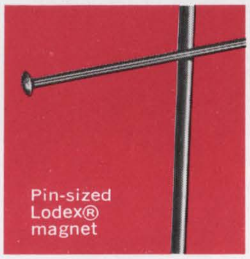
New 25 amp triac offers several exceptional performance features

GE has extended its broad thyristor line with the addition of a new 25 ampere triac. SC60 (stud-mounted) and SC61 (press-fit) offer several exceptional features:

Current rating	25A RMS
Voltage rating	200V, 400V, 500V
Surge current	250A Peak
Commutating dv/dt	5V/μ sec. MIN.
Static dv/dt	200V/μ sec. TYP.

The SC60/61 triac can handle up to 6KW at 240 volts and is compatible with PA424 and PA436 IC's for control of heaters, lamps and motors.

SC60/61 is well suited to high volume use in residential and industrial space heating, large lamp-dimming controls, temperature control in copying machines and many other applications. For details, circle 503.


Pin-sized Lodex® magnet

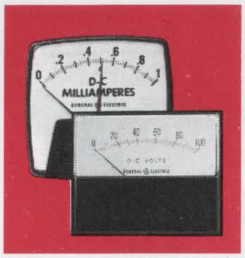
Now get proved Lodex® permanent magnets in sizes smaller than a pin

When designs call for tiny (even less than 1 millimeter) permanent magnets, GE has the answer. GE can produce powerful microminiature magnets at low cost—and in complex configurations, too.

The magnets are made of proved Lodex material. This exclusive GE product makes it possible to produce magnets in tiny, intricate shapes meeting extremely tight physical and magnetic tolerances.

Close piece-to-piece physical and magnetic uniformity often eliminates the need for final testing of the end product. These magnets are the perfect answer for such precise applications as reed switches.

For details, circle 504.



General Electric meter relays give you reliability at lower cost

Reliable performance at lower cost makes GE your best meter relay choice.

Functions include energizing alarms; close differential relaying; and controlling temperature, power, speed and frequency.

Proved GE design is better three ways:

- **New contactless control action.** Solid-state, light sensitive switch means simple, reliable control.
- **"Piggyback" control module.** Plug-in design saves installation time.
- **Choice of styles.** Easy-reading BIG LOOK® or low-profile HORIZON LINE® meter relays.

Applications range from critical monitoring in hospital intensive-care units to deep-well drilling control.

For details, circle 505.


100-CFM unit

Get reliable cooling for computer cabinets with proved GE fan assemblies

GE cooling fan assemblies offer years of continuous duty without maintenance. Available in two sizes, these blower fans feature all-angle operation and efficient air flow.

Small **90** and **100 CFM** fans have KSB33-frame Unitized® motors and fit an opening 4¾" square. Near perfect bearing bores, accurate shaft-bearing alignment and metered oil bearings virtually eliminate bearing wear for long motor life.

GE's **500 CFM** fan mounts on a 9.7" diameter bolt circle through holes in its aluminum venturi. Its KSP11-frame unit-bearing shaded-pole motor provides quiet, long-life operation.

For more information, circle 506.

New GE transistor is the ideal epoxy replacement for "hermetic" devices

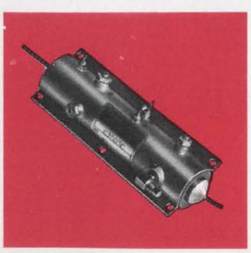
General Electric's GET transistor series is a new answer to design problems. GET is the newest addition to GE's proved family of epoxy-encapsulated transistors dating back to 1962 . . . over 7 years of epoxy experience.

GET is the ideal epoxy replacement for "hermetic" devices . . . no expensive redesign needed. The new D32 package conforms to TO-18 mounting patterns and is available in these silicon planar passivated models:

GE Model	Type	JEDEC No.
GET706, 708, 914	NPN	2N706, 708, 914
GET2221, 2222	NPN	2N2221, 2222
GET3638, 3638A	PNP	2N3638, 3638A
GET2369, 3013, 3014, 3646	NPN	2N2369, 3013, 3014, 3646
GET929, 930	NPN	2N929, 930

GE's quality epoxy forms a true chemical bond with metal to provide increased resistance to moisture and vibration damage. Low profile package means smaller circuits and lower cost.

For more information on GET and GE's "specials" capability, circle 508.



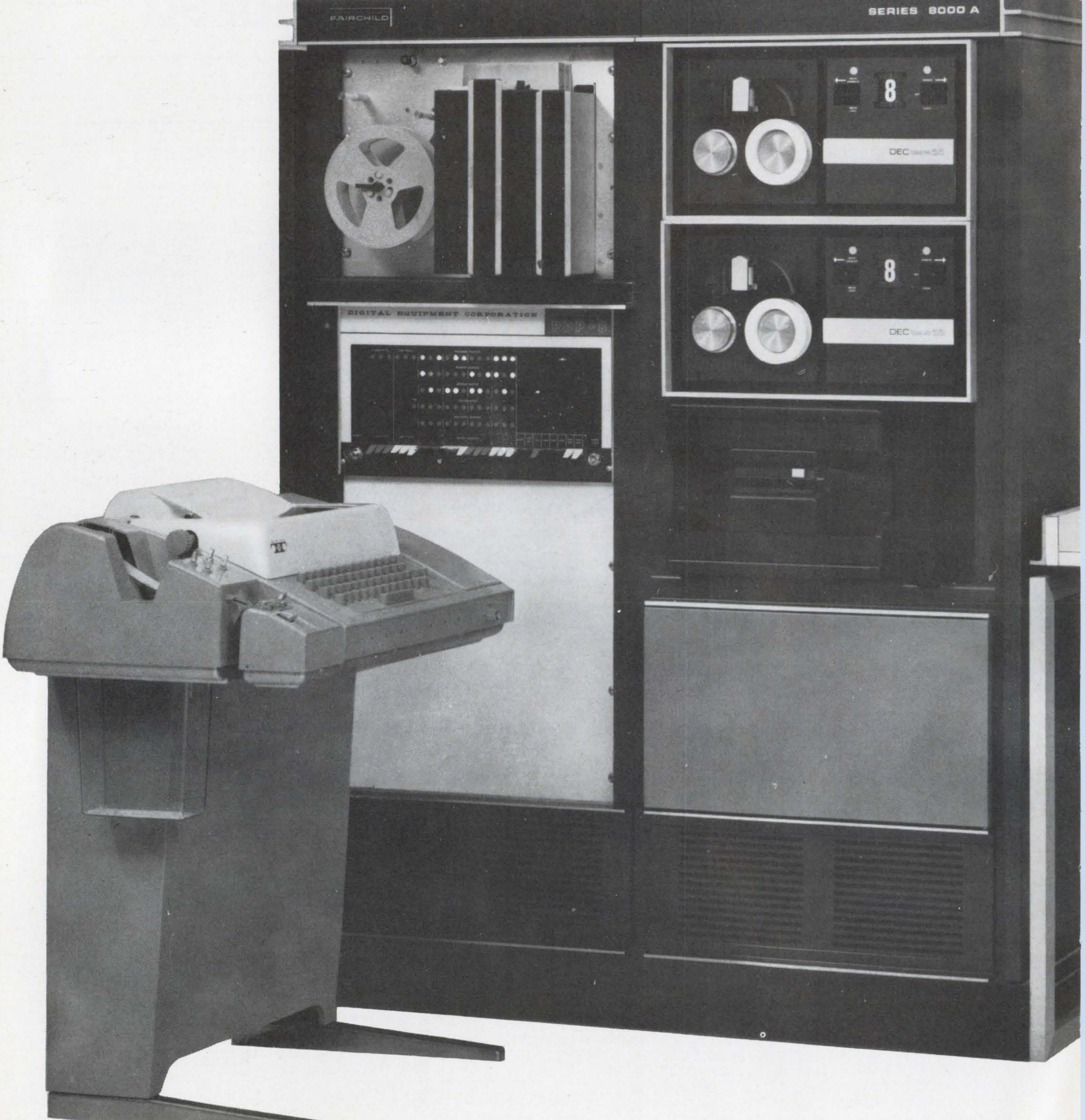
Check this new GE transmitter design

GE's C2003C transmitter is a Microwave Circuit Module containing a master oscillator and power amplifier using planar ceramic triodes.

It is one of many GE MCM's that help reduce design cycles, provide retrofit and lead to improved system performance.

C2003C benefits: meets performance and military requirements of the transmitter portion of IFF transponder • permits two transmitters to function in space formerly used by one • light weight • significantly smaller • simplified heat sinking • excellent frequency stability with wide variations in antenna VSWR. For details, circle 507.

If you've been discounting the Fairchild



Who's Who in electronics

Tatum of Fairchild

Problem: pride before production. Solution: John G. Tatum, Fairchild's new silicon power products manager, production man who puts business before pride.

Lester Hogan, president of Fairchild Camera & Instrument, said recently that one of Fairchild's biggest woes was "getting things from Palo Alto [R&D] to Mountain View [production] before they get to Sunnyvale [Signetics]." Though this was meant as a joke—Jim Riley, Signetics' president, was sitting next to Hogan at the time—Fairchild did have problems in getting ideas into production. San Francisco Bay Area electronics folklore has it that in the old days—1960 to 1965—the production staff refused to consider manufacturing anything that came out of advanced resarch —they thought the only semiconductor devices worth making came from production itself. Now Tatum will try to rewrite that folklore.

Enter Tatum. Tatum was with ITT Semiconductor in West Palm Beach, Fla., and moved to Fairchild just as ITT was phasing out its r-f transistor operation.

Tatum started in the r-f semiconductor business at the old Shockley Labs in 1963. Next came Clevite, which sold its r-f power line to ITT. The new owner moved the operation from the Bay Area to Florida.

Regarding his prospects at Fairchild, Tatum says: "There has been a lot of development work and so I have a broad base to work with, and we expect to have a lot of new products." One of the biggest coming markets for r-f power devices is in mobile communications systems, both commercial and military, says Tatum. "TI tried to build 12-volt devices but they lost key people and had to drop the project. ITT also had the same problem, but I think we can make it at Fairchild."

Behind the man. "Another ITT problem was that they did not have the technical backup that Fairchild has." Tatum says that he will be working closely with the microwave R&D people as well as r-f power R&D. Some of the problems Tatum plans to concentrate on are increasing the safe operating area, improving diffusion techniques, and getting finer line resolution. "We're working with large chips," says Tatum, "and we have to hold to 0.1-mil lines over the whole surface, so we have to work with the integrated circuit people as well as the power and microwave groups."

Looking at the big picture is a way of life for Sidney L. Hasin. As president of North American Rockwell's new information systems company (Narisco), he'll have an opportunity to bring that philosophy to bear on major financial, industrial, and government management problems. Narisco, formerly part of the corporation's Autonetics division, entered the growing information-management systems market this month and became free to chart an independent course, reporting only to the NR general office.

Narisco's 46-year-old president, while no newcomer to the business, is one of a new breed of managers who believe implicitly that the systems technology that made possible the Apollo and Minuteman programs can be put to work on many of the problems facing industry, finance, and government.

Broad. His philosophy is straightforward: Take a large overview of the customer's problems. "The first step is to evaluate a contract from

The new Fluke 893A will retire lots of good old Fluke voltmeters.

They won't be the only ones to go!

All kinds of differential voltmeters are likely to find quick retirement when you check out the new solid state Fluke Model 893A AC/DC Differential Voltmeter. Here's a low cost differential voltmeter with infinite resistance at null to 1100 volts, dc accuracy of 0.01%, ac accuracy of 0.05%, and integral battery pack operation.

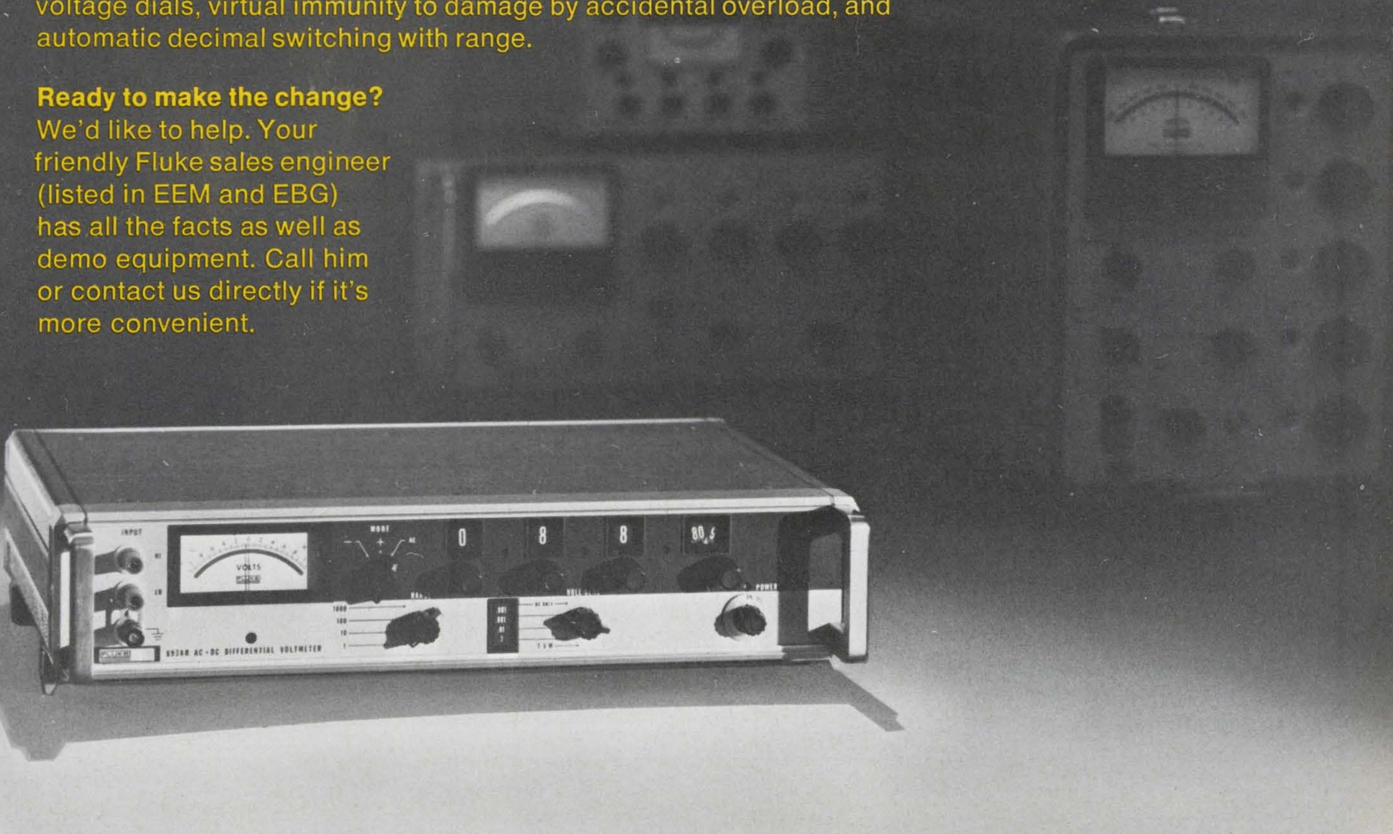
Available in both half and full rack models, price is $995 for either. Battery operation can be added at any time for only $100. Grounded recorder output is available for $50 more.

Ranges are 1, 10, 100, and 1000 volts ac and dc with 10% overranging. Resolution is 1 ppm of range. Reference regulation is the best available. Reference stability is 15 ppm/hr.

Using the instrument in the battery mode assures portability and complete isolation from the effects of power line interference. In the ac mode, the useful frequency range is 5 Hz to 100 KHz with a 1 mv accuracy. In the TVM mode, input resistance is 100 megohms, so you get the same advantages of low source loading as with older vacuum tube differentials.

Other user features include large, in-line readout with 360° rotation of voltage dials, virtual immunity to damage by accidental overload, and automatic decimal switching with range.

Ready to make the change?
We'd like to help. Your friendly Fluke sales engineer (listed in EEM and EBG) has all the facts as well as demo equipment. Call him or contact us directly if it's more convenient.



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FLUKE®

Who's Who in electronics

Hasin of Narisco

a total problem standpoint," says Hasin. "Always look at the forest before looking at the trees. Then, get into the programs needed."

A transplanted New Yorker, who received his BSEE from New York University in 1944, Hasin in later years joined the trek of engineering talent to the West Coast. He landed his MSEE from the University of Southern California this year. Following management positions at Ramo Wooldridge, Litton Industries, Hughes Aircraft, and Bendix Aviation, he became manager of information-processing systems for North American Rockwell's Space division in 1963. Following a stint as assistant director of the Information Systems division and director of technology from 1964 through 1966, he was appointed director of the division, and later was made vice president of information systems for the Autonetics division.

Some of his coworkers are, in fact, a little in awe of Hasin's computer-like memory. Says one associate: "He has the ability to instantly retrieve anything he ever heard about a particular problem."

Crystal ball. The computer analogy fits when Hasin leans forward at his desk and, eyes flashing, rapidly describes his plans for Narisco.

"I expect the company to do at least $12 million in business in fiscal 1970, based on a $9 million backlog from 1969, and $3 million in new contracts. There is no reason why Narisco shouldn't be a $50 million-a-year operation within five years."

No. 7-69

SEMICONDUCTOR newsbriefs

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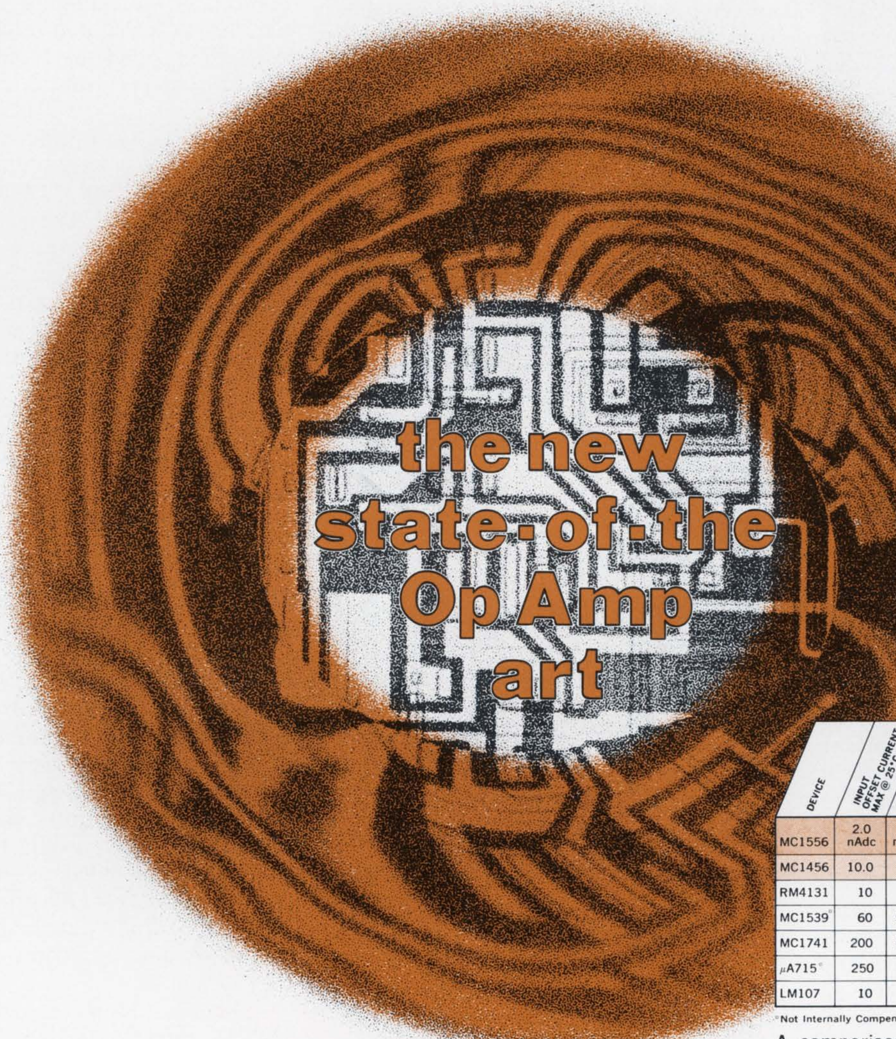


DEVICE	INPUT OFFSET CURRENT MAX @ 25°C	INPUT BIAS CURRENT MAX @ 25°C	INPUT OFFSET VOLTAGE MAX @ 25°C	OPEN LOOP VOLTAGE GAIN MIN @ 25°C RL-2K	SLEW RATE, TYPICAL (UNITY GAIN)	POWER BANDWIDTH, TYPICAL (UNITY GAIN)	POWER CONSUMPTION MAX @ ±15Vdc	PRICE 100-UP
MC1556	2.0 nAdc	15 nAdc	4.0 mVdc	100K V/V	2.5 V/μs	40 kHz	45 mW	$28.00
MC1456	10.0	30	10	70K	2.5	40	90	$15.00
RM4131	10	50	2.0	50K	2.0	—	57	$20.00
MC1539*	60	500	3.0	50K	4.2	50	150	$ 7.50
MC1741	200	500	5.0	50K	0.8	5.0	85	$15.00
μA715*	250	750	5.0	50K	20	—	210	$48.00
LM107	10	75	2.0	50K	0.5	—	90	$33.00

*Not Internally Compensated

A comparison of performance characteristics clearly indicates the superiority of the MC1556 over other popular monolithic Op Amps.

. . . makes others obsolete!

Most high-performance op amps today are of monolithic construction – to save space and to increase reliability. A few are internally-compensated – to reduce the need for external componentry and their associated higher cost.

Only one offers all three benefits . . . *(1) high performance; (2) monolithic construction; and, (3) internal compensation!* That's the **MC1556**, an operational amplifier that promises to become the new linear IC standard of the industry!

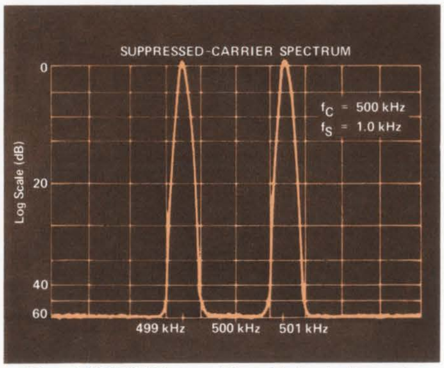
The MC1556 and its reduced temperature-range counterpart, the MC1456, are designed for use as summing amplifiers, integrators, or amplifiers with operating characteristics as a function of the external feedback components.

Both of these new linear circuits are available from distributor stock in the 8-pin TO-99 "G" suffix package.

For details circle Reader Service No. 281

Balanced Modulator/Demodulator IC Ups Carrier-Suppressed Performance

Closely-matched transistors, on a single monolithic chip, give Motorola's new **MC1596G** the ability to provide a high signal-to-carrier ratio and low-distortion, in a variety of modulator/demodulator designs. As its output is the



The MC1596G provides high, balanced, signal strength vs. carrier performance.

product of both an input voltage (signal) and a switching function (carrier), the MC1596G can serve to improve the performance, yet lower the cost of functions such as: synchronous AM-FM and phase or single side-band detection, frequency doubling, mixing and, of course, suppressed-carrier and amplitude modulation.

When used as a balanced modulator, this linear IC provides a high suppressed-carrier figure of typically 60 dB at 0.5 MHz and 40 dB at 10 MHz; and, a high common-mode rejection ratio of 85 dB (typ.). In addition, it has adjustable gain and signal-handling capabilities and balanced inputs and outputs — and can operate over a wide bandwidth (transadmittance: carrier-300 MHz; input signal — 80 MHz). It operates over the full −55 to +125°C temperature range.

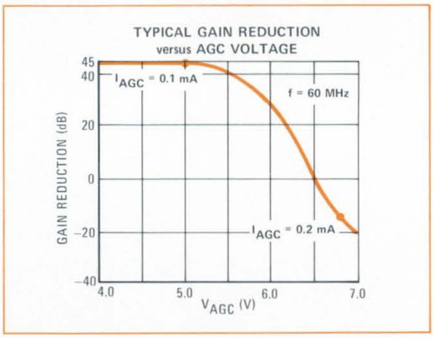
And even though the MC1596G gives you all these superior performance characteristics, in a single, hermetically sealed, long-leaded version of the TO-100 case, you can reduce your modulator-circuit costs by up to a factor of three. For example, designs of this nature using discrete devices require expensive, closely-matched balancing transformers and a diode bridge. Even in quantity, a single transformer may cost as much as the total 100-up price of the MC1596G — only $4.80!

For details circle Reader Service No. 282

IF Wideband Amplifier Has A Wide AGC Range, High Gain

Now Motorola offers the designer of precision RF/IF circuits a wideband amplifier that has both a broad AGC range (60 dB min. from dc to 60 MHz) and a minimum power gain of 40 dB at 60 MHz . . . the **MC1590G!** Packaged in the TO-99 hermetic 8-lead metal-can (−55 to +125°C), and inexpensive — only $3.95 in 100-up quantities — it will be warmly welcomed by builders of high-performance military and commercial communications equipment, radar and video instruments. It also makes an excellent audio amplifier with AGC.

The power gain and AGC range of the MC1590G is equal to, or better than *two* well engineered discrete-component stages. And, the AGC has little effect on IF response as the input and output impedances remain practically constant. As the MC1590G can replace a complete discrete device assembly consisting of several capacitors, a slew of resistors and two or more IF transistors, a substantial savings in componentry and mounting costs can be realized. In addition, the wide-range gain control of the



MC1590G appreciably lessens "detuning" effects.

Here are some other parameters that help make the MC1590G an outstanding value for high-performance HF and VHF designs:

- High Power Gain (typ):
  - — 50 dB at 10 MHz
  - — 45 dB at 60 MHz
  - — 35 dB at 100 MHz
- Single-power-supply operation:
  - — 6.0 to 15 Volts
- Low Reverse Transfer Admittance:
  - — >10 μmhos (typ) @ 60 MHz

For details circle Reader Service No. 283

Five More IC Complex-Functions Join Motorola's Burgeoning MTTL Line!

The **MC4012** 4-Bit Shift Register leads-off five new MTTL complex-function introductions. Consisting of four D-type flip-flops (operated in the synchronous mode), the MC4012 can be operated in either the serial or parallel-mode by application of a proper signal on the mode control. It will simplify the design of parallel-to-serial and serial-to-parallel converters, divide-by-N counters, number converters and adder/subtractor systems.

And, when your problem is the logical addition of two binary numbers, Motorola's new **MC15482/17482** provide an optimum answer! These units perform the addition of two 2-bit binary numbers and the look-ahead "carry" is provided internally between the two-bits. They can be interconnected to form longer words. Although functionally the same, the **MC25482/27482** have the exclusive OR of the two sets of input bits brought out. This reduces package-count when using these adders in look-ahead "carry" applications. Both types can be plugged directly into designs presently served by older T²L adders.

The new **MC5493/7493** 4-bit binary counters provide true high-speed counting versatility. For example, by using only one external gate it is possible to count to 7, 9, 10, 11, 12, 14, or 15. Hook-up two of them, add two gates and you can divide by any number up to 256.

And, for reliable Nixie Driver designs consider Motorola's new **MC7441AP**. It delivers up to 55 Volts with a maximum 200 μA leakage current. Output clamp-diodes are included to prevent oscillation. The MC7441A combines with the MC7475 quad-latch and MC7490 decade counter to form a complete read-out system.

These new Motorola complex-function MTTL integrated circuits are all available for your immediate evaluation from your local distributor's warehouse stock.

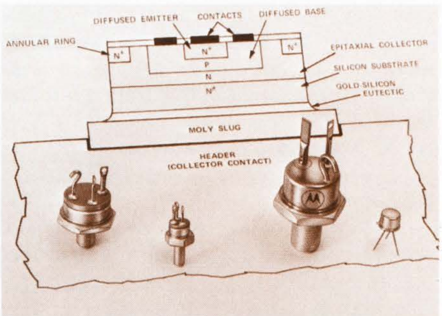
Type	Function	Price (100-up)
MC4012L	4-Bit Shift Register	$11.50
MC15482/17482L	2-Bit Full Adder	16.00/9.00
MC25482/27482L	2-Bit Full Adder	16.00/9.00
MC5493/7493L	4-Bit Binary Counter	21.25/13.15
MC7441 AP	BCD-TO-Decimal Decoder And High-Level Driver	7.00

L suffix denotes TO-116 ceramic dual in-line case
P suffix denotes TO-116 Plastic dual in-line case

For details circle Reader Service No. 284

New Homogeneous-Bond Annular Silicon Power Transistors Shrug-Off High Temperature Excursions

Combining Annular, epitaxial, passivated die structures . . . with a unique homogeneous high-temperature "hard-



solder" die-to-header bonding method, Motorola advanced silicon power technology now adds a whole new dimension of reliability for power switching/amplifier circuits! Designers of industrial and military equipment which must operate at top efficiency and be fail-proof – even when subjected to stringent overload and temperature-excursion conditions – can now specify silicon power transistors with assurance of long-term reliability.

For instance, the units' closely matched expansion coefficients preclude the development of "hot-spots" and/or junction rupturing due to high internal heating and thermal fatigue. (Extensive stress-testing has proven their ability to withstand 5,000 temperature cyclings, as performed on intermittent life tests, without any apparent damage or degradation!) And, Annular die structures virtually eliminate high-leakage problems so common to ordinary diffused-junction devices.

The first of these ultra-rugged power transistors are available in an assortment of hermetic "stud" and lead-mount metal cases, with I_C's from 5 to 60A.

Type No.	Package	Polarity	I_C (cont.)	V_{CEO} (sus)	$V_{CE(sat)}$* @ I_C	h_{FE} @ I_C/V_{CE}	I_{CBO}* @ V_{CB}
MJ7200 MJ7201	TO-114	NPN	60 A	80 V 100 V	1.0 V @ 20 A	20-100 @ 20 A/5 V	100 μA @ 100 V 100 μA @ 120 V
MJ7000	TO-63	NPN	30 A	100 V	1.0 V @ 10 A	20-100 @ 10 A/4 V	5.0 μA @ 100 V
MJ500 MJ501	TO-59 (col. to case)	PNP compl. to 2N5477/80	7.0 A	60 V 80 V	1.2 V @ 7.0 A	25-180 @ 2 A/2 V	10 μA @ rated V_{CB}
MJ6700 MJ6701	TO-59 (isolated -col.)	PNP compl. to 2N5346/49		60 V 80 V			
MJ8100 MJ8101	TO-39	PNP compl. to 2N5336/39	5.0 A	60 V 80 V	0.7 V @ 2.0 A		

*Maximum

For details circle Reader Service No. 285

Premium NPN 20A And 30A Amplifiers And Switches For Peanut Prices

Specify the 2N3771/72 and you'll get power amplifiers that can handle V_{CEO}'s of 40V and I_C = 30A(2N3771) and 60V and I_C = 20A(2N3772); dissipate up to 150W at T_C = 25°C; and, deliver minimum betas (h_{FE}) of 15 at 15A and 10A, respectively. Or, when you require the same power handling capability plus nanosecond switching speeds and saturation voltages below one-volt, plug-in the MJ3771/72. Whichever you need, you'll get peak-performance from all, all at the same low prices ($2.50 each in 100-up quantities)!

In addition, you'll be getting high f_T values (especially with the MJ series) and exceptionally good safe operating areas. Check over the highlights in the accompanying table and order units for evaluation from your distributor right now. He has ample local stock, backed by extensive factory inventory and production capacity.

Both series are packaged in low-silhouette TO-3 cases and operate over a −65 to +200°C temperature range.

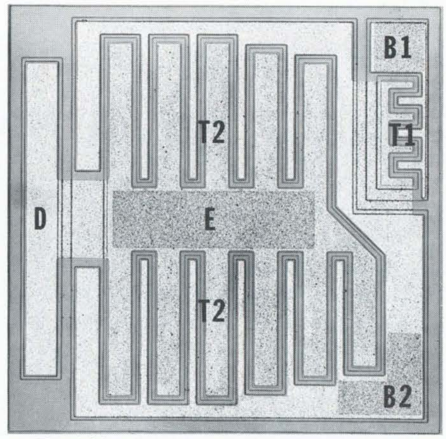
Highlights	MJ3771/12	2N3771/72
Major Usage †Ic(cont) *typ	Pwr. Switching (tr=350ns* @ 10A)	Pwr. Amplifier (up to 20/30A†)
Low V_{CE}(sat) @ I_C (max)	1V @ 15A(71) 1V @ 10A(72)	2V @ 15A(71) 1.4V @ 10A(72)
High f_T @ $I_C/V_{CE}/f$ (min)	2 MHz @ 1A/ 10V/1.0 MHz	0.2 MHz @ 1A/ 4V/50 kHz
V_{CEO} & I_C (cont)	40V & 30A(71); 60V & 20A(72)	
Low Prices (100-up)	$2.50	

For details circle Reader Service No. 286

Rugged 60K Beta, 10-Amp, 40-Watt Darlingtons Debut

Now there are rugged power Darlington amplifiers/switches around with nearly "out of sight" beta values . . . the **MJ3801-02** series . . . and they run cool, calm and collected even under extremely high temperature conditions! At 6 Amps and 4 Volts, for example, the MJ3801 furnishes an ultra-high 10,000-60,000 gain range, while at 10 Amps it has an h_{FE} of over 1,000.

And, their Annular, passivated, two-



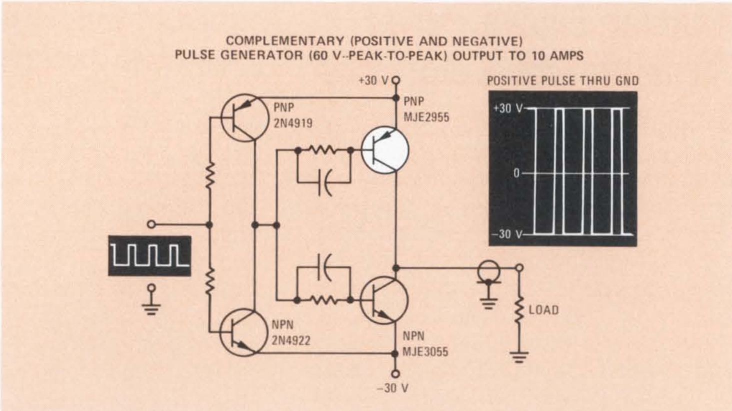
The 110-mil square die for the MJ3801-02 contains two power transistors in a Darlington configuration and a large diode.

transistor-plus-diode power chips (see illustration) are high-temperature "hard-solder" bonded into high-dissipation, TO-66, three-leaded cases. The result: microamp leakages, nanosecond switching and highly efficient, reliable performance, even when subjected to fatiguing high junction temperatures to 200°C!

Check the highlight specs in the accompanying table. They will show you how these new power Darlingtons can up the performance of even your most stringent series-pass regulator, ultra-high-gain amplifier, motor-control and inverter application requirements. And, get the whole story by perusing the data sheet for these reliable power Darlington amplifier transistors.

Highlights	MJ3801	MJ3802
High h_{FE} @ I_C = 6 A	10 K to 60 K	1.0 K to 20 K
Low Leakage Current (I_{CBIO})	10 μA (max) @ 80 V	
High I_C	10 A (cont); 15 A (peak)	
Low $V_{CE2(sat)}$ @ I_C/I_{B1}	1.5 V (max) @ 6 A/15 mA	
High BV_{CEO}	80 V (min)	
Fast Rise-Time	200 ns (max) @ 6 A	
Prices (100-up):	$11.95	$7.95

For a copy circle Reader Service No. 287



The PNP MJE-2955 complements its NPN counterpart to form low-cost, transformerless power-outputs as shown in the diagram.

Popular Plastic 90-Watt NPN Now Has A PNP Power-Mate!

The MJE3055, a Thermopad plastic-packaged, low-cost version of the popular NPN 2N3055 silicon power transistor (introduced in NEWSBRIEFS Vol. 2 No. 4), now has a PNP "alter ego" . . . the **MJE2955!** All its electrical and mechanical specifications are the same as its NPN counterpart, making the pair a perfect match for complementary power-output designs.

And, their low prices qualify them for a broad range of consumer/industrial applications, where economical transformerless design simplicity is keynoted. Or, they can be used separately to optimize either PNP or NPN polarity circuits.

The 60-Volt PNP MJE2955 dissipates a full 90 Watts at $T_C = 25°C$, due to its unique 0.030″ direct chip-to-heat-sink Thermopad case design (operating temp. range: -55 to $+150°C$). Its beta is spec'd at two points, affording a complete picture of its high-gain-holdup capability over a wide current range.

And, as with its NPN mate, the MJE-2955 offers both high frequency response and fast switching times. It should prove a boon to designers of servo and low-frequency amplifiers as well as series and shunt regulators and power supplies, requiring both economy and top performance.

PNP Type	h_{FE} @ I_C	$V_{CE(sat)}$ @ I_C (max)	f_T (min)	Price (100-up)
MJE2955	20-70 @ 4 A 5 min @ 10 A	1.1 V @ 4.0 A	2 MHz @ 500 mA	\$1.95

For details circle Reader Service No. 288

250-350V Thermopad Transistors Make H-V Design Costs Tumble

Imagine being able to get 250/300/350-Volt silicon power transistors for your line-operated audio and servo amplifier, low-current, high-voltage converter and AC line-relay designs . . . *at quantity prices well below the one-dollar mark!* Well, now with Motorola's new NPN **2N5655-57** Thermopad plastic packaged silicon power series you can do this and more!

Not only are they able to handle sustaining voltages up to 350 V (at inductive I_C's of 100 mA), but they also provide high gain figures. For example, they have an h_{FE} of 30-250 at 50 mA. In addition, they display a maximum $V_{CE(sat)}$ of just 1.0 V at 100 mA; a minimum f_T = 10 MHz at 100 mA/10 V/10 MHz; and, an output capacitance of 25 pF at 10 V/100 kHz.

Their exclusive Annular triple-diffused die structures also provide exceptionally low-leakage currents (e.g. – maximum I_{CEX} values are only 100 μA at rated V_{CE}) and excellent safe operating areas. Continuous I_C is a high 500 mA with a peak of 1.0 Amp. They operate up to junction temperatures of $+150°C$ and dissipate 20 Watts at $T_C = 25°C$.

All three types are immediately available. 100-up prices: 2N5655 (250 V) – 75¢; 2N5656 (300 V) – 90¢; and, 2N5657 (350 V) – \$1.10. Call your Motorola distributor for evaluation units TODAY!

For details circle Reader Service No. 289

Five Fresh FETs Fit Frugal Fast-Switching Functions!

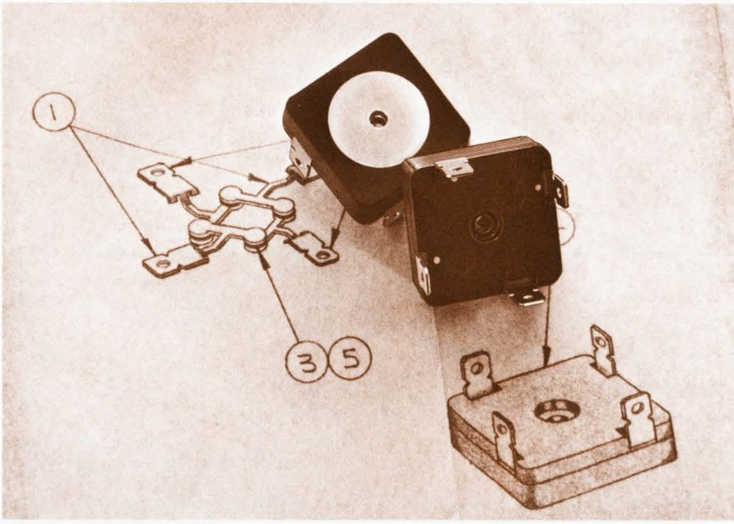
One of Motorola's five new Unibloc plastic, N-Channel JFETs should prove to be both an economical and high-performance solution for whatever low-power chopper or high-speed switching design requirement you may have. Labeled the 2N5638-40 series and the 2N5653/54, they all have exceptionally low resistance and capacitance values, thus assuring fast switching characteristics. For example, the rise time of the 2N5638 is just 5.0 ns max. @ I_D (on) =12 mA. They all have breakdown voltages of 30 Volts at I_G = 10 μA and gate-currents (I_{GF}) of 10 mAdc. In addition, the units exhibit low leakage currents, as demonstrated by a maximum specified I_{GSS} value of 1.0 nA at 15 Volts.

And, as they are packaged in economical, yet rugged, TO-92 Unibloc transfer-molded cases, their prices are as much as one-half lower than their previously available metal-can counterparts.

Immediate prototyping needs are readily available from your local distributor and Motorola's extensive production capability can match even your most stringent large-quantity scheduling requirements.

Characteristics	2N5638	2N5639	2N5640	2N5653	2N5654
Low $r_{ds(on)}$ (max) @ f = 1.0 kHz	30 Ω	60 Ω	100 Ω	50 Ω	100 Ω
Low C_{iss} @ 12 V f = 1.0 MHz	10 pF (max)				
Low C_{rss} @ 12 V f = 1.0 MHz	4.0 pF (max)			3.5 pF (max)	
Fast Rise Time (max) (t_r) @ 10 V/50 Ω	5.0 ns @ 12 mA	8.0 ns @ 6 mA	10 ns @ 3 mA	5.0 ns @ 5 mA	8.0 ns @ 5 mA
Prices (1,000-up)	95¢	80¢	70¢	72¢	64¢

For details circle Reader Service No. 290



Four passivated silicon dice are combined in two compact, transfer molded packages (with or without metal insert) to form new high-surge Motorola MIDA bridges.

MIDA Bridges Now Have 12-27A Ratings

Motorola, the first to build economical MIDA (**M**iniature-**I**ntegrated-**D**iode-**A**ssemblies) rectifier bridges, now offers the brawniest power handling versions ever – the MDA980 series, with a dc output current rating of 12 Amps and the MDA990 series which handles 27 Amp loads (both at $T_C = 55°C$). And, thanks to their unique structures – incorporating passivated, diffused-junction silicon dice, which have been carefully interconnected by integral heat-sinks and encapsulated in voidless, transfer-molded, compact packages – they provide above-and-beyond performance, even under the toughest environmental conditions.

For example, the MDA990 series has a built-in, electrically-insulated, aluminum disc heat-sink for high heat dissipation when metal-chassis mounted. Its top output current rating (27 Amps) is a full two-Amps higher than similar, yet larger and more cumbersome encapsulated bridges. And, both series can easily take non-repetitive, one-half cycle surges up to 300 Amps (over 30% higher than other bridges in the same power class)!

All this, yet these "high current in a small package" single-phase, full-wave bridges carry cost/ampere prices comparable to discrete rectifiers having similar power output ratings. And, whether your job calls for reverse voltages below 50 Volts or up to 600 Volts, these bridges afford rectification efficiencies of up to 70%, or more, over a repetition recovery rate to 15 kHz.

A Designers Data Sheet, containing comprehensive curves as well as complete data, so fully describes these new MIDA bridges that the engineer gets all the information he needs from a single source – at a glance!

Series	I_O @ $T_C = 55°C$	V_{RM} Range	I_{FM} (surge)	V_F (max)	I_R (max)	Prices (100-up)
MDA980 MDA990	12 A 27 A	50 V to 600 V	300 A for ½ cycle	1.0 V @ ½ I_O	0.5 mA @ rated V_{RM}	\$2.40 to \$5.20 3.00 to 5.90

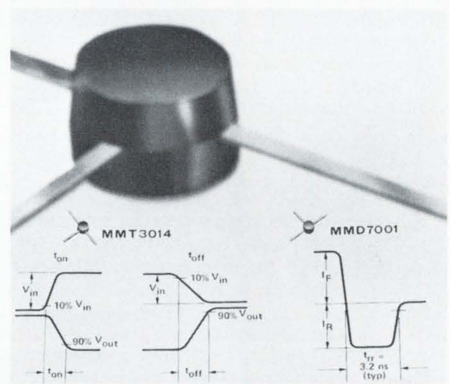
For a copy circle Reader Service No. 291

High-Speed Switches Added To Micro-T Menage

The introduction of a new Micro-T packaged high-speed dual switching diode – the MMD7001 – along with a fast NPN saturated switching transistor (MMT3014), now expands Motorola's ability to serve designers of high-density and miniaturized circuitry.

The MMD7001 is particularly well suited for fast switching applications requiring high breakdown voltages (45 V min. @ 10 μA) and low capacitance values – just 3.5 pF, typ. Add to this a reverse-recovery time of only 3.2 ns (typ) @ $I_F/I_R = 10$ mA – along with a maximum forward voltage drop (at $I_F = 500$ mA) of 1.15 V – and you have a letter-perfect answer for high density switching designs requiring a comparatively high current handling capability.

As with the dual-diode, Motorola's new MMT3014 is speedy and efficient.



Both the Micro-T MMD7001 and MMT3014 have nanosecond switching speeds.

It has a combined t_{on}/t_{off} of less than 41 ns and a collector saturation voltage below 0.22 V, both at $I_C = 30$ mA. Capacitance is also low ($C_{ib} = 8$ pF and $C_{ob} = 5$ pF, max.). Its minimum f_T is a high 350 MHz @ 30 mA/10 V/100 MHz. It sells for \$1.52 (100-up).

For details circle Reader Service No. 292

New Ultra-Fast Plastic PNP Switches Offer Low Prices—Volume Availability!

Manufacturers of instrumentation equipment and plated-wire memories can now realize a substantial savings, in costs and delivery time, by specifying Motorola's new Unibloc (TO-92) plastic packaged **MPS-L07/08** PNP high-speed silicon switching transistors. Their ultra-fast, efficient, parameters amply qualify them for applications such as digit-drivers and complementary flip-flop designs.

For example, they have a typical combined t_{on} and t_{off} time of only 50 ns and maximum storage times of just 15 ns (MPS-L07) and 20 ns (MPS-L08), both at $I_C = 10$ mA. In addition, their exceptionally low saturation voltages – 0.07 V typ. at 10 mA – and high f_T's (500 MHz and 700 MHz min., at 10 mA), ensure efficient operation, even in the most demanding switching designs.

And, Motorola can deliver them fast – whether you need just a few or production volume quantities – at economy prices (just 25¢ for the MPS-L07 and 32¢ for the MPS-L08, in 5,000-up quantities)! Call your local distributor for immediate delivery from warehouse stock.

For details circle Reader Service No. 293

PRODUCT BRIEFS

TWO NEW LOW-NOISE RF SILICON TRANSISTOR SERIES

– Fulfill Both Critical And Economy Requirements Up To 1.0 GHz

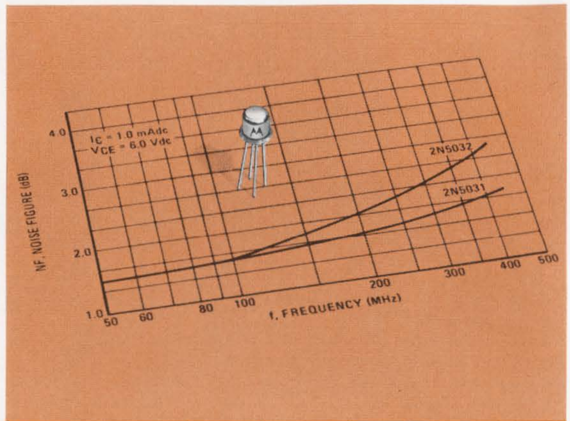
Two new sets of NPN silicon RF, low-noise, high-gain amplifier transistors for military and industrial applications, have joined Motorola's broad line of small-signal devices to serve high-frequency design requirements. Both the premium 2N5031/32 versions and the lower priced MM8006/07 are well suited for video wideband and general-purpose amplifiers ranging from 50 MHz to 1.0 GHz.

They are all packaged in the TO-72 four-lead metal can and have breakdown voltages of 10V (min.) @ 1 mA and $V_{CE(sat)}$ of just 0.35V @ 80 mA.

Type No.	Gpe (typ) @ f	NF @ f	f_T (min)	$r_b'C_c$ (typ)	C_{cb} (max)	Prices (100-up)
2N5031/32	17 dB @ 450 MHz	2.5 dB/3 dB* @ 450 MHz	1.0 GHz @ I_C = 5 mA	5 ps @ 10 mA/6 V/ 31.8 MHz	1.5 pF @ 6 V/0.1 MHz	$14.00/8.00
MM8006/07	25/20 dB @ 200 MHz	2.2 dB/2.7 dB† @ 200 MHz				$ 4.00/2.60

*Maximum †Typical

For details circle Reader Service No. 294



12.5-VOLT AND 28-VOLT RF POWER TRANSISTORS

– Operate From 470 MHz To 1.0 GHz At Efficiencies To 60%!

Three new NPN BET silicon UHF high-current transistors – the 2N5644/45/46 – have now joined Motorola's broadening EIA registered, ceramic stripline packaged, RF power family. These devices are primarily designed for 12.5V supplies in industrial/consumer FM equipment operating up to 520 MHz. They have an excellent broadband capability thanks to their low lead-inductance stripline packaging. And, their balanced-emitter construction provides protection against destructive secondary breakdown.

In addition, four new microwave types (for use with 28V supplies) have been added to the RF power line. The MM4429 and MM4430 are multiple-emitter devices which are packaged in ceramic stripline cases, while the 2N4428 (also multiple-emitter) is packaged in the TO-39 case. Their prime usage is in military and industrial UHF and L-band (1-2 GHz) microwave power amplifiers and transmitters. The MM8009, on the other hand, is ideal for frequency-multiplier or oscillator applications to 1.68 GHz.

For details circle Reader Service No. 295

Type	P_{out}	G_{pe} (min)	@ f	V_{CC}	Efficiency η	Price (100-up)
2N5644	1.0 W	7.0 dB	470 MHz	12.5 V	60% (min)	$ 8.30
2N5645	4.0 W	6.0 dB				11.90
2N5646	12 W	4.7 dB				22.50
MM4429	1.0 W	5.2 dB	1.0 GHz	28 V	45% (typ)	9.00
MM4430	2.5 W	5.0 dB				19.00
2N4428	0.75 W	10 dB	500 MHz	28 V	35% (min)	5.50

Type	P_{out}	@ f	f_T	V_{CC}	Efficiency η	Price (100-up)
MM8009	0.9 W (min) 0.3 W (osc) (typ)	1 GHz 1.68 GHz	1.0 GHz @ 50 mA	28 V	35% (min)	$ 7.50

Packages: All in ceramic opposed-stripline cases (case 145A) except for the 2N4428 and MM8009 which are in TO-39 cases.

2-GHz OSCILLATOR MICROWAVE TRANSISTORS

– Eliminates Need for Costly Frequency-Multiplier Chains

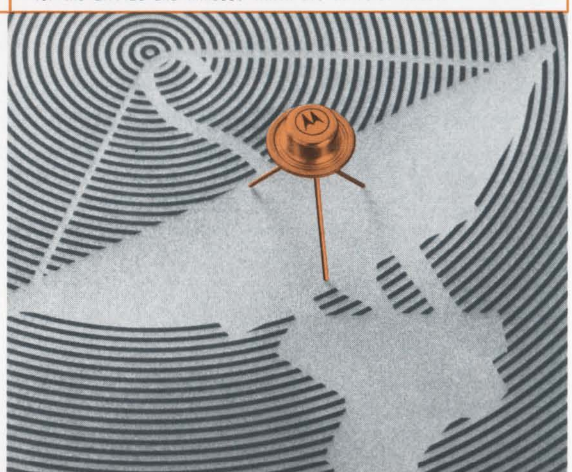
Motorola's new MM8008/10/11 NPN silicon microwave transistors, designed primarily for military and industrial oscillator, frequency-multiplier, and UHF amplifier applications, represents a major high-performance vs. low-cost break-through. *Crystal and tuned-oscillators can now be economically developed which operate at frequencies previously possible only with expensive multiplier chains!* The result . . . not only a reduction in costs but also the simplification of circuitry, lower noise-levels and improved harmonic spacing.

Effective in the S-Band (2 to 4 GHz) and L-Band (1 to 2 GHz) microwave frequency spectrums, these devices are ideal for use in radar antenna systems, navigational instruments, telemetry, proximity fuzes and as varactor drivers.

Type No.	$P_{out(osc.)}$ Min @ 2.0 GHz	$P_{out(osc.)}$ Typ @ 1.68 GHz	f_T (typ) @ I_C	C_{ob} (typ) @ V_{CB}	$V_{CE(sat)}$ (max)	Prices (100-up)
MM8008	300 mW	550 mW	1.1 GHz @ 50 mA	1.3 pF @ 30 V	0.3 V @ I_C = 100 mA	$17.50
MM8010	200 mW	450 mW				12.00
MM8011	100 mW	300 mW				7.10

Case Type — TO-107

For details circle Reader Service No. 296



NEW MRD500/510 SILICON PIN PHOTO DIODES

– Respond In Less Than 1.0 ns, And Are Sensitive To Low Radiation Levels

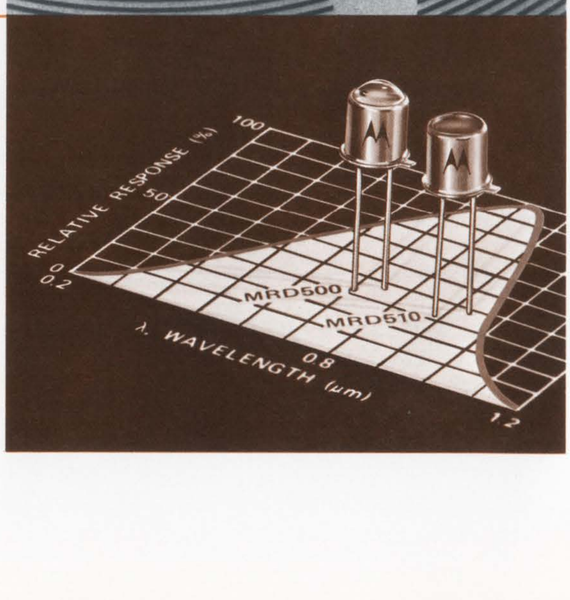
They turn-on in less than 1.0 ns (typ) and can be activated by low-intensity radiation sources. *They're the new Motorola MRD500/510 PIN photo diodes!* High radiation-sensitivity, fast turn-on-time and high signal-to-dark-current response make them ideal for use in such functions as: laser detection, light demodulation, light-emitting-diode coupling and shaft/position encoding.

Their Annular, passivated structures assure long-term stability. The MRD500 has a convex lens (for high sensitivity), while the MRD510's is flat, for use with external lens-systems.

Photo Diode Type	Response Time @V_R/R_L (typ)	Radiation Sensitivity –μA/mW/cm² (typ) Note(1)	@λ=0.8μm	Dark Current @ $V_R/R_L/T_A$ (max)	Breakdown Voltage (min)	Capacitance @ V_R/f (max)	Prices (100-up)
MRD500	1.0 ns @ 20V/50 ohms	1.8	6.6	2.0 nA @ 20V/ 1.0 meg/25°C	100V @ I_R = 10μA	4.0pF @ 20V/1.0MHz	$7.25
MRD510		0.42	1.5				$6.60

Note (1): Radiation Flex Density H = 5.0 mW/cm² — tungsten source (color temp. = 2870K)

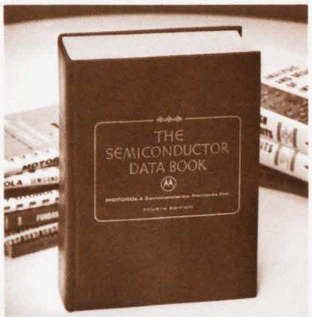
For details circle Reader Service No. 297



NEWSBREAKS

4th Edition "Data Book" Now Bigger-Than-Ever With An Improved Data-File System

Motorola's fourth edition of "The Semiconductor Data Book," *the Bible of the industry,* is now available! It's the largest yet — **2160 pages** — and includes key specifications for all EIA registered discrete semiconductors. This latest edition has an improved format that makes it easier to quickly locate detailed data on Motorola products by type numbers.



As in the past, this issue includes a 185-page numerical listing section covering the key parameters of all semiconductors registered by the EIA. The largest part of the Data Book is devoted to data sheets that give complete information on all Motorola discrete semiconductors **(3626 types)**. They are arranged in alphanumeric sequence for easy location of information on any device whose number is known.

Other sections of the book include case outlines, selector guides and selected application notes.

It is still available for the same price as last year's issue (just \$4.95 per single copy). A supplemental service is available for just \$2.00 (a minimum of two supplements will be published). Use the special coupon in this issue to order.

New Motorola Prototype Kit Provides A Broad Scope Of FET & Bipolar Choppers

Motorola's new **MK48C HANDYLab Kit** will surely prove both a time and money savings aid in the design and prototyping of chopper circuits. It contains a broad assortment of popular FET and bipolar types (see table), all packaged in a convenient, sturdy, vinyl-covered carrying case.

The "kit" includes a comprehensive brochure which contains selector guides, complete data sheets on all Motorola chopper transistors and application notes covering both FET and bipolar design considerations.

The complete kit sells for just **\$84.50!** Considering that the total small-quantity price of the units in the kit is over \$175.00*, you save more than \$90.00 just on the products alone! Order a MK48C Chopper Transistor kit from your Motorola distributor TODAY!

Offer expires April 1, 1970.

*based on current Motorola 1-99 published prices.

MK48C CONTENTS

FET	QUAN.	BIPOLAR	QUAN.
2N4091	2	2N2944	2
2N4093	2	2N2945	1
2N4351	4	2N2946	6
2N4352	4	2N5231	5
2N5555	6	MM4052	5
MFE2009 ...	2	Value . . \$179.75	
MFE2012 ...	2	**Special**	
3N155	2	**Price . . \$ 84.50**	

Tear Along Perforated Line and Drop in Mail (No Postage Required)

LITERATURE REQUEST FORM

NOTICE: Requests for literature on items described in this publication cannot be honored after **April 1, 1970.**

NEWSBRIEFS No. 7-69

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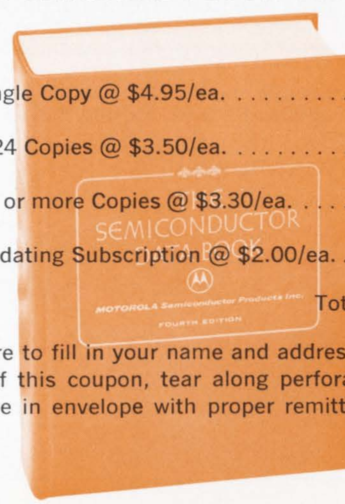

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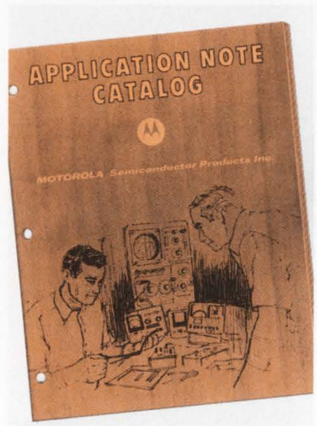
NEW LITERATURE BRIEFS

69 New Application Notes Bring Total Subjects Covered in 1969 Catalog to 189

Since the issuance of Motorola's 1968 Application Note Catalog (approximately one year ago), 69 new "notes" have been published. Abstracts on these latest additions have now been incorporated into the new **1969 edition.**



The notes cover a broad spectrum of solid-state application ideas embracing practically every area of electronic and electromechanical design. They include both analog and digital circuitry spanning the frequency spectrum from dc to 12 GHz. The use of Motorola digital and linear ICs (both monolithic and hybrid) and discrete devices are detailed in the notes.

As a further aid in selecting pertinent notes, the catalog is divided into two parts. The first part indexes the notes by both semiconductor category and application area. The second, lists notes in numerical sequence and includes an abstract on each. The new notes are clearly indicated.

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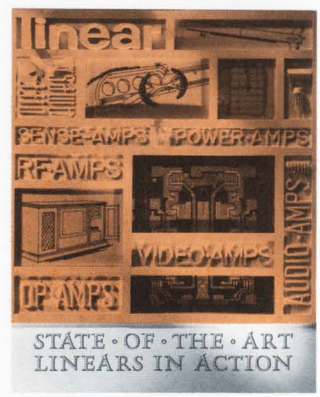
For the first time, in a 56-page volume, Motorola Application Engineers have compiled a series of "how-to-use" articles covering all major linear integrated circuit categories. These application discussions, reviewing the latest in Motorola product developments and capabilities, include: Op Amps, Voltage Regulators, Multipliers, High-Frequency ICs, Sense Amps and ICs for consumer designs.



They have been combined, in one brochure, in order to present the status of today's linear IC applications, and to "bridge the information gap" concerning the uses for the multitude of new linear circuits which Motorola has recently introduced. It will prove a valuable aid to engineers who are already using, or are contemplating the use of linear ICs in their designs.

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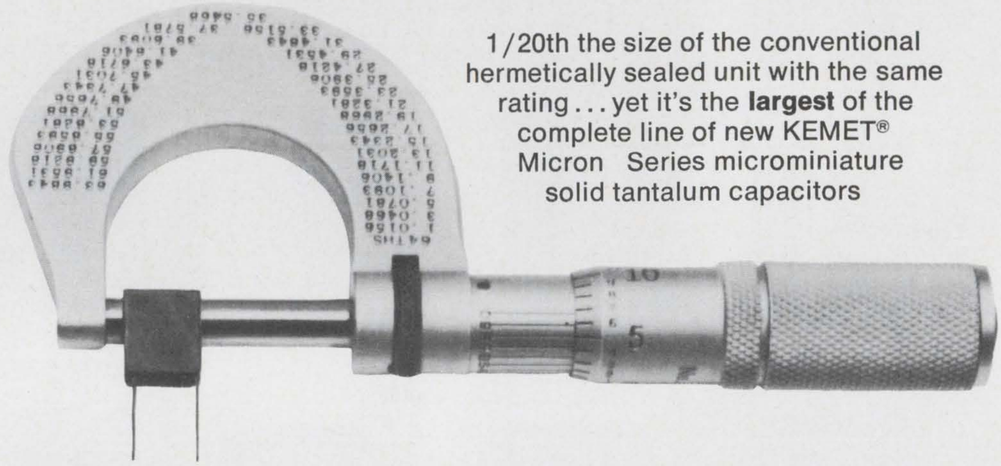

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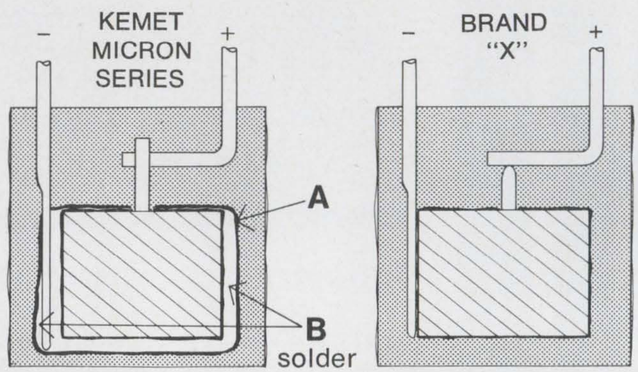

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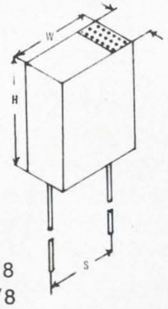

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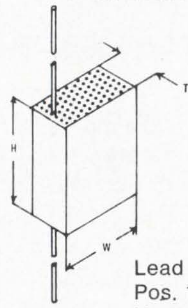

Lead Length:
Pos. 1-5/8 ± 1/8
Neg. 1-3/8 ± 1/8

Capacitor Outline Drawings

Case Dimensions—Inches

Case Size	H Case Height Max.	W Case Width Max.	T Thick-ness Max.	S Lead Spacing	Capac-itance uF
A	.125	.070	.040	.050	.001-1.5
B	.165	.120	.070	.100	.0047-10
C	.225	.185	.075	.150	.68-22
D	.290	.220	.110	.180	2.2-47
E	.310	.230	.130	.200	6.8-68
F	.475	.375	.150	.300	10-220

T 374 T 376 Polar Cylindrical 2-50 VDC

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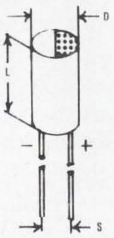

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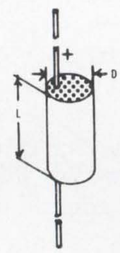

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Neg. 1-5/8 ± 1/8

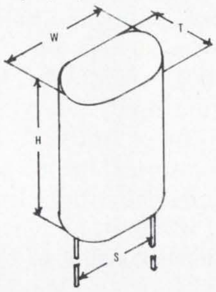
Capacitor Outline Drawings

Case Dimensions—Inches

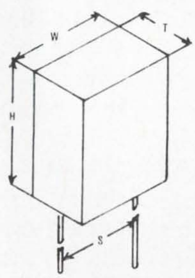
Case Size	L Case Length Max.	D Case Diameter Max.	S Lead Spacing	Capac-itance uF
A	.125	.070	.050	.001-2.2
B	.160	.070	.050	.001-.68
C	.200	.080	.050	.33-10
D	.225	.100	.070	.68-22
E	.250	.150	.120	1.5-47

T 371 Non-Polar, Radial Lead 2-50 VDC

A, B, C, E & G Case



D, F, H & J Case



Case Dimensions—Inches

Case Size	H Case Height Max.	W Case Width Max.	T Thick-ness Max.	S Lead Spacing	Capac-itance uF
A	.135	.120	.070	.100	.001-1.0
B	.160	.120	.070	.100	.001-2.2
C	.200	.140	.080	.100	.15-4.7
D	.180	.125	.125	.100	.1-4.7
E	.235	.190	.105	.125	.33-10

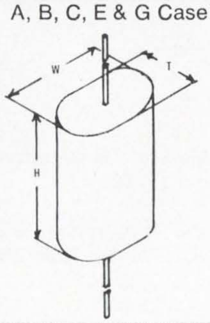
Case Dimensions—Inches

Case Size	H Case Height Max.	W Case Width Max.	T Thick-ness Max.	S Lead Spacing	Capac-itance uF
F	.240	.140	.180	.100	.47-10
G	.270	.290	.155	.200	1.5-22
H	.315	.180	.220	.150	3.3-22
J	.335	.230	.230	.200	6.8-33

Lead Length: All Cases 1-5/8 ± 1/8″

T 373 Non-Polar, Axial Lead 2-50 VDC

A, B, C, E & G Case



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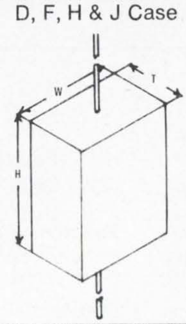

Case Dimensions—Inches

Case Size	H Case Height Max.	W Case Width Max.	T Thick-ness Max.	Capac-itance uF
A	.175	.120	.070	.001-1.0
B	.210	.120	.070	.001-2.2
C	.240	.140	.080	.15-4.7
D	.220	.125	.125	.1-4.7
E	.275	.190	.105	.33-10

Case Dimensions—Inches

Case Size	H Case Height Max.	W Case Width Max.	T Thick-ness Max.	Capac-itance uF
F	.280	.140	.180	.47-10
G	.310	.290	.155	1.5-22
H	.370	.180	.220	3.3-22
J	.390	.230	.230	6.8-33

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Meetings

FJCC: Las Vegas is a natural

The decision makers at the American Federation of Information Processing Societies, which sponsors the Fall Joint Computer Conference, presumably picked Las Vegas and its Convention Center for this year's meeting (Nov. 18-20) to avoid a mad crush like the one that occurred last fall at San Francisco's Civic Auditorium, or last spring at Boston's War Memorial Auditorium. The Convention Center's size may well be adequate—but perhaps another crush will be averted because a third of the delegates will be out trying their luck against the one-armed bandits while another third are trying to catch a glimpse of Howard Hughes.

For the remaining third, the meeting itself promises to be quite interesting, although, as always, perhaps a bit too broad to satisfy any individual's particular needs. For example, R.A. Henle, I.T. Ho, G.A. Maley, and R. Waxman from IBM have prepared a discussion on applying the regularity of memory structures to logic circuits, thereby making the latter more amenable to large-scale integration. An entire session is devoted to computer privacy and security, and another to the field of medical data processing.

Representatives from four firms of ostensibly widely divergent interests are authors of a paper on a sophisticated new display system; the firms are Shell Development Corp., Shell Oil Co.'s R&D subsidiary; Bolt Beranek & Newman Inc., a prominent computer-systems and applied physics organization; Sanders Associates, which recently made a splash in the compact memory field; and the Evans & Sutherland Computer Corp., an incorporation of two of the most sophisticated names in display technology. Four other papers discuss various way of attaining reliability through computer architecture.

A session entitled "What happened to LSI promises?" is reminiscent of two similarly titled sessions at last year's FJCC, one on hardware and the other on software. Lutz Micheel, from Wright-Patterson Air Force Base, will discuss a threshold-logic gate that can switch in 1 nanosecond and from which a multiplier could be built that would multiply two 16-bit numbers in 80 nsec. And Bell Telephone Laboratories will blow some of its magnetic bubbles in public—one of the first, or perhaps the first, public discussion of these devices.

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Calendar

Nuclear Science Symposium, IEEE; Sheraton Palace Hotel, San Francisco; **Oct. 29-31.**

International Electron Devices Meeting, IEEE; Sheraton Park Hotel, Washington; **Oct. 29-31.**

Northeast Electronics Research & Engineering Meeting (NEREM), IEEE; Sheraton Boston Hotel, War Memorial Auditorium, Boston; **Nov. 5-7.**

University Conference on Ceramic Science, Dept. of Metallurgical and Materials Engineering, University of Florida; **Nov. 10-14.**

Symposium on Adaptive Processes, IEEE; Pennsylvania State University, State College; **Nov. 17-19.**

Fall Joint Computer Conference, IEEE; Convention Hall, Las Vegas; **Nov. 18-20.**

Commerce Laser Colloquium, Electronic Industries Association and the U.S. Commerce Department; Paris, France; **Nov. 18-20.**

Conference on Magnetism and Magnetic Materials, IEEE, American Institute of Physics; Benjamin Franklin Hotel, Philadelphia; **Nov. 18-21.**

Conference on Image Storage and

(Continued on p. 32)

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Meetings

(Continued from p. 30)

Transmission for Libraries, U.S. Dept. of Commerce; National Bureau of Standards, Gaithersburg, Md., **Dec. 1-3.**

Annual Conference, IEEE Group on Vehicular Technology; Columbus, Ohio, **Dec. 4-5.**

Conference on Applications of Simulation, Association for Computing Machinery, IEEE; International Hotel, Los Angeles, **Dec. 8-10.**

Fall USNC/URSI Meeting, IEEE; The University of Texas at Austin, **Dec. 8-10.**

Symposium on Circuit Theory, IEEE; San Francisco, **Dec. 8-10.**

National Electronics Conference, Conrad Hilton Hotel, Chicago, **Dec. 8-10.**

International IEEE G-AP Symposium, The University of Texas at Austin, **Dec. 9-11.**

Symposium on Application of Magnetism in Bioengineering, IEEE, Israel Society for Biomedical Engineering; Rehovot, Israel, **Dec. 9-11.**

Asilomar Conference on Circuits and Systems, Naval Postgraduate School, The University of Santa Clara, Stanford University, and IEEE; Asilomar Hotel and Conference Grounds, Pacific Grove, Calif., **Dec. 10-12.**

Winter Power Meeting, IEEE; Statler Hilton Hotel, New York; **Jan. 25-30, 1970.**

Annual Symposium on Reliability, Group on Reliability of the IEEE, American Society for Quality Control, American Society for Nondestructive Testing, and the Institute of Environmental Sciences; Ambassador Hotel, Los Angeles; **Jan. 27-29, 1970.**

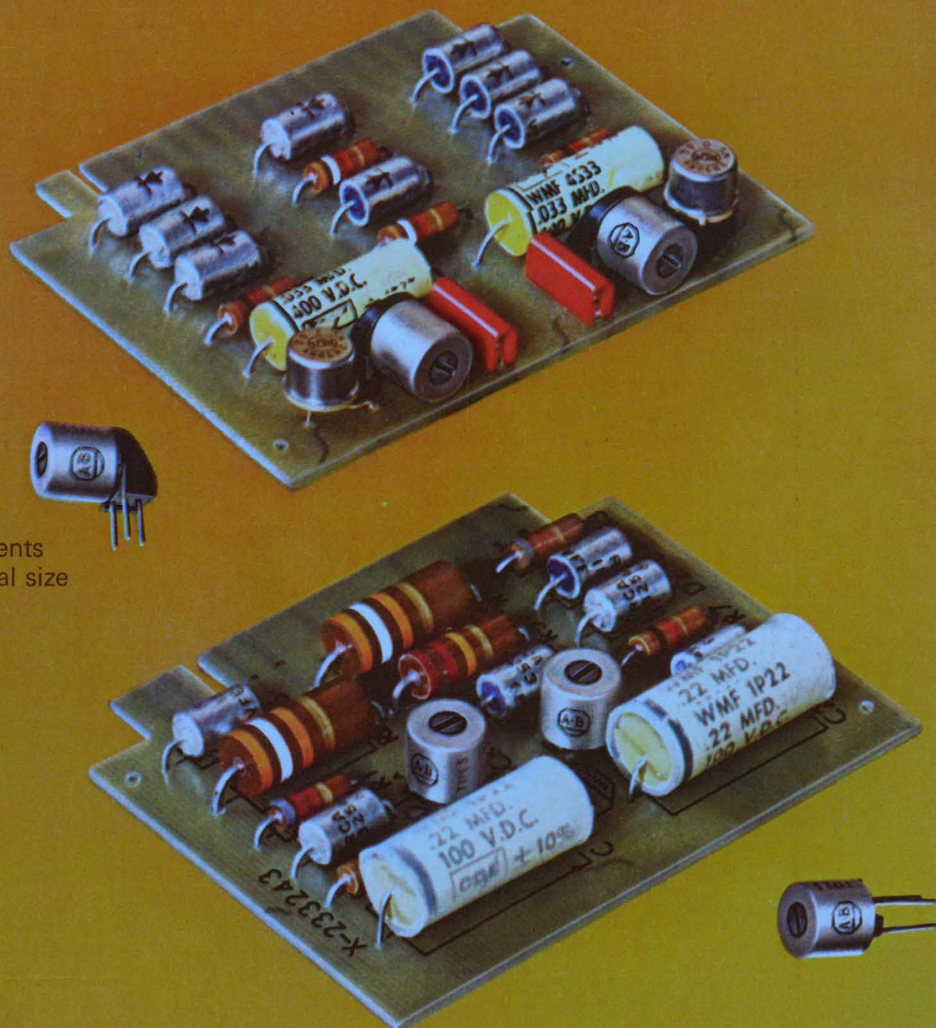
International Solid State Circuits Conference, IEEE, University of Pennsylvania; Sheraton Hotel and University of Pennsylvania, Philadelphia, **Feb. 18-20, 1970.**

Short courses

System Effectiveness—From the Support Point of View, University of California at Los Angeles, **Dec. 1-5.** $275 fee.

Characterizations and Models of SCR Circuits, University of Wisconsin,

(Continued on p. 34)



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Meetings

(Continued from p. 32)

Madison, **Dec. 9-10.** $70 fee.

Computer Control, University of Wisconsin, Madison, **Dec. 11-12.** $70 fee.

Electronic Components, University of Wisconsin, Madison, **Feb. 19-20.** $70 fee.

Call for papers

Electronic Components Conference, Electronic Industries Association and IEEE; Statler-Hilton Hotel, Washington, May 13-15, 1970. **Nov. 15** is deadline for submission of abstracts to Darnell P. Burks Sprague Electric Co., Marshall St., North Adams, Mass. 01247.

Computer Group Conference, IEEE; Washington, D.C., June 16-18, 1970. **Nov. 15** is deadline for submission of papers to T.C. Foote, IEEE Computer Group Conference 1970, P.O. Box 1727, Rockville, Md. 20850.

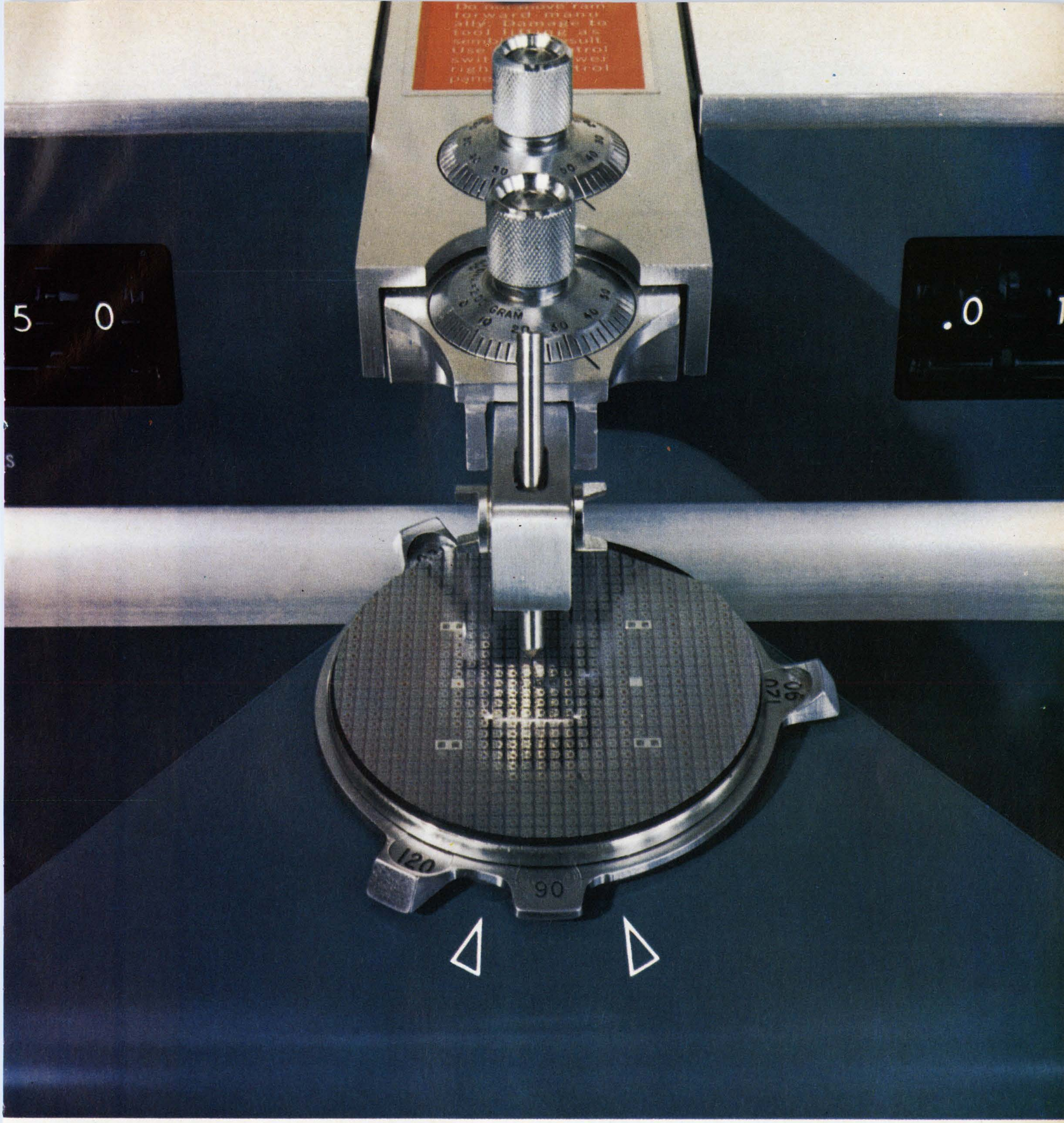
National Aerospace Electronics Conference (NAECON) IEEE and American Institute of Aeronautics and Astronautics; Sheraton-Dayton Hotel, Dayton, Ohio, May 18-20, 1970. **Dec. 1** is deadline for submission of abstracts to Mrs. Rita Gustin, 5455 Flotron Ave., Dayton, Ohio 45424.

Southwestern IEEE Conference, Memorial Auditorium, Dallas, April 22-24, 1970. **Dec. 1** is deadline for submission of abstracts and summaries to Prof. Andrew P. Sage, Information and Control Sciences Center, SMU Institute of Technology, Dallas, Texas 75222.

Symposium on Management and Economics in the Electronic Industry, IEE; University of Edinburg, Scotland, March 17-20, 1970. Synopses should be sent immediately to Conference Department, IEE, Savoy Place, London WC2.

Conference on Gas Discharges, IEE; London, England, Sept. 15-18, 1970. **Dec. 1** is deadline for submission of synopses to Conference Department, IEE, Savoy Place, London, L.C. 2.

Frequency Control Symposium, U.S. Army Electronics Command; Shelburne Hotel, Atlantic City, N.J., April 27-29, 1970. **Dec. 15** is deadline for submission of summaries to Director, Electronics Components Laboratory, Army Electronics Command, Fort Monmouth, N.J. 07703.



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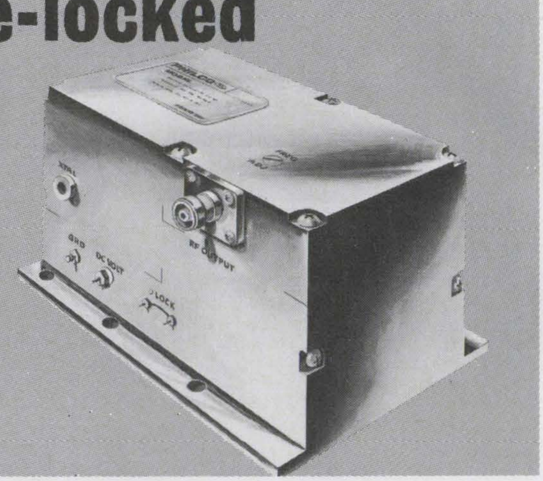
New phase-locked avalanche oscillator source



For the first time anywhere, we've applied the stability of phase-lock control to an avalanche oscillator power source. Frequency stability equals that of conventional multiplier chain sources. Power output is an order of magnitude greater than conventional phase-locked transistor oscillators—up to 250 milliwatts in Ku band.

Its unique phase-lock loop provides broad phase-modulation capability. Spurious output is minimized because the oscillator operates at its fundamental frequency, without need for multiplication.

This unique new power source is smaller and costs less than a multiplier chain source. It's available from C through Ku band, and operates from −25° to +72°C.

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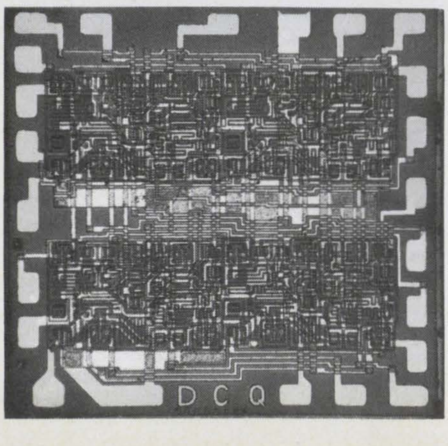
Digital Crosspoint Quad Switch... another MSI bipolar array



Now you can do the equivalent of telephone-style crossbar switching in solid state, by means of Philco-Ford DCQ—Digital Crosspoint Quad—bipolar array. The DCQ is a 2 x 2 array of crosspoints which can be configured to produce a switching matrix of whatever complexity you require. It is now being used in communications switching networks, and is applicable to switching of input-output lines connecting peripheral equipment to computers, or for any switching application where the information to be switched is in digital form. Each crosspoint is bidirectional, and includes selection and hold logic.

The chip contains the equivalent in complexity of 20 NAND gates. Double layer metallization is used for interconnections. The DCQ utilizes T^2L logic and will interface directly with Series 74 circuits. Power dissipation is a low 36 milliwatts. Selection and hold mode is accomplished typically within 60 nanoseconds. Information can be transferred through the data lines at rates up to 2 MHz.

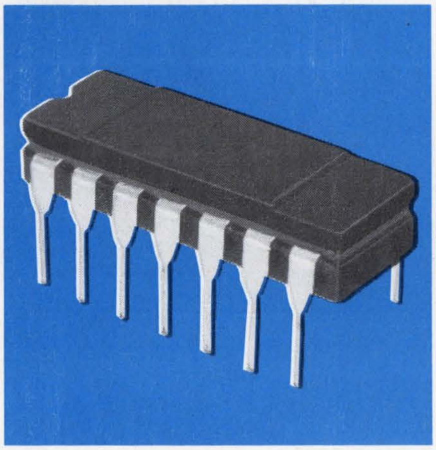
The master chip can perform other functions beside crosspoint switching, simply by customizing the multilayer interconnection pattern. Think of it as an array of four basic cells, each consisting of two AOI gates and one NAND gate . . . which you can receive from us hooked up in just about any configuration you want. Tell us your application, we'll be glad to examine feasibility.

CIRCLE 328 ON READER SERVICE CARD

the better idea people in microelectronics **PHILCO** Ford

PHILCO-FORD CORPORATION • MICROELECTRONICS DIVISION • BLUE BELL, PA. 19422

Something new in Series 74 T^2L... glassivated chips in cerdip packages



Why consider another source for Series 74 T^2L? Here are three good reasons from Philco-Ford.

RELIABILITY

As a final production step, we put an added layer of glass over the completed chip. This glassivation process protects the circuit against damage, and gives an extra measure of reliability.

HERMETIC DUAL-IN-LINE PACKAGES

All Philco-Ford Series 74 circuits are manufactured in hermetically sealed ceramic dual-in-line packages... AND at prices comparable to plastic. Your assurance of quality is the experience we have gained in manufacturing many millions of cerdip DTL and T^2L circuits.

CLAMP DIODES

All Philco-Ford Series 74 circuits have been designed with clamp diode inputs to reduce ringing and improve system noise immunity.

All popular Series 74 circuits are now available from our Lansdale facility, one of the country's largest IC manufacturing plants.

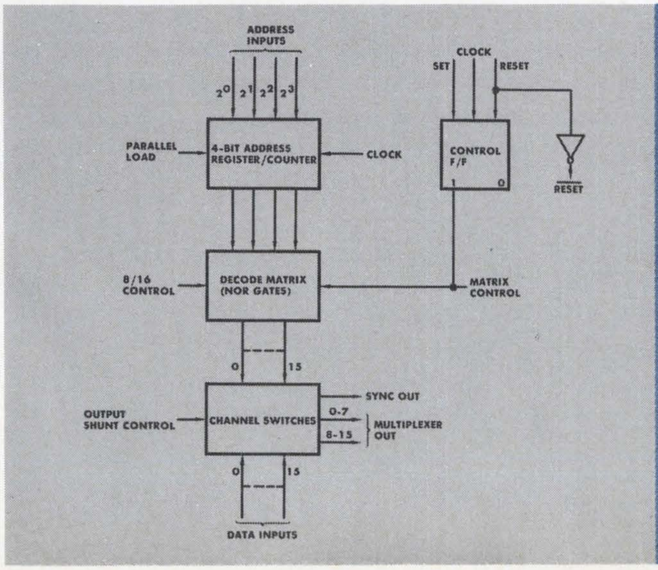
CIRCLE 329 ON READER SERVICE CARD

16-channel MOS multiplexer for time-division systems

The pL4S16C is a different kind of switch that can add new versatility of multiplexing functions in your telemetry, data sampling or communication system. Offset voltage is zero. Leakage current is less than 10 nanoamps. And it is voltage-driven ... needs no complicated drive network. You can clock it externally, or allow it to free-run on its 100 KHz internal clock.

As a 16-channel multiplexer, the pL4S16C gives you a choice of random access switching, or sequential sampling of all 16 channels, or of simultaneous sampling of two banks of 8 channels ... just by changing external wiring. Stack them up, and you can get switching in sequential or random access modes, in multiples of 16 channels. Or, if you like, you can use it to switch 2 to 16 channels.

CIRCLE 330 ON READER SERVICE CARD



Typical Specifications

Offset voltage:	0 volts
Signal voltage swing:	10 volts max.
Channel leakage:	10 nA
"ON" resistance:	1000 ohms
Power dissipation:	150 mW max.
Input capacitance:	5 pF
Max. clock (sequential mode):	100 KHz
Package:	34-lead flat pack

Editorial Comment

Redefining computer goals

Should industry back off from stressing greater computing capability (bigger and faster computers) and concentrate, instead, on smarter computer systems? Such systems would converge on wanted solutions rapidly rather than merely pour out reams of data, most of which is useless. Some computer theorists, and even some pragmatists, believe priorities are misplaced insofar as hardware versus software is concerned.

At a seminar on "computers, communications, and the public interest," which was cosponsored recently by Johns Hopkins University and Brookings Institution and held in Washington, Herbert Simon, a professor of computer science at Carnegie-Mellon University, emphasized certain factors that bear upon the relative importance of faster processing and input-output techniques.

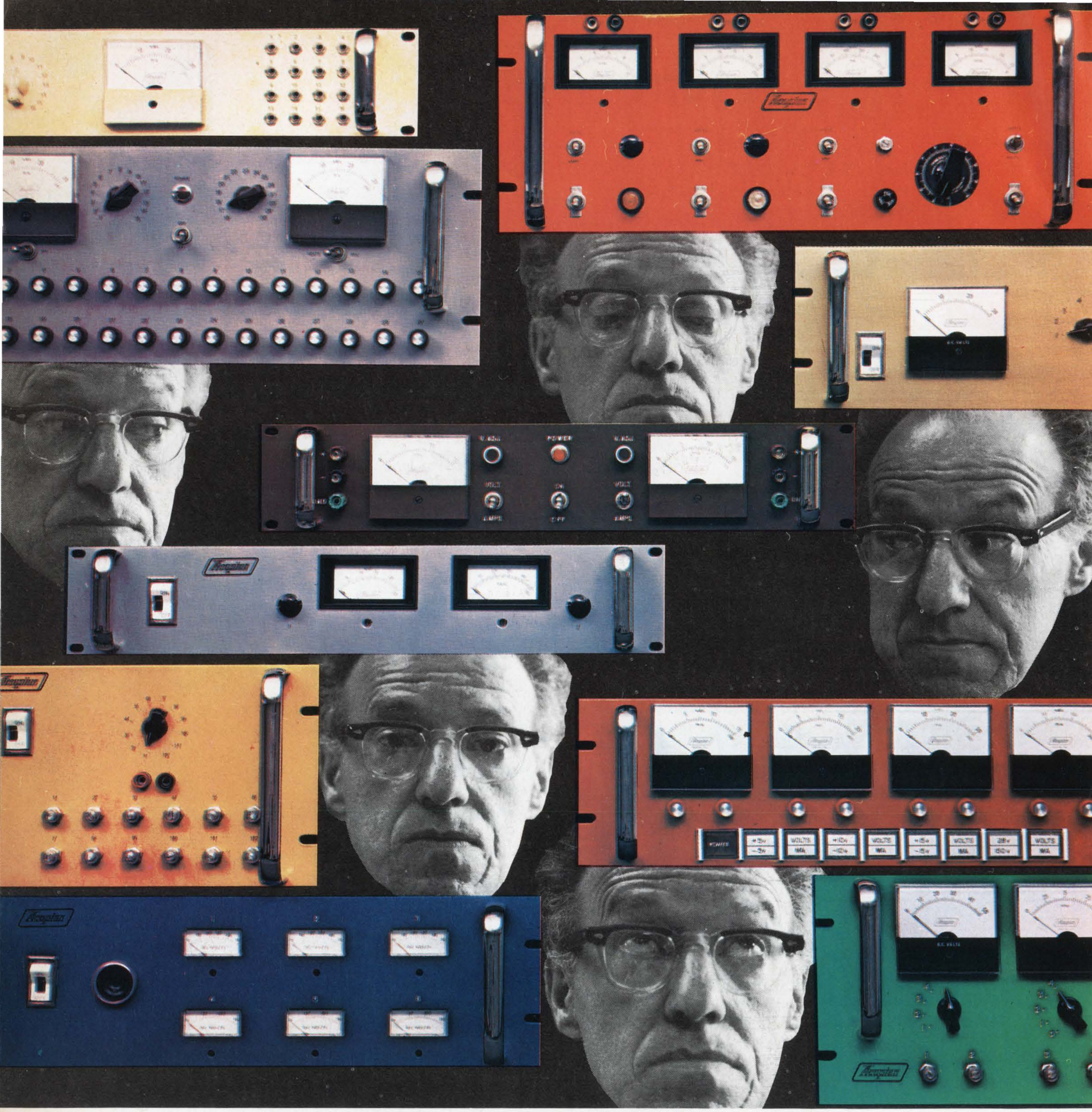
First and foremost on his list is what Simon calls "information overload." Simon contends that in the drive to develop greater data-processing capability, user attention somehow has been given short shrift. Unless information is processed in such a way that it can be absorbed by the user during the precise attention span that the user has allocated for it, it is of scant value. Simply, the information explosion consists of a proliferation of vast amounts of partly processed information, solutions to certain specific problems, and a great deal of arbitrary and/or obsolete data. Given the proliferation of computers and computer systems, the implication is that society will encounter a situation analogous to the development of a highway network that speeds traffic toward a city like New York, which cannot accommodate the result. A parallel would be the rapid accumulation of facts and figures in a management-information system. Such an accumulation could be so outsized and unwieldy that it could not be further reduced for the use of the chief executive, for whom it's intended.

What is really needed, then, is a system that is a good filter. It must analyze, digest, and screen information, not merely juggle data, print it, or duplicate previously processed data.

Computer systems that acquire the human failing of being "information savers" frighten not only Simon, but others as well. Simon and those who agree with him suggest more work be done on programs that do not rely on the storage of vast amounts of data. Rather, they contend, programs are needed that can regenerate or recreate solutions either "from nature" or from a logical set of programed problem-solving instructions. In the ideal situation, they observe, recreation of information in this manner could be cheaper than retrieval of stored information.

In light of these thoughts, what about the company that is facing the question of whether to buy another computer? Simon believes computer systems must deliver more pointed answers or the decision to acquire more computing power may be the wrong one; such a decision may only "worsen the disease" of information overload.

If this suggestion seems to cast a note of gloom over the optimistic outlook for the computer industry, consider these other factors. First, the goal of faster convergence of computer systems upon wanted solutions does not necessarily conflict with the objectives of computer technologists who are developing faster, more efficient hardware. Furthermore, the design of hardware and software has long since progressed to where neither can be considered independently. New partitioning techniques and logic-process schemes are aimed toward programing that will lead not only to greater efficiency in filtering, but to faster convergence to useful solutions as well. List processing is coming into use. There are also several new and sophisticated display systems which show complicated systems graphically so that man can easily understand them. Finally, it should be noted that even Simon is not favoring a moratorium on the production of computers. "We must build and use [computers] before we know *how* to use them," he suggests. ■



Electronics Newsletter

October 27, 1969

Honeywell to need million digital IC's a week by 1973

Honeywell's Electronic Data Processing division is leaking word to suppliers that, based on market forecasts for its H-3200 computer, **production demands could reach 1 million digital IC's per week by 1972 or 1973.** That's 52 million digital IC's a year—more than were produced in the U.S. in all of 1966 and almost as many as were produced in 1967, according to EIA figures. The Honeywell IC's would be TTL, many of which would be custom designs, and at least some would be arrays with medium-scale integration.

If Honeywell's growing use of IC's is typical, the semiconductor industry had better expand at more than a linear rate. **Industry predictions for 1972 pegged IC production between 200 million and 300 million units,** low in light of the requirements of a single user.

Coming from TI: discretionary-wired shift registers . . .

Texas Instruments isn't wasting time. Just last summer it introduced its first commercial discretionary-wired product, an LSI digital differential analyzer [*Electronics,* Aug. 18, p. 145]. **Now, the company is planning to introduce the industry's first line of discretionary-wired shift registers.**

Making their bow next month will be three dynamic bipolar devices —a dual 253-bit unit, a dual-349 device, and a dual-501 unit. They will sell initially for about 40 cents per bit in medium quantities, **but TI officials see the price dropping to less than 20 cents per bit in the next two years.** Unlike the DDA introduced first, which has three layers of metalization, these products have only two metal layers, one of which is discretionary routed.

. . . and 16 more TTL devices

TI is also continuing to fill out its nondiscretionary wired transistor-transistor logic line. **Sixteen more products will be unveiled by year's end, four of which employ two layers of metalization.** These devices—a synchronous decade counter, a synchronous binary counter, a six-bit binary rate multiplier, and a 64-bit read-write memory—have been furnished on a custom basis.

Jack Carsten, TTL marketing manager, says Fairchild has also sold some custom devices using two layers of metal, but the new TI products will be available in production quantities. And, he says, the two-layer devices will by medium- and large-scale integrated TTL. **Carsten expects the extra cost of a second metal layer to be offset by higher yield because the dice can be made smaller.** TI won't use two layers of metal for "much less than 50 gates," Carsten says.

High-power r-f: new light for end of plasma blackout

It may be possible to transmit signals through the reentry plasma—which blacks out communications with manned space vehicles—by pumping extra radio energy into the plasma itself. **The high-power r-f boosts the energy of the plasma's free electrons so they'll combine with other plasma particles—which then are too massive to soak up other transmissions.**

Working at the Air Force's Cambridge Research Laboratories in Bedford, Mass., the scientists already have tried "overfeeding" a plasma with a 20-watt beam of 7 megahertz r-f, and call their results to date excellent.

The next step: a tryout on a Trailblazer rocket to be fired from Wallops Island, Va.

Meanwhile, researchers contemplate seeding a reentry vehicle's ablative outer coating with chemicals like sulphur hexafluoride for more efficient electron absorption—the chemical equivalent of a larger appetite and smaller stomach.

Believe it or not! IBM, Government on same side

An unlikely, if unintentional, alliance for protection of computer software seems to have come about between IBM and the Government. Unlike their divergent positions on antitrust, **IBM and the Government are suddenly promoting markedly similar views on the still unresolved issue of software protection—views that are different from those held by both just a year ago.**

Patent Commissioner William E. Schuyler Jr., is rescinding his predecessor's software protection guidelines and the Patent Office is exploring new protection approaches that would stimulate software investment and encourage information exchange between competitors and users. IBM, opposed to software patenting a year ago, now wants protection for all software—patentable or not—to protect corporate investments. It wants a new type of protection, specifically tailored for computer programing.

Automation eyed as answer to rise in offshore tariffs

With the Federal Tariff Commission considering an increase in the import tax on "offshore-assembled" devices, semiconductor firms with operations in Hong Kong, Korea, and Singapore face the loss of the price advantage afforded by 20-cents-an-hour labor. **Some IC makers feel that automation of their domestic operation would take up the price slack.** One manufacturer is already preparing to switch to automated beam-lead bonding, should the Government raise the import tax.

TI, Motorola, and Fairchild reportedly are ready to make the changeover despite the high cost of automated equipment. It's estimated that automating a medium-sized plant could cost beween $5 million and $10 million. And for a large operation, the cost for machinery can run as high as $50 million.

However, at least one major manufacturer has adopted a wait-and-see attitude, **declaring that automation just can't make up for the loss of cheap labor.**

Addenda

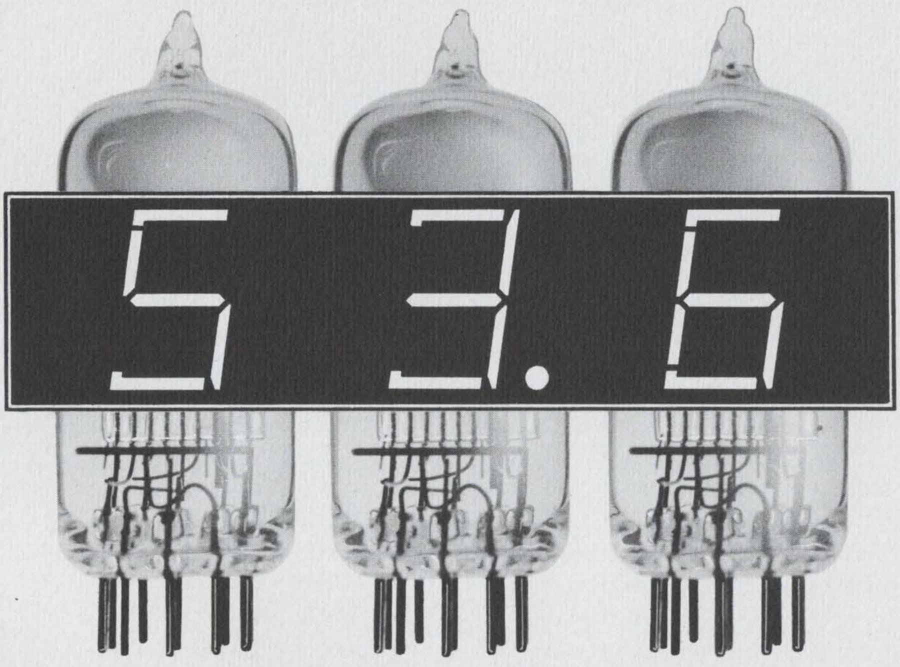
Despite the market dominance of its own 54/74 transistor-transistor logic, TI hasn't given up on Sylvania's version, SUHL. **The firm has been selling both SUHL 1 and SUHL 2 for some time, and soon will show data sheets on a full line of gates and flip-flops.** However, the SUHL effort is divorced from the Houston-based 54/74 TTL work. The devices are produced in metal flat-packs and plastic dual in-line packages in the same department in Dallas that makes diode-transistor logic devices and linear integrated circuits. . . . The Imlac Corp. of Waltham, Mass., will introduce at the Fall Joint Computer Conference a 16-bit computer, with a 4K memory—an integral display system capable of both alphanumerics and graphics. Buyers of Imlac's PDS-1 will get a 1,040-character crt display capability and minicomputer processing in a single package for a price to original equipment manufacturers of $6,500—**several thousand dollars less than the cost of most displays alone.**

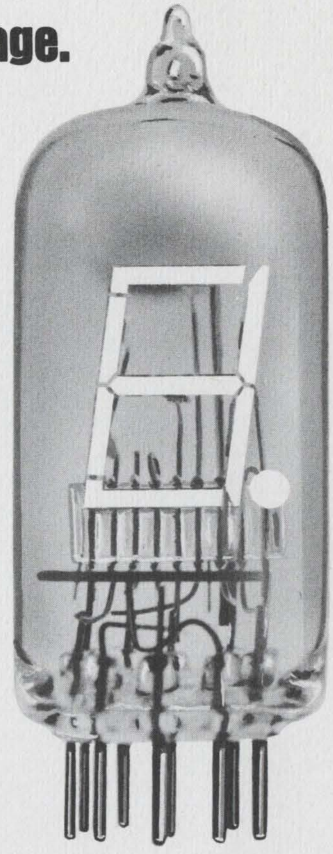
Component and Circuit Design IDEAS FROM SYLVANIA

DISPLAY DEVICES

Low-cost display tube operates on low signal voltage.

New "Flurotron" fluorescent indicator tube is compatible with voltage levels available in computers.





Our new "Flurotron" indicator tube combines the advantages of low cost with low signal and power operation. That alone should make it the device to consider for your next project requiring a numeric readout.

Priced at about $\frac{3}{5}$ the cost of comparable readout tubes, the "Flurotron" is an ideal display device for computer readouts, digital voltmeters, frequency counters and desk calculators. It operates from a 25 Volt signal as compared to 80 to 90 Volts required by other display tubes.

The "Flurotron" works on a simple principle and is not much more complicated than an ordinary incandescent bulb. It consists of directly heated cathode and eight anodes coated with fluorescent phosphor. When a voltage is applied to any of the anodes, they glow green. The anodes are arranged in a "figure-8" configuration (7 segments) so that any number from 0 through 9 can be formed by lighting the appropriate anodes.

Each "Flurotron tube" also includes a decimal point that may be used optionally. All connections to the "Flurotron" are made through a 10-pin base. The tube comes in a T-6$\frac{1}{2}$ envelope and is designed for extra ruggedness. Light output is on the order of 200 foot-lamberts.

Because all fluorescent segments are located on a single plane near the tube wall, there are no parallax problems. The display can be viewed easily from a wide variety of angles. The in-line display also means that you don't have to look through a maze of unlighted characters in order to see the readout.

The "Flurotron" is a low current device. At 25 Volts, current requirements are only 0.5 mA per anode segment. The specially designed filament operates on only 1.4 Volts at low power drain. Low phosphor persistence provides a high-speed readout capability. With all of these advantages, doesn't it make sense to solve your next display problem with "Flurotron"? CIRCLE NUMBER 300

This issue in capsule.

INTEGRATED CIRCUITS

You can mix and match with our functional arrays.

No matter which TTL logic system you are designing with, Sylvania arrays will be compatible.

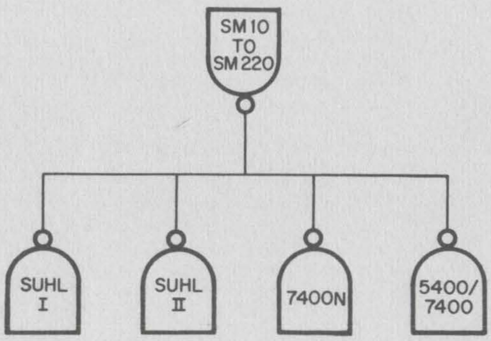
Our functional arrays are versatile. They'll work with any TTL logic system and most kinds of DTL logic, too. They have been specifically designed to have input/output characteristics that interface with all of these logic forms. As you can see from the table, our functional arrays match up with SUHL I, SUHL II, 7400N and 5400/7400 logic families.

The reason for this compatibility is a built-in commonality. All of our functional arrays use a 5-volt supply with TTL logic throughout. All have input/output buffering and all have the high noise immunity common to TTL circuitry. Sylvania functional arrays also have other advantages. They come in military and industrial temperature ranges.

But the really big advantage is the number of different functions available. These include fast adders, storage registers, scratch pad memories, binary and decade dividers and counters. The list shown is the most complete line of functional arrays available in the industry. All units are designed to give you the maximum in functional density at the lowest possible cost. All are available in 14-lead flat packs or dual in-line plug-in ceramic packages.

If you are designing with arrays or thinking of using arrays in your next project, you'll find our functional arrays applications booklet a handy design guide. Just circle the reader service number listed below to get your copy.

CIRCLE NUMBER 301



Sylvania arrays interface effectively with four major forms of TTL logic.

Compatibility of Parameters for Different TTL Families

			Input		Output	
	Logic	V_{CC}	V_{IL}	V_{IH}	V_{OL}	V_{OH}
Arrays	TTL	5	—	—	—	—
SUHL I	TTL	5	0.9	1.4	0.5	2.8
SUHL II	TTL	5	0.9	1.6	0.4	2.7
Sylvania 7400N	TTL	5	0.8	2.0	0.4	2.4
Sylvania 5400/7400	TTL	5	0.8	2.0	0.4	2.4

Functional arrays, typical characteristics (+25°C, +5.0 Volts)

Function	Type No.	t_{pd} (nsec)	Avg. Power (mw)	Noise Immunity +(Volts)—		Fanout
Full Adder	SM10 Series	Sum 22 Carry 10	90	1.0	1.0	These arrays are available in fanouts up to 15 and are completely compatible with SUHL I, SUHL II, and other TTL integrated circuits.
Dependent Carry Fast Adder	SM20 Series	Sum 22 Carry 10	125	1.0	1.0	
Independent Carry Fast Adder	SM30 Series	Sum 22 Carry 10	125	1.0	1.0	
Carry Decoder	SM40 Series	2	25	1.0	1.p	
4-Bit Storage Register	SM60 Series	20	30/bit	1.0	1.0	
Bus Transfer Output 4-Bit Storage Register	SM70 Series	20	30/bit	1.0	1.0	
Cascade Pullup Output 16-Bit Scratch Pad Memory	SM80 Series	25	250	1.0	1.0	
Decade Frequency Divider	SM90/92 Series SM91/93 Series	35MHz 30MHz	125 85	1.0 1.0	1.0 1.0	
4-Bit Shift Register	SM110 Series	25MHz	120	1.0	1.0	
Parity Generator/Checker	SM120 Series	22	125	1.0	1.0	
Comparator	SM130 Series	17	120	1.0	1.p	
Programmable Binary Divider	SM140 Series	25MHz	150	1.0	1.0	
Programmable Decade Divider	SM150 Series	25MHz	150	1.0	1.0	
Binary Counter	SM160 Series	25MHz	135	1.0	1.0	
Decade Counter	SM170 Series	25MHz	135	1.0	1.0	
Binary Up/Down Counter	SM180 Series	25MHz	205	1.0	1.0	
Decade Up/Down Counter	SM190 Series	25MHz	205	1.0	1.0	
BCD to 7-Segment Translator	SM200 Series	85	280	1.0	1.0	
Dual 4-Bit Multiplexer	SM210 Series	10-20	130	1.0	1.p	
Demultiplexer	SM220 Series	9-14	225	1.0	1.0	

EL DISPLAYS

New decoder-driver cuts EL display cost.

Compact unit plugs directly into back of electroluminescent display panel.

We've made a major reduction in both the size and cost of decoder-drivers for electroluminescent displays. Our new SME-160 and SME-161 decoder drivers have the lamp socket as a part of the printed circuit card. As a result, these units plug in directly to the back of the EL panel. A separate lamp socket is eliminated thus reducing the cost of the entire assembly.

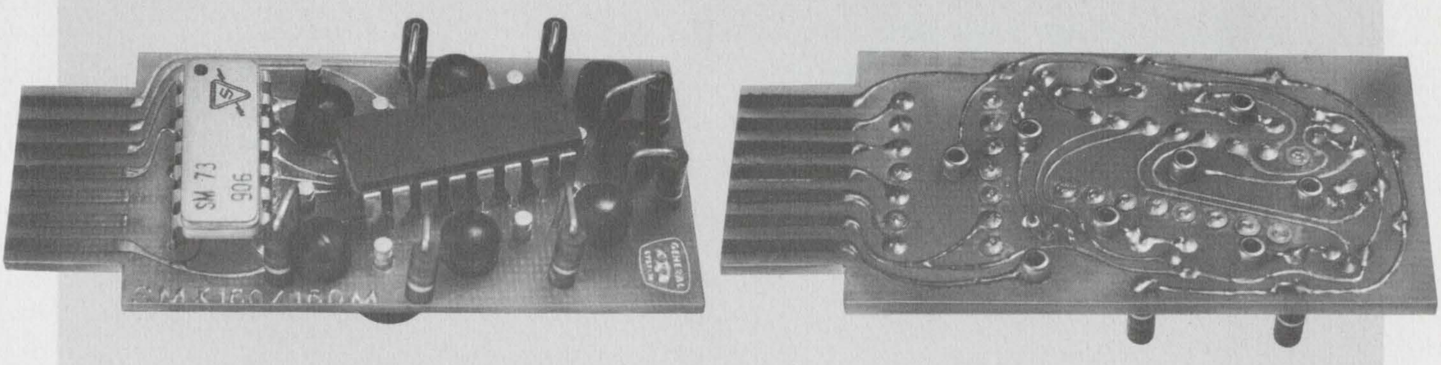
The decoder-driver socket has been specifically designed to mate with the 1″ size numeric digit and takes up only 7/16″ of mounting depth behind the panel. Width of the driver module has been held to the width of the display digit, so that it is possible to mount individual modules side by side in multi-digit displays.

If you want to use these decoder-drivers with ½″ digit sizes, we have a special adapter panel available to interface between the display panels and the decoder which is limited to two digits. For digit sizes larger than 1″, adapter panels can be made with no restrictions on the number that can be mounted side by side. Use of the adapter panel increases mounting depth to approximately ¾″ behind the panel.

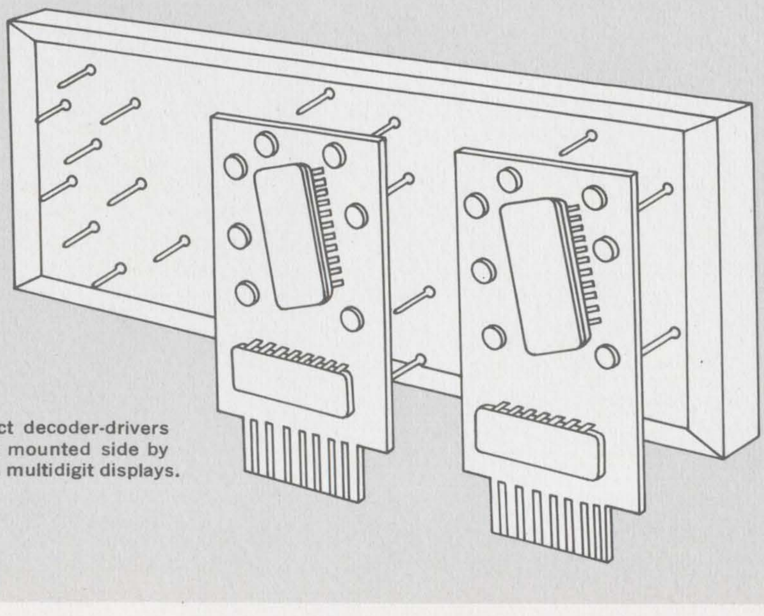
Electrically, the SME-160 and SME-161 decoder-drivers are identical to the larger and more expensive SM-158 and SM-159 modules. All special functions such as leading-edge zero suppression, lamp intensity modulation and lamp test input are standard features of these modules.

These modules are just one more reason for considering electroluminescent displays for all types of readouts. Among the many advantages of EL is the fact that catastrophic failures just don't happen. Power consumption is minimal. It takes as little as 1 mA at 250 Volts to drive a ½″ EL numeric. Because of the low power levels, EL devices are cool running. There are no heat dissipation problems. In addition, the spectral output of an EL display closely matches the response curve of the human eye.

CIRCLE NUMBER 302



Decoder-driver mounts on the rear of 1″ EL display.

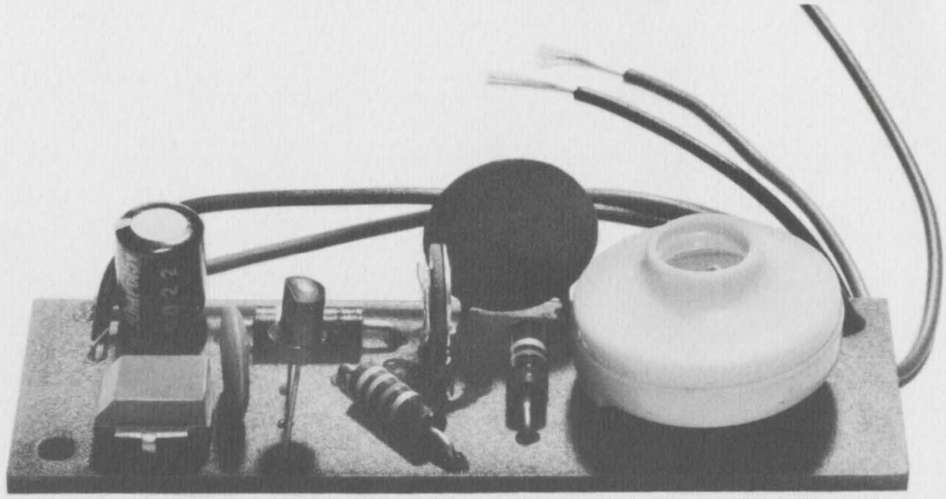


Compact decoder-drivers can be mounted side by side on multidigit displays.

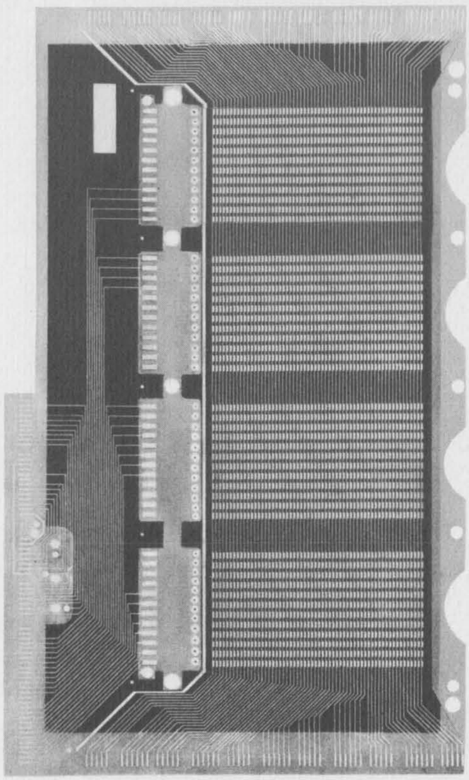
CIRCUIT ASSEMBLIES

Variety adds spice to circuit board production.

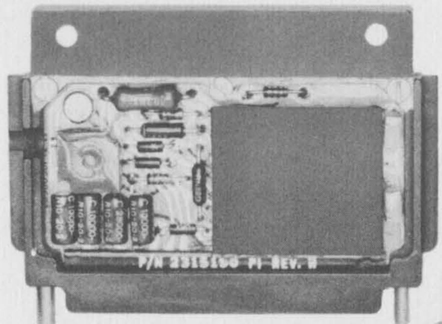
Our circuit assembly facility is capable of taking on jobs with a wide variety of requirements.

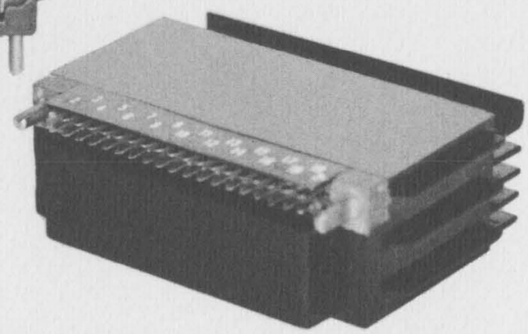


Simple circuit assembly for children's toy was turned out in large quantities at low cost.



Large-size computer board holds 0.0005" tolerances over 20" span.





We've produced 20,000 of these NAFI modules in 82 different types.

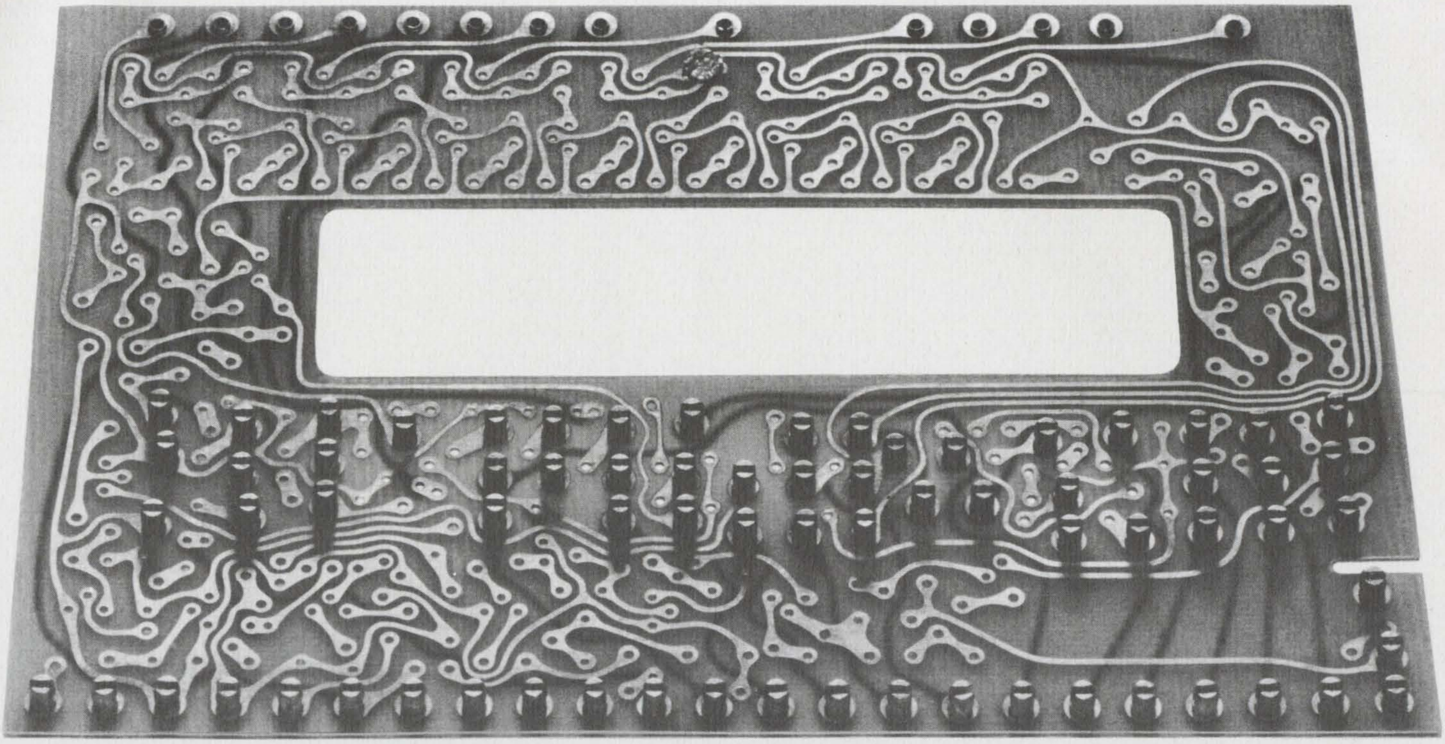
Not all printed-circuit board and circuit assembly production have the same standards of quality and reliability. Some jobs are high volume, some are low. But they all have one thing in common. They have to meet the customer's requirements. We at Sylvania have a high degree of flexibility built into our operation. As a result, we can handle work requiring ultra-high reliability for space missions or low-cost circuits for children's toys.

Here are four case histories that illustrate our flexibility and show how we can meet the varying requirements of our customers:

High reliability, high production—In our NAFI program, we have turned out over 20,000 printed-circuit assemblies in 82 different types. These modules are part of the Navy's Standard Hardware Program and have been used in the Fire Control and Guidance System for the Poseidon missile system. Of course, high reliability was a must. Specs called for a 30,000-hour operating life with a 10-year shelf life. In this project, we were supplied with input/output requirements. Our engineers were responsible for component selection, circuit layout, packaging density to meet thermal and reliability requirements. *Ultra-high reliability, low volume*—Only 50 circuit boards were shipped to the customer in our lunar module circuit board production. But, very tight tolerances on these single and double sided boards made this a special project. Tolerances on these very high packing density boards were held to 0.0020" to 0.0025". Each board was inspected under 30 power magnification to make sure it measured up to specs.

Similar tight specs were required on a subassembly we made for Minuteman missile launch complex. These subassemblies are used in a checkout system and for a multiaperture ferrite core driver.

High volume, commercial application—Typical of our capabilities for commercial applications is a circuit board made for a large computer manufacturer. This large-size board required holding dimensional tolerances of 0.0005" over a 20" span. Our fast-turnaround capability enabled us to get into production at a rate of 1200 boards a day only four weeks after start-up. *High volume, low cost*—A toy manufacturer needed a simple audio-activated control for a children's toy. He needed them at low cost and in large volume. We were able to come up with the assembly that would do the job for him. And we were able to produce them at the rate he needed—up to 2400 assemblies per day



Circuit boards for lunar module required extremely tight specs in a small production run.

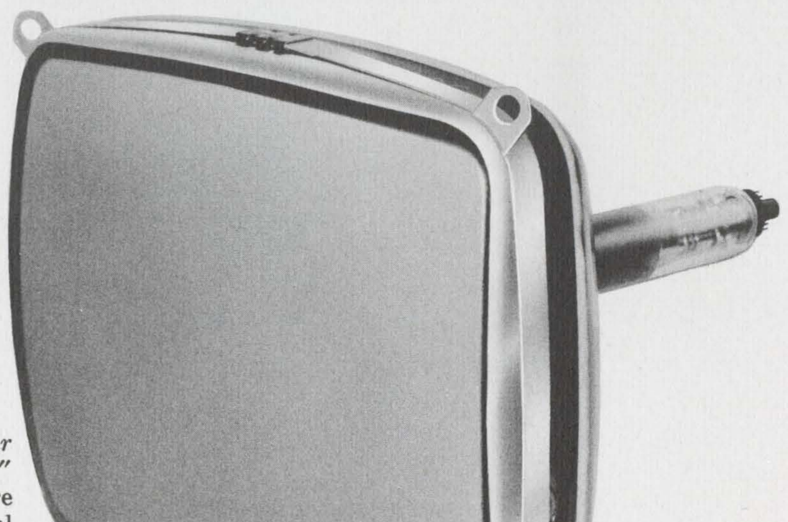
with 100-percent testing for the desired audio sensitivity.

As you can see, we can work with a wide variety of circuit and assembly board requirements, both military and commercial. And we'll work with you from any stage of the game—from the drawing board, breadboard or from your own artwork. Our fast turnaround capability will enable us to meet your most demanding specs, whether they involve time, volume or tight tolerances. CIRCLE NUMBER 303

TELEVISION

Coming: a bright new 17" tube for your line of color sets.

New addition to color bright 85® line gives you a complete choice of sizes from 15" to 26" in 90° color tubes.



Type ST-4774A color tube comes with integral mounting lugs.

All of the well-known advantages of Sylvania's *color bright 85*© color picture tube line will be available in a 17" size. The new tubes, types ST-4773A and ST-4774A, are identical except that the ST-4774A comes with integral mounting brackets.

Both tubes utilize the Sylvania developed Europium activated yttrium vanadate phosphor that gives brighter reds. Brighter blues are obtained from an improved phosphor and brighter greens are attained by altering the chemical composition in conjunction with a change in particle size and distribution on the screen.

The brightness of the overall tube is further improved by Sylvania's patented process of depositing the phosphors in a dry state. This unique process optimizes the physical and chemical parameters that influence brightness and uniformity of coating.

As with all *color bright 85* tubes, an aluminized faceplate is used for enhanced brightness. A 48-percent neutral gray filter glass face panel is used to improve picture contrast.

These 17" color tubes also incorporate a low focus electron gun that provides circuit savings by eliminating the need for an intermediate high-voltage supply. Generally, the depth of focus is very broad and the three electron guns can be focused sharply at a particular compromise focus voltage.

Each tube provides a 145-square-inch-usable viewing area and has kimcode implosion protection. This system eliminates the need for an integral protective glass cap of a separate safety-glass window. Another benefit is reduced weight. This tube type will be available in production quantities in 1970. CIRCLE NUMBER 304

MICROWAVES

Precision microwave resistors are current controlled.

Series resistance of PIN diodes is tested and specified over their operating range.

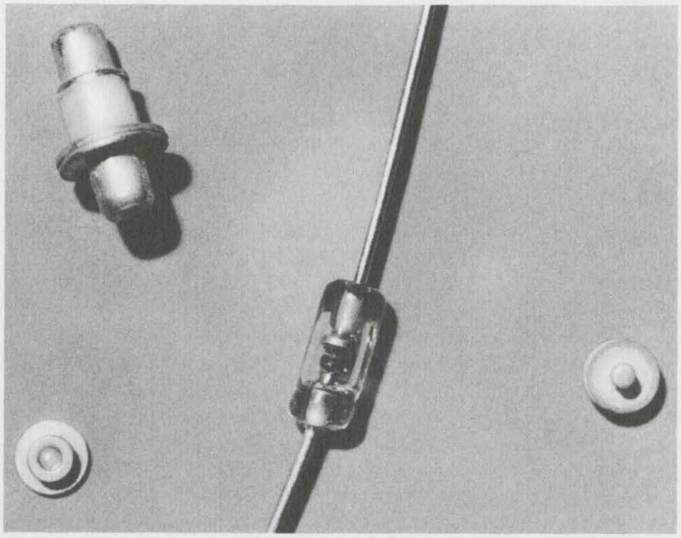
Now we've added an entirely new family to our PIN diode line. By specifying the series resistance of these diodes over their operating range, we can tell you exactly the resistance you will get at any current level. The result–a precision current-controlled microwave resistor.

These resistors are useful from 10MHz to X-band depending on the mounting structure. We classify them into the six categories shown in the charts to assure close tracking of series resistance from unit to unit.

This family of PIN diodes is fabricated by diffusing P-type impurities into one side of a wafer that has an epitaxially grown high-resistivity layer. This intrinsic layer provides the PIN diode with its unique properties at microwave frequencies. At low frequencies, these devices exhibit rectification properties as a PN junction does; however, at higher frequencies charge storage in the intrinsic region prohibits rectification.

The current-controlled microwave resistor has many uses in the RF and microwave regions. It can be used as a device for building precision attenuators, modulators, leveling circuits, AGC circuits, and many other circuits where a low frequency of DC controlled microwave resistor is needed.

CIRCLE NUMBER 305



Current-controlled resistor family is available in a variety of package configurations.

Absolute maximum ratings:

Total Power Dissipation	P_T	See Note 1
Peak Power Handling Capability	P_P	to 10 Kw
Reverse Working Voltage	V_R	At breakdown voltage
Storage Temperature	T_{stg}	175°C
Operating Temperature	T_{opr}	150°C
Switching Time	T_s	4 nanoseconds typical

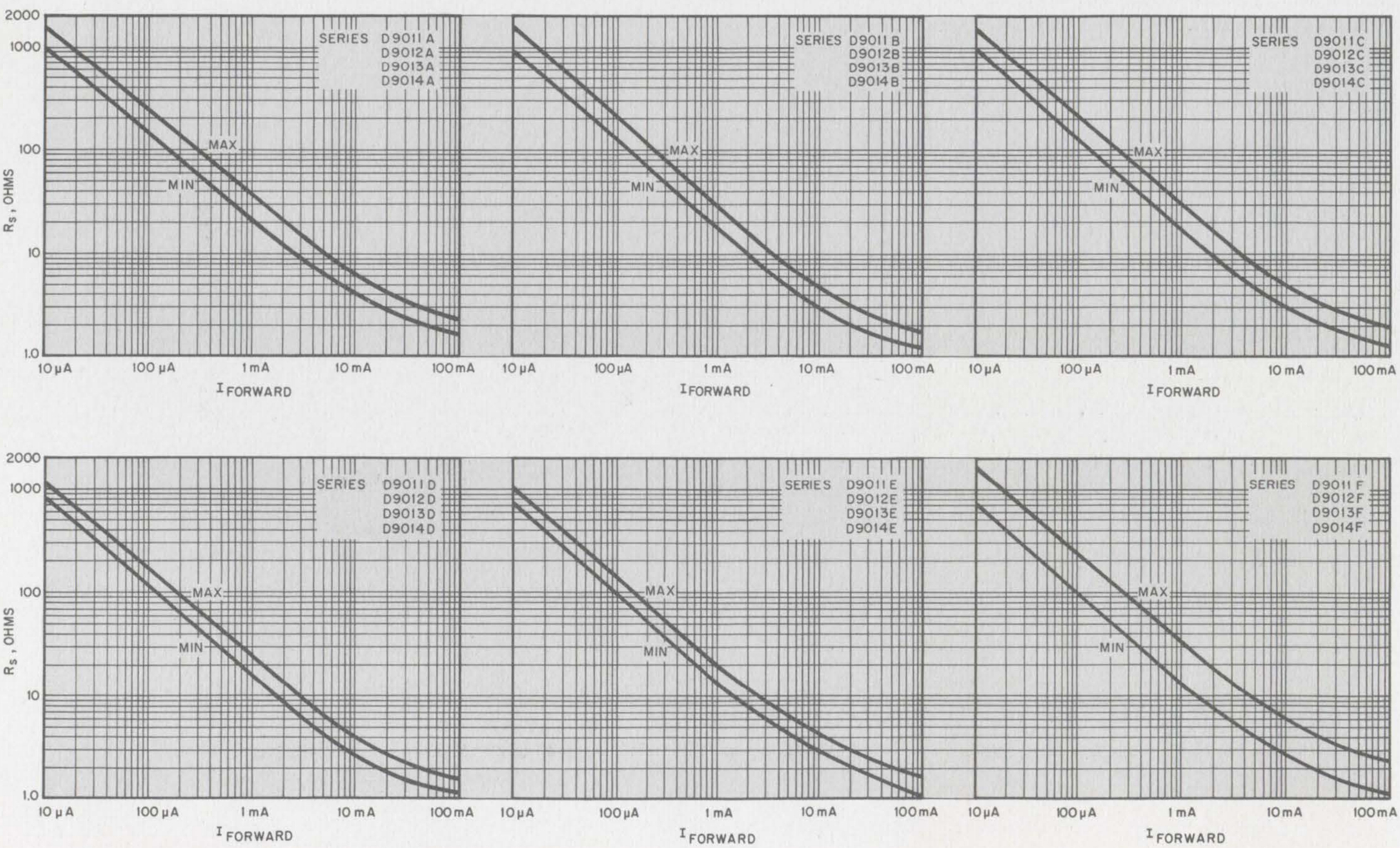
Note 1: $P_T = \dfrac{150°C - T_A}{R_TD + R_TM}$

P_T = Total Power Dissipation

T_A = Ambient Temperature

R_TD — Thermal Resistance of Diode

R_TM — Thermal Resistance of Mount



CRTs

Our CRT designers solve engine tester problem.

Unique scope requirement met by modified conventional TV tube.

When Sun Electric Corporation was developing its new 1120 electronic engine tester, everything was progressing smoothly except the scope for ignition-system testing. The scope is used to show primary and secondary ignition patterns in three different display positions (for easier diagnosis), and can also be used to test coils both on and off the engine.

The advanced design for the 1120 called for a CRT that was bigger in viewing area, yet smaller in overall size than previous tubes. The problem was that such a tube didn't exist. Sylvania's CRT engineers came up with a modified version of a conventional television picture tube that filled the bill perfectly. The result—a perfectly satisfactory display at a cost far less than that of a custom design. It is a 12" black-and-white tube modified for 6.3-Volt, 450-mA heater operation.

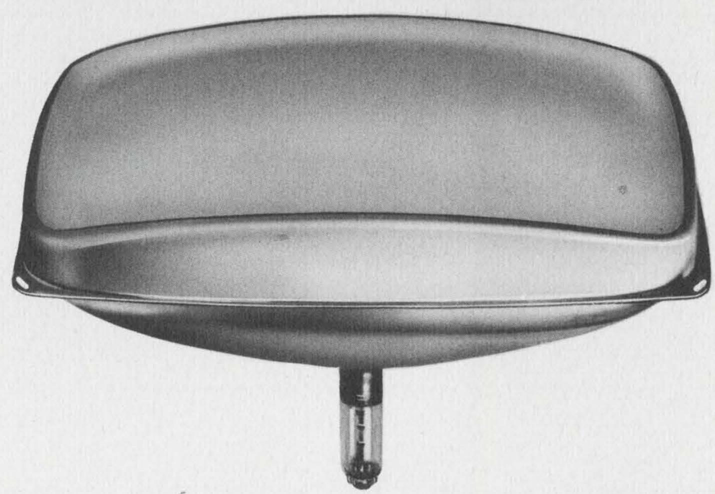
The tube has a rectangular gray filter glass faceplate with a viewing area of 74 square inches. The short neck—only 3.75 inches—made it possible to fit the tube into the cabinet of the engine tester. It also features a bonded frame integral implosion-protection system that eliminates the need for an extra safety-glass faceplate.

As used in the automotive tester, the Sun scope provides test facilities for analyzing all types of ignition systems. Sun uses a specially treated reticule faceplate to minimize annoying and distracting light reflections. The tester can be used on both conventional and transistorized ignition systems. The brilliant pattern retains constant width regardless of engine speed and the patterns can be displayed independently or superimposed just by flicking a switch.

This application of Sylvania CRT's is just another example of how our extensive background in industrial, military and commercial cathode-ray tube design can be put to work for you. If you've got a CRT problem, talk to us. We've got the men that have the answers.

CIRCLE NUMBER 306

Sun ignition scope uses
conventional television picture tube specially modified by Sylvania.



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MANAGER'S CORNER

How to make a good thing better.

With all the talk about LSI, beamlead devices, computer-aided design, and other such glamorous happenings, the so-called typical engineer has relegated the receiving tube to a respected, but nonetheless lowly, slot in his thinking.

That's certainly not the case at Sylvania's receiving tube operation. Here our engineers are faced daily with the task of monitoring and constantly improving the performance and reliability of the "old workhorse" of the electronics business. And that's a full-time job, largely due to the demands of color television for better performing components at lower cost.

Particularly noteworthy from performance and reliability standpoints were sharply increased tube requirements for critical socket areas, such as horizontal deflection, vertical deflection, damper and horizontal regulation. The performance objectives of these sophisticated circuits were such that they uncovered problem areas in tube engineering not previously encountered. The problems of arcing, heat dissipation, thermal stress, heater failure and slumping emission, became increasingly magnified.

As a result, our engineers had to go back to their electronics, chemistry and metallurgy textbooks and came up with some basic state-of-the-art advances. For example—

(a) Cathode coatings with powdered nickel additive and reduced sodium content to improve emission, coating adherence to the cathode sleeve, and reduction of arcing.

(b) Reduction of heater wire crystallization and long life failures by the use of rhenium tungsten heater wire.

(c) Precise control of cathode materials by the use of powdered metals.

(d) Improvement of heat dissipation and transfer within the tube by new and "sandwich-type" plate materials.

Sylvania also took a fresh look at mechanization and automation of manufacturing techniques and how they could be applied to tube production. Our Equipment Development organization for many years has provided Sylvania manufacturing plants with the highest caliber, most modern production machinery in the industry. Reduction or elimination of variables typical of manual methods has been accomplished by auto-grid machines, auto-mount assembly, auto-welding, auto-heater winding, auto-testing, etc. Uniformity of parts and sub-assemblies used in the finished tube has been amazingly well controlled, and uniformity and reliability of the finished product are natural results.

In a highly sensitive device, such as an electronic tube, cleanliness is synonymous with quality. Sylvania has sharply increased the use of controlled atmospheres (filtered air, temperature and humidity controls) in its manufacturing areas to reduce another group of variables adversely affecting product uniformity and reliability.

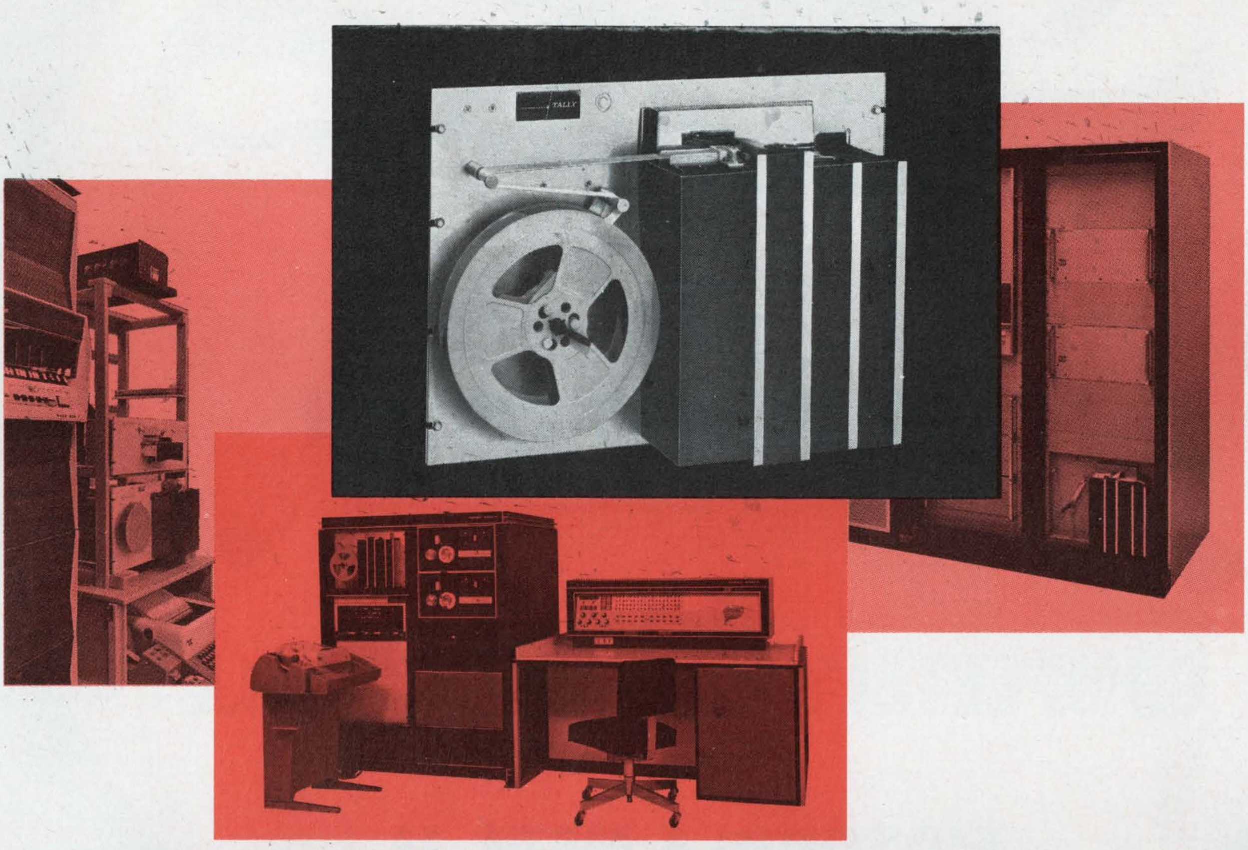
Sylvania's adherence to rigid quality control principles is well recognized. Its tube making organizations are essentially quality-oriented, with broad-based quality departments defining and monitoring all materials and processes from the raw material stage to the finished product. These are highly technical groups, well disciplined and with authority to take immediate action when the product quality deteriorates.

Sylvania's receiving tube organization gladly accepts the challenge of providing and maintaining the highest quality and reliability to the users of its products.

William B. Bowes

W. B. Bowes
Operations Manager, Receiving Tubes

The proven way to capture data output: call on "The Perf."



Our customers aren't much on model numbers (are any of us?). They call it "the Tally," or just as frequently, "The Perf."

Technically, it's the Tally P-120 perforator which features asynchronous operation up to a speed of 120 char./sec. You'll find it in use almost everywhere. For instance here, we're showing "The Perf" in use with two of the most popular scientific computers and one of the best known solid state component checkout systems. You'll also find the P-120 being used by a lot of other computer and data system equipment makers.

Why? Specifically because the Tally "performance quotient"... a dividend of features, specifications, price, and above all reliability... is the best in the industry. We package the P-120 in a rack size panel with integral tape handling including both supply and *take-up*. We build it from the most reliable components available based on knowledge acquired from twenty years experience. And we build it with built-in error checking capability.

If service is needed, our growing force of field engineers is as near as your telephone. Prompt, experienced service is yours on a nationwide basis.

For more information on the versatile P-120, as well as other Tally perforators, please address Tally Corporation, 8301 South 180th St., Kent, Wash. 98031. Phone (206) 251-5500. In the U.K. and Europe, address 6a George St., Croyden, Surrey, England.

TALLY®

L-band satellite plan hits a tailspin

Failure of ATS-5 stalls NASA-FAA-Air Force tests of precision navigation-communications program and jeopardizes its future

Two and a half months after its launch, Applications Technology Satellite 5 spins in orbit about the earth, and that's the catch; ATS-5 never was intended to rotate. Like ATS-1 and ATS-4, it was to have used gravity gradient stabilization booms to keep it in an earth-oriented attitude.

If there had been no spin, an array of 12 cavity-backed spiral antennas would have radiated and received L-band signals (at 1.55 and 1.64 gigahertz) to be used by NASA, the FAA, and the Air Force for experiments in satellite communications and navigation for ships and aircraft. Ironically, installation of this L-band transponder system—and the time it took to decide to install it—delayed the launch of ATS-5 almost a year. It originally was to have gone up in September 1968.

Dash it all. The FAA and NASA were just about to agree on a coordinated set of L-band experiments when the satellite failed. Though the agencies would have shared some aircraft, equipment, and data, no final agreement was made and all L-band work, including that of the Air Force's 621B Navsat program, seems stalled by the ATS-5's gyrations.

NASA and the FAA had similar goals. Both agencies wanted to test tone-ranging schemes for fixing the positions of planes in flight. TRW Systems is said to have an approach theoretically capable of spotting a plane with an error of ±100 feet, and NASA would have begun testing it.

Both FAA and NASA were concerned about multipath, signal fades, and propagation delay, problem areas with potentially severe effect on the accuracy of a Navsat system, especially over the Atlantic Ocean with its widely variable sea states.

The Air Force's Space and Missile Systems Organization (Samso) could have used data on ionospheric effects on satellite transmissions. One knowledgeable source says the requirements for 621B fix accuracy are so exacting that a 10-foot change in aircraft-to-satellite path length could be intolerable. If the experiments showed excessive refraction of radio beams, the Air Force probably would be forced to hike the power of satellite transmitters or change frequencies —and this would rise the price of the already costly 621B.

Noising around. Both NASA and the FAA wanted information on aircraft radio noise; r-f noise from cities, the ground, the sky, and precipitation static; and interference from on-board equipment. This would have yielded a base line for satellite and aircraft transmitter power.

The FAA particularly wanted to test digital data transmission and to do intelligibility tests of voice communications relayed through the satellite. There's now a question in airline circles as to whether vhf or L-band will be most cost-effec-

What went wrong

ATS-5 carries a heat-transfer pipe to help cool its sunward and heat its spaceward sides. It's now thought at NASA that someone miscalculated the forces caused by fluid movement in the heat pipe. As a result, when the satellite went into orbit it also went into a flat spin on an axis 90° to the correct one.

At that point NASA officials began to worry about ejection of the kick-stage engine; they feared the released engine could damage the spacecraft, knew that even if ejection was clean, the axis of rotation of the ATS would change, and that there was only a 50-50 chance that the new direction of rotation would be the right one. The engine departed cleanly, but NASA caught the wrong end of the odds; ATS-5 began to rotate around the right axis, but in the wrong direction.

Weights which would have spun outward at the ends of long wires to slow the satellite's spin instead became more tightly wound, and the gravity gradient booms were deemed too fragile to extend.

NASA now plans to get all the data it can from ATS-5, then take braver action. For now, millimeter-wave propagation and other experiments are working well, and these will be completed. Then NASA plans to inch out the gravity gradient booms slowly. Although ultra-fragile, it's hoped that if they are pushed out slowly enough, they might stop the spin and stabilize the satellite. But nobody is betting on it; the heavy ATS-5 is spinning at 76 rpm, making for a lot of momentum.

tive in the 1970's, and results here would have helped the FAA and the airlines to set guidelines for avionics already being planned and purchased for such aircraft as the Boeing 747 and the SST.

Though the L-band situation looks grim, the agencies involved are working to find alternatives to ATS-5. Meanwhile, the Boeing Co., under contract to equip a KC-135 and a DC-6 for high- and low-altitude tests, respectively, has been told by the FAA to cool it for about three months. The first segment of this three-phase program already has cost the FAA $500,000 in study money and the stretch-out should add about $90,000, according to Boeing. And assuming the FAA finds a way out, the last two phases of the contract—the actual fitting out of the planes—still will remain.

Another basket. NASA, which might have shared some of the planes' time with the FAA, seems to have been hurt least by the ATS-5 failure. Perhaps because almost everything NASA designs has a little redundancy in it, NASA's L-band test program provided for a backup should the satellite fail.

TRW Systems is under a $500,000 contract to NASA's Electronics Research Center to deliver L-band test gear in March—and in the package is equipment that could be carried in a high-flying plane to simulate signals from a satellite.

Leo M. Keane, head of ERC's satellite programs office, says NASA is talking with Samso about the loan of either a U-2 or modified B-57 to carry TRW's transponder gear to 80,000 to 100,000 feet. Presumably the planes, to be equipped by Boeing and TRW, could operate with a fake ATS-5 almost as well as with the real thing.

But Samso might not be too eager to deal with NASA on this. Most of its interest is in ionospheric effects, and not even a U-2 flies that high.

The FAA also is cautious about simulations, less for technical reasons that for psychological ones. The FAA must make a pitch to international air carriers within the next few years for a worldwide agreement on a Navsat system, and they feel data taken from an aircraft wouldn't have the credibility of that from a satellite.

Eureka. So it's not suprising that the FAA is casually mentioning that it seems to have located an unallocated Thor-Delta launch vehicle; or that NASA has quietly asked Philco-Ford's WDL, Hughes, TRW, and Boeing to submit rough outlines of the lead time, cost, and capabilities of a small satellite carrying L-band gear alone.

Meanwhile, NASA headquarters has asked its scientists to determine exactly how much valuable data can be gained from ATS-5, and how much more could be gotten from a smaller satellite. Insiders say that the various centers involved will be making their pitches during the fall, hoping for a backup satellite decision around the turn of the year.

Both agencies realize that Congress is not feeling philanthropic, and an FAA spokesman quotes a $10 million price tag for a new small satellite. It's not known whether this quote covers an FAA-only program, or a joint NASA-FAA development, or even if it includes launch costs. But even if new items appear in the fiscal 1971 budget, launch is more than a year away.

Getting late. Meanwhile, a clock ticks loudly in the background. A TRW-NASA study predicts up to five years' lead time for a useful Navsat system. Even if started now (and the government won't start without the needed experimental data), it's thought that a 1975-1977 estimated operational date is optimistic. And by then the North Atlantic air routes will be crowded with a mix of SST's, jumbo jets, and aging first-generation commercial jets.

Air traffic control

At the crossroads

The Federal Aviation Administration will look at a back-up source if Raytheon fails to resolve by December the design problems with its planned view display consoles for the en-route portion of the advanced National Airspace System (NAS). That's the word of Gustav

Test. AIL's direct altitude identity readout.

E. Lundquist, a retired Air Force general who's director of the NAS program office.

"Raytheon must make its schedule," says Lundquist, adding that the company will get no more money until the equipment becomes acceptable for production.

The FAA's award of $44.8 million to Raytheon's Equipment division of Wayland, Mass., in January 1967 has slipped 15 months; $15 million in additional funding has been approved, the agency says. The award, largest equipment contract by the FAA at the time of the authorization, covers one-third of the material in the advanced NAS. It's the final link to provide air traffic controllers with an automatic display of aircraft positions in three dimensions using alphanumerics in identification and altitude of each target on a scope.

The problems. Lundquist says Raytheon's problems are in display brightness and line width. Richard F. Frakes, NAS en-route systems division chief, notes quality of display appearance is poor—brightness varies within characters as well as around them, line widths are too wide and nonuniform, and focusing is not uniform. For example, "if alphanumerics are not crisp, the letter S and the figure 5 are easily confused," Frakes points out.

Asked about reports that Raytheon's computer data channels were unable to handle a fast data stream, Frakes replies, "Writing speed was never a problem." He explains that Raytheon's equipment initially was designed to handle only 60 consoles in a center. A year ago, however, FAA's traffic forecast for five high-density centers—New York, Washington, Chicago, Cleveland, and Forth Worth—indicated that up to 90 consoles per center and more sophisticated hardware to drive them would be necessary. Thus, Raytheon's total system—data channels and consoles—will go into 15 centers with lower activity.

At the five high-density centers, the FAA has turned to IBM's Federal Systems division in Gaithersburg, Md., for 9020E display channel processors, which will be able to drive up to 90 consoles—presumably Raytheon's—per center. The FAA decision led to a $38.4 million award to IBM at mid-month.

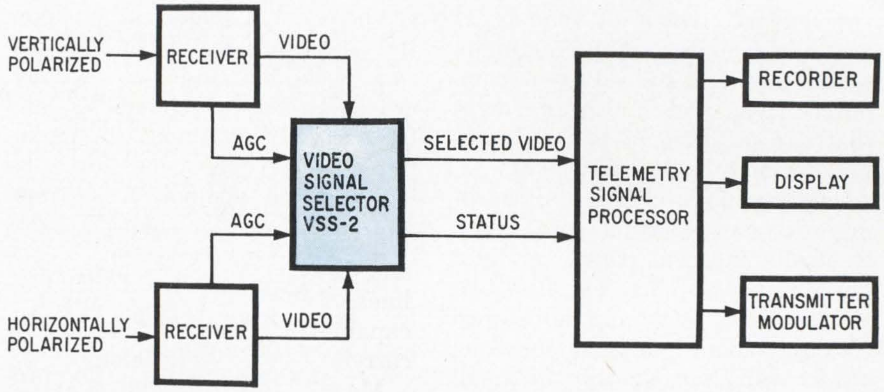
In the IBM package are 9020E systems for control centers in New York and Cleveland in 1971, another for Washington a year later, plus 9020D central computer complexes, which perform the basic computing function, for 1971. New York, Cleveland, Chicago, and Fort Worth will get 9020E's.

At the same time, IBM got another $7.8 million for two smaller 9020A computers for the Minneapolis and Miami centers, the same as ordered earlier from IBM for the first stage of the NAS automation effort.

The changes. An FAA official spokesman declined to call Raytheon's added $15 million funding a cost overrun. Instead, he attributed the need for extra money to contract changes covering such things as altitude filtering, select beacons, and weather substations, plus permission to expand the cabinetry housing the hardware.

At the time of the first Raytheon award, it was explained, there was limited space in the en-route ATC centers. This strictly proscribed Raytheon's equipment size. Subsequently, FAA decided to expand its centers, permitting larger cabinetry.

As for the 22 pieces of computer update equipment in the Raytheon contract, the FAA says it will take early delivery for installation at 20 centers, its Atlantic City test site, and the Tennessee FAA Academy.



Pick 'em. Dynalex's VSS-2 compares AGC voltage from the receivers. The video signal with the higher voltage is switched to telemetry signal processor in 500 nanoseconds, averting loss of data frames. DEI 1074 receivers were used in Navy evaluation tests.

Communications

Switch in time

When the Navy wants to switch rapidly between two airborn ultrahigh frequency telemetry receivers to avoid video signal fading, the job is done by a device that fills a 19-inch rack. Now a two-channel video signal selector that does the same task—in a plug-in module that's just 1.5 inches square and 0.5 inch high—is being evaluated by the Navy. Developed by Dynalex Inc., the VSS-2 selector features a 500-nanosecond switching time.

An accepted means of avoiding the loss of telemetry data has been to use two receivers, one with a horizontally polarized antenna system, and a second with a vertically polarized unit assuring a strong signal on at least one of the two antennas. Rapid switching between the two receivers is vital because a 2-microsecond data gap can cause loss of a complete data frame.

Comparison. The selector picks the strongest video signal for relay to the telemetry signal processor by comparing the magnitude of two automatic gain control inputs from the two receivers, using a differential window comparator to look at the telemetry bit stream. Two externally mounted trimpots adjust the comparator network's window limits, or hysteresis, from ± 5 millivolts to ± 550 mv, and vary the offset within a range of ± 1 volt. Adjustment of the window limit controls comparison sensitivity, and the threshold adjustment allows the insertion of offset to compensate for bias within the AGC of either receiver. The AGC inputs can be 0 to -10 volts d-c, with 50 ohms input impedance.

The video signal inputs, ± 5 volts d-c to 450 kilohertz, are brought to two MOS FET switches, and the signal from the receiver found by the comparator to have the highest AGC voltage is switched to a high-speed, integrated circuit op amp. Output for the selected video channel is ± 5 volts d-c to a minimum 1,000-ohm load. Accuracy is $\pm 0.05\%$ from 0°C to 70°C. A 0 volt and $+5$ volts d-c output indicates to the telemetry signal processor which video signal has been selected. External power requirements for the selector are ± 15 volts d-c at 30 milliamps.

Hold. When a video channel is chosen, the selector will not switch again until the AGC voltage for that channel drops below the comparator's window limit. This prevents excessive cycling between channels that otherwise would result from nearly identical AGC voltage levels.

Displays

On the big board

Not to be left out of the act, the Navy, like the other services, wants a large-screen display system for its war rooms. But the Navy hasn't yet decided which of four types eventually might meet its minimum requirements—a 16-by-16-foot, computer-driven, real-time arrangement that can position up to 100 forces in color on a background map.

The four possibilities: multiscribing or multispotting projectors, electroluminescent panels, or light port matrix systems. The first two are available now and appear to cost only about half as much as the others, which exist only in small feasibility models—large working versions are at least several years and much costly research and development in the future.

Thus, the Navy's dilemma is whether to settle for the simple, cheaper system now or sit still for the far more sophisticated and expensive layouts.

Banking. The multispotting system employs a bank of projectors, each of which uses a symbol wheel displaying one force, such as a plane, carrier, destroyer, or submarine, and its identification number. The wheel can be changed instantly to display other forces. The force type, identity (friend or foe) and course is indicated by the symbol's color, shape, and position. Its characteristics, including mission, weapons, and fuel capacity, are identified by its number, and the viewer's attention can be attracted to a particular force by blinking the symbol. A separate reference projector shines a background map on the screen.

Hugh Caligiuri, Naval War College Major Improvement Plan project officer, has been experimenting with a prototype multispotting projector built in 1965 by Dumont for the Army Electronics Command at Fort Monmouth, N.J. He feels it can be expanded easily from its present 48 projectors.

The multiscribing system is similar to the multispotter in that it, too, utilizes a bank of projectors, but it differs in employing slides. Up to 10 forces can be inscribed on each slide with a diamond or metal stylus, but updating is slow—about a minute—and the individual symbols cannot be blinked. Models of the system made by LTV, Northrop Corp., and Kollsman Instruments are being evaluated aboard ships, at the Pentagon and the White House, and by NASA.

Apollo maps. One of the most advanced multiscribing units—a rear projection system developed by Philco-Ford—is used by NASA at its Manned Spacecraft Mission Control Center in Houston. A slide showing a lunar map in one color and primary and secondary landing sites in another color is projected on a 10-by-20-foot screen. Six other projectors, driven manually or by a computer, display predicted lunar orbit trajectories, and blips representing the command/service and lunar modules in other colors. The color differentiation enables flight controllers to distinguish points of importance faster than if a single-color display were used to locate the modules.

As with all such rear-screen systems, high heat (about 400°F), extreme magnification (240 times), and ultraviolet radiation (a 2,500-watt xenon lamp is used) are major problems.

The electroluminescent (EL) panel and light port matrix displays, on the other hand, consist of a number of addressable light elements, similar to, but more sophisticated than, the animated advertising signs seen, for instance, around New York City's Times Square. Both displays can be tape-driven—a rather slow method—or can be operated in real-time by a digital computer. The display proposed by the Navy would have 2,048 EL elements, or 1,024 light port elements to a side.

Follow the girl

Will the Navy brass follow the advice of a civilian only two years out of college—and a mere girl, at that?

Wendy Billett, 23, is considered by her superiors one of the brightest electronics engineers at the Naval Electronic Systems Command's technology branch at the Washington Navy Yard. One of her first projects at Navelex was to develop a new system of cost-effectiveness analysis, which, if used correctly by the Navy, might get it out of hot water with Congress and the public. To show her bosses that her analysis is a workable and useful engineering tool, Miss Billett used it to evaluate the four war room display systems being considered by the Navy. Her recommendations: the Navy's best bet, rated 100%, would be the multispotting projector. The multiscribing projector scored 91%, while electroluminescent panels are a poor third with 40% and the light ports trail badly at 19%.

She explains her study this way: "The model forces the definition of minimum requirements and ideas between which cost-effectiveness analysis is meaningful. It outlines trade-offs and provides two evaluation parameters: system value and cost effectiveness."

She determined the cost-effectiveness index for each display by dividing its performance effectiveness by its 10-year life cycle cost. Performance effectiveness includes system capability, performance quality, response time, reliability, maintainability, flexibility, expandability and human engineering.

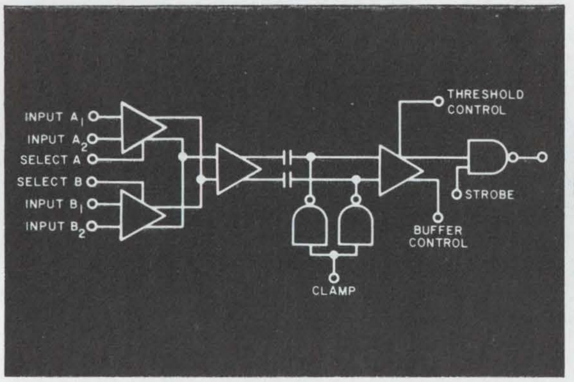
Miss Billett joined Navelex on graduation from Ursinus College in Collegeville, Pa., because she liked the idea of working with computers —in the first 18 months she attended five computer schools. Her home town is Yardley, Pa.

Computers

Bit by bit

A new company hopes to use an 18-bit computer that's smaller than most eight-bit machines as a springboard into end-user applications in industrial control and data acquisition, automatic testing, data communications, typesetting, medicine, traffic control, navigation, and other areas. The machine, called the CLS-18, would sell to original equipment manufacturers for $7,500, well below the price of most 12- and 16-bit models; it's the brainchild of Computer Logic

ON ONE CHIP:



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Systems Inc. of Billerica, Mass.

The first CLS-18 is due to be assembled and powered up by mid-November; by the end of the year it should be operational. But the CLS-18 may be a stalking horse for an as yet unnamed computer.

The CLS-18 will use a versatile multiaccumulator architecture reminiscent of much larger machines. Twelve major registers are planned, and six of these will be accessible by the programer. Also, four so-called general registers are individually addressable and mutually interactive with the 4K-by-18 core memory.

First claimed. All four of these registers handle 18-bit words, and perform group arithmetic, shifting, logical operation, comparison, and checking. This ability to reach all four general registers from memory and access each individually prompts company president Charles H. Wheelock to term the CLS-18 "the first minicomputer with fully usable multiaccumulator architecture."

Wheelock also considers the machine's 18-bit word length and the consequently powerful instruction set unique in minicomputers. The nearest competition seems to come from a few bulky 18-bit minicomputers costing $20,000 or more.

Another feature rarely found in minicomputers is the CLS-18's push-down list. Reacting to interrupts, the list saves and, afterward, restores machine conditions; during an interrupt, it locates storage areas for interim calculations, freeing registers to accept data from peripherals or other sources.

The CLS-18's input-output structure includes microprogramed data transfer instructions which allow the programer to work easily with the general registers and up to 64 peripheral devices.

To aid I-O control and interrupt operations, an optional microprogramed computer will be available to control the machine's direct memory access channel, dividing its use among peripherals with up to 144 levels of priority interrupt.

In other minicomputers, most such operations are handled through software, but the push-down list, I-O processor, and microprogramed data-transfer scheme should make for an efficient, easy to program, interrupt system with response well below 3 microseconds.

Over the horizon. Though the machine to come afterward will inherit most of these characteristics, it is to be only about 1.75 inches high compared with the CLS-18's seven inches.

Vice president Bruce K. Smith claims that in industrial control, each inch on a 19-inch rack costs about $1,000, thus such a computer could mean a system cost reduction of $3,000 to $8,000, depending on the computer replaced.

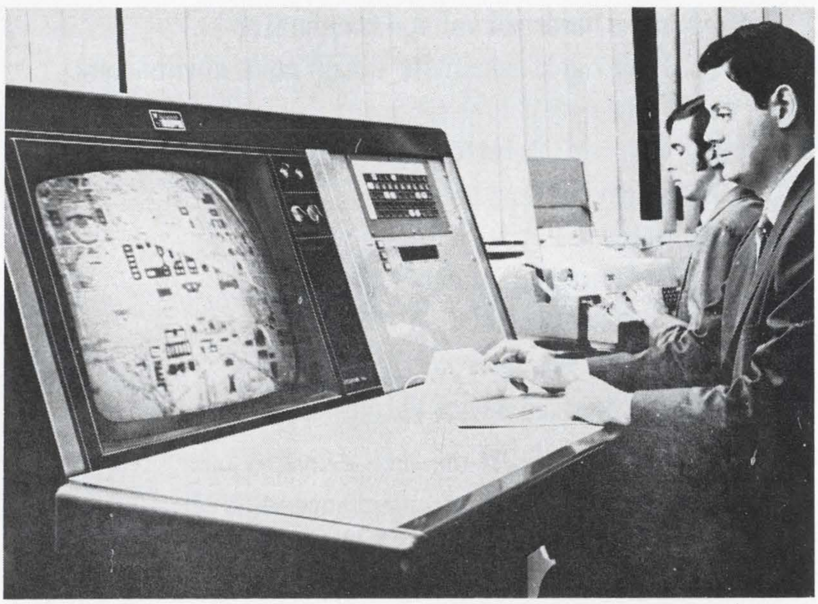
But to squeeze a computer down to the thickness of a club sandwich is, says Smith, going to mean careful application of thin film, multi-IC hybrid techniques.

It's already apparent to Smith that heat sinking will be one of his major design problems, but careful partitioning, and the division of functions into two or more hybrids, should handle the problem, he feels. And the CLS-18 already is being partitioned with hybrids in mind to ease transfer of its architecture from one format to the other.

Already slated for hybridization are the CLS-18's arithmetic and multiplex units, and the memory control logic soon may follow.

Smith figures that he can lay down up to 20 medium-scale IC chips per square inch without pushing the hybrid art; thus he expects about two square inches of hybrid substrate to hold all necessary memory control logic in the future machine.

Panel problem. The contemplated design is too thin for a muffin fan, and Smith expects that heat sinking and partitioning will solve the thermal problems. But he does admit that the control panel



Making the scene. With New York City's police "war room" already operating—direct phone links to precincts, tv at likely trouble spots, and a small computer—Sylvania is field testing this computerized dispatch system with other police departments. It's aimed at getting police to where they're needed quickly. The Sylvania approach is called automated command control and dispatch. When a crime or accident is reported, a clerk types the location on the computer console, keying in a priority code indicating the seriousness of the situation. In seconds, the computer displays a letter symbol at that location on the dispatch monitor, a cathode-ray tube. Simultaneously, patrol units assigned to the area are indicated on the crt; a color code indicates the availability of the units. The dispatcher then selects a unit, assigns it by radio to where it's needed, and feeds this information to the computer, which displays the assigned unit on the monitor.

might take some engineering time. "After all, there's a limit to the size of a knob or indicator—one can't miniaturize eyes or fingers," he says. And there's not much room on a 1.75-by-19-inch panel.

So far the answer to this one is a remote control panel, connected by an umbilical and placed near the machine's teletypewriter console. The CLS-18's basic architecture already treats the control panel as a peripheral device, making necessary only a modest change to usual control practice as the panel would access the mainframe through the I-O controller.

Components

Navy plugs in

High-power rectifier tubes have been just one more headache for military radar operators. The tubes require at least 15 minutes of warmup; have a high noise-to-signal ratio, generating lots of "hash;" require costly air-conditioning systems; and have an average life span of three months—six with luck.

The Air Force licked the problem with the Unitrode Corp.'s controlled reverse avalanche silicon diode modules as replacements. The two modules have voltage ratings of 2,000 through 5,000, and 5,000 through 10,000 volts, respectively. They can be stacked and attached to a tubelike base to achieve plug-in replacements with ratings up to 500 kilovolts. The Federal Aviation Administration has adopted the concept for its radars—the modules not only are cheaper, but they operate without cooling, last for the life of the equipment, and produce virtually no noise.

Flank speed. But it is the Naval Electronic Systems Command which has moved to widen the module market, expanding applications to sonars and transmitters, and specifying them as replacements for 105 different rectifier tube types. With this new spec in hand, the Defense Electronics Supply Center in Dayton, Ohio, is scheduled to make a major purchase of the modules later this year, expected to top $1 million.

A number of manufacturers are scrambling to get aboard DESC's qualified product list before the purchase. In addition to those already in the market—Unitrode, Semtech Corp., and Solitron Devices—expected competitors will be General Electric, Hughes, IRC, RCA, Varo, and Westinghouse. Of the Westinghouse effort, one government official notes, "They're eating crow as they do it. They didn't believe there would be any market."

What is the market? If the solid state rectifier replacements last the life of the system, and new systems go solid state from the start, what happens when all existing hardware is retrofitted? Senior NESC engineer William Rhodes says, "The potential in the commercial broadcast transmitter market is even bigger than the military requirement."

Money talks. The Naval Electronics System Command chief, Rear Adm. Joseph E. Rice, nonetheless is excited about the savings the modules developed for the Air Force could bring the Navy. "We are the first to use this technique for applications right across the board," he points out. Potential economies are high in submarines, as they cannot use mercury-gas-filled tubes for safety reasons and have had to employ more expensive rectifiers filled with argon and other exotic gases. Now Adm. Rice says he has issued a specification to all segments of the Naval Material Command requiring use of the solid state modules in all applications as replacements for high-power rectifier tubes.

Savings on Navy's AN/FRT-39 and 40 transmitters, according to Adm. Rice, work out to $481,000 a year in terms of tubes eliminated. Overall, he says, the Navy figures it will save $2 million a year by not having to replace an estimated 300,000 tubes.

Representative of the 105 tube types the modules will replace is the 6895. "It's in the upper-middle-class category," says engineer Rhodes, with a peak inverse voltage rating of 20,000 volts. On the Navy's last order, the tubes cost about $109 each. Its modular equivalent would cost "roughly $50," according to Rhodes.

Since an operational tube never achieves its peak voltage rating, a replacement for the 6895 would not necessarily mean stacking four 5,000-volt modules together. More likely, says Rhodes, three modules with a combined 15,000-volt rating could be used to replace a 6895 tube running at 12 or 12.5 kilovolts.

Memories

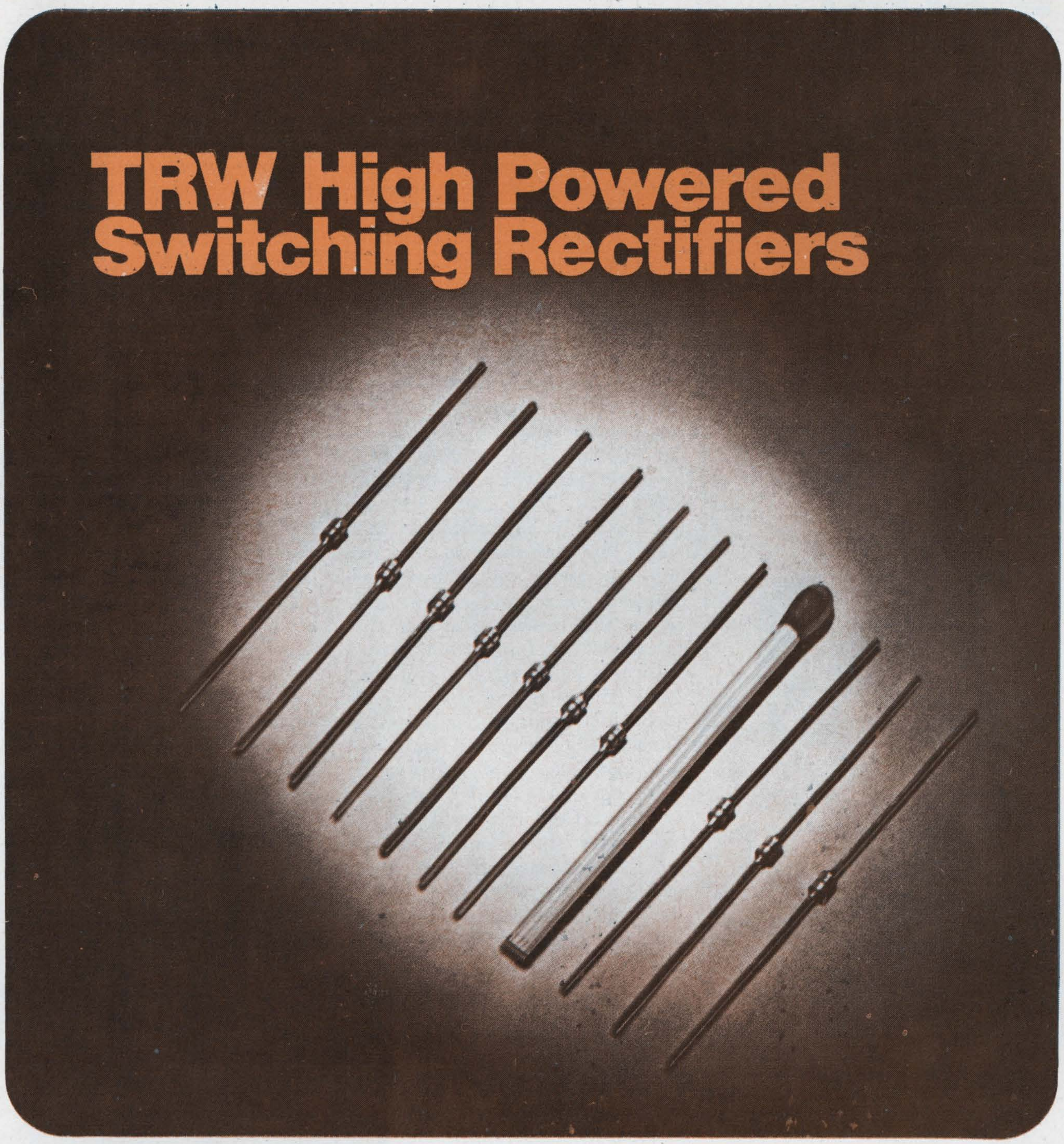
Remember the mainframe

Two enterprising engineers have formed a company that they hope will supply computer mainframe makers with modular memories for just about any function they need—and several they haven't gotten around to needing yet. The two, Joseph F. Kruy and Richard J. Egan, are president and vice president, respectively, of Cambridge Memories Inc. in Newton, Mass.

Educated in Hungary, Kruy founded CMI after more than 10

Alterations

The Electronic Data Processing division of Honeywell—Joseph F. Kruy's alma mater, so to speak—uses alterable read-only memories in some of its large-scale computers. But these can be made only by servicemen who make the changes during regular maintenance calls; the electrical alterations are a good deal quicker and easier than the only alternative, mechanically replacing the memory. This is to prevent an inexperienced operator from possibly disabling the entire computer. Kruy's idea is to make the read-only memory alterable by the supervisory program while the system is running, so that it might, for example, look like an IBM System 360 for a few milliseconds while communicating with one satellite, and like a Univac 1108 for a few more while tied to another satellite.



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years at Honeywell's Electronic Data Processing division, where he directed work in advanced memories, circuits, and logic (including LSI), plus optical character recognition, displays, and optical mass memories. With Egan, formerly memory products marketing manager at Lockheed's Data Products division, Kruy plans to carve out sales in a market which has yet to materialize—advanced computers.

Versatile. The company's marketing approach already is clear. "We want to take the load off mainframe designers by supplying modular, expandable memories, which need as little special design attention as possible and which are reliable," says Kruy. Thus CMI's first two products were an expandable (from 4K) 18-bit core main memory system mounted on 12-by-12-inch plug-in boards, and a sequential-access MOS memory subsystem that stores data in forms from 50 one-bit words to 200 words at eight bits each. The MOS unit is on a 5.75-inch-square plug-in board, and is aimed at the peripheral equipment field and buffer applications.

To be shown at the Fall Joint Computer Conference will be a 1K-by-nine-bit core memory module with 850-nanosecond cycle time, and a shift register using domain tip propagation logic, a magnetic logic format developed at the Laboratory for Electronics, and purchased by CMI [*Electronics*, March 20, 1967, p. 48].

All four products use a maximum of two supply voltages ("Power supply cost can be high relative to memory cost," says Kruy); need minimal power conditioning, and use little standby power. This isn't just to attract customers, Kruy maintains—it's also designed to make CMI a force in the 1970's—during which, says Kruy, "memory in its varied forms may become the most important feature of computer architecture."

Design. Kruy feels EDP hardware and logic design are becoming less and less important as techniques like LSI force use of ever-larger building blocks. But larger blocks alone could remove flexibility from computer design—and perhaps operation. Trying to offset this by applying memory techniques, Kruy looks ahead to a "fluid architecture" wherein a multiprocessor would adapt its mode of operation to suit tasks and programs at hand through use of control computers, microprograming, and alterable read-only memories.

An alterable ROM sounds like a contradiction, but says Kruy, "an alterable ROM could combine great speed with the real-time alterability of core to allow a fluid microprograming system in which various computers could be emulated, and differences in software or machine language largely offset."

Kruy says that "fluid architecture" originated at the Standard Computer Corp. in Los Angeles. A spokesman for Standard calls the concept "a multimemory, multilanguage, computer-within-a-computer" approach that eliminates fixed relationship between functional blocks, making it both problem and program adaptable.

Later load. Thus, CMI is developing an alterable core ROM with 100-nanosecond estimated read time, and a write time of less than 1 microsecond. Kruy notes that in addition to a software alterable form, it could be sold without write electronics, or in turnkey format, where its program would be loaded at CMI's (or the user's) plant with a plug-in peripheral loader.

Envisioning the advanced computer as a central processor surrounded by other processors using alterable ROM-stored instruction sets, Kruy also is preparing to supply anticipated massive memory needs for the central or control computer—the central processor would have to supply lengthy, detailed sets of instructions for each satellite.

CMI's entry in the mass-memory field will use etched permalloy technology—developed under Air Force sponsorship by LFE and sold to CMI along with domain tip propagation logic [*Electronics*, July 11, 1966, p. 135].

Egan says that CMI expects to achieve storage costs of 0.25 cent per bit, and estimates that standard core memory techniques will be hard-pressed to move much below a penny. "We'll shoot for the so-

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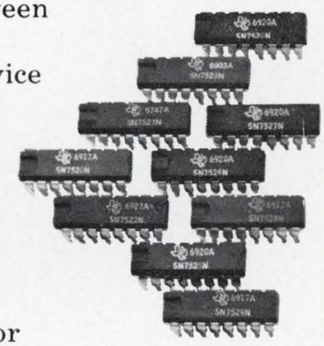
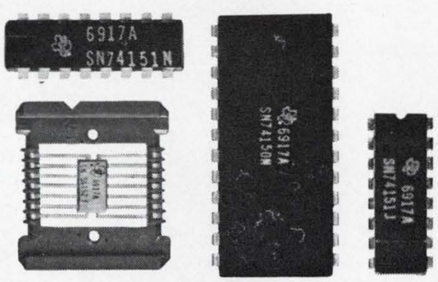
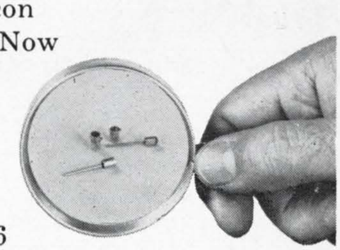


TI's 10 sense amplifiers simplify system circuit interfacing. Interfacing between high speed, ferrite memory cores and TTL logic systems no longer presents a "no-man's land" of problems because of TI's choice of sense amplifiers. All device types feature dual pre-amps (4K memory cores per input) with individual channel strobing and TTL compatible outputs. The SN7520N/21N pre-amps drive a single cascade-gate output, while the SN7522N/23N output is an open-collector gate. The SN7526N/27N feature the industry's first data register output for narrow strobe windows. The SN7524N/25N and SN7528N/29N have individual channels, each input having its own gate output. The pre-amp outputs in the SN7528N/29N are also available for use as test points. We can furnish an application report and data sheet on TI's 10 or circle 274 on the Service Card.



TI's 3 new MSI data selectors cool multiplexing costs. You can put the cost of multiplexing "on ice" with TI's new data selectors—each of which selects one of 16 (or eight) data sources determined by the binary address inputs. Each contains both inverter-drivers and AND-OR-INVERT gates in a single package. Result: reduced design time, inventory and circuit costs. The SN54150/SN74150 are 16-bit data selectors in 24-pin plastic packages. SN54151/SN74151 are 8-bit circuits in either the 16-pin plastic or ceramic dual-in-line packages. The SN54152/SN74152 are 8-bit selectors available in flat packs. For data sheet on this trio of data selectors, get in touch with us.Or circle 275on the Service Card.



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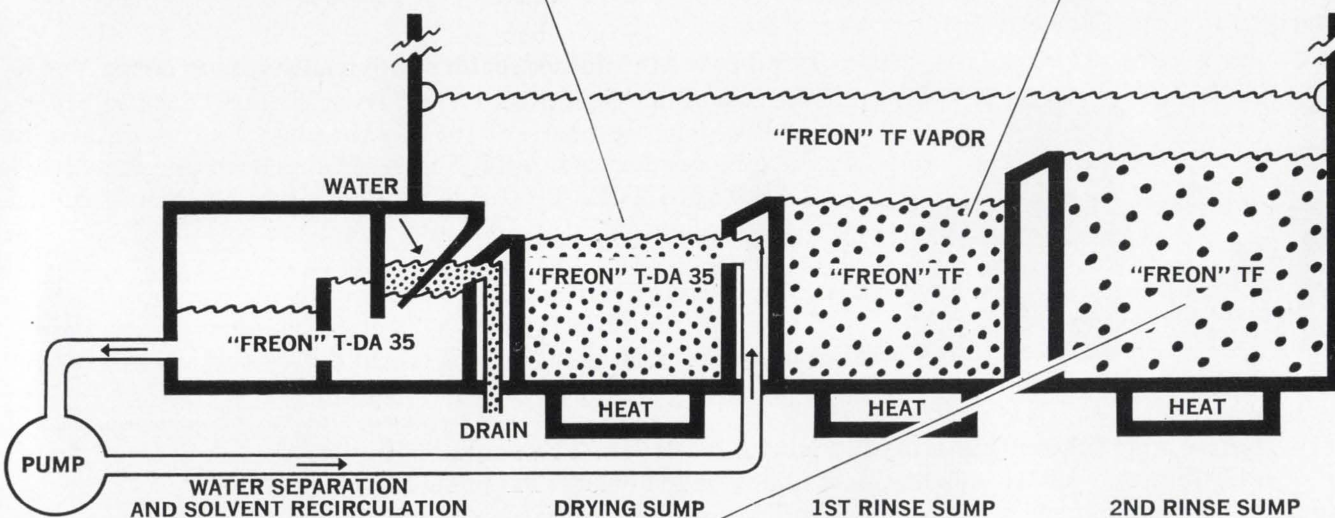

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called bulk core market with this—the 17-to-20-megabit random access memory area," says Egan; "we really don't expect much competition here from monolithic memory techniques, even though in two years the market should exceed $150 million."

Making it. Egan's bullishness derives from the batch-assembly technique used to make etched permalloy memory planes. "Today 80% of the cost of a core memory is in wire, cores, and stringing—right where etched permalloy can save us the most: magnetics."

If yields are high enough, etched permalloy even might sell against disk stores. "This would be stiff competition," says Kruy, "but even though our cost per bit would be perhaps 10 times higher, we might outsell disks where fast random access, zero latency time, and high (nonmechanical) reliability and redundancy are needed."

Integrated electronics

Print it!

Though thick-film hybrid technology is enjoying handsome growth, it still labors under the burden of a separate manufacturing step for inserting active devices. But George D. Lane, president of Electro Materials Corp. of America, Mamaroneck, N.Y., flatly predicts that within five years it will be practical to print some active devices of modest performance on a substrate, using manufacturing operations and resistor pastes like those for printing passive elements.

Resistor pastes, which are silkscreen-printed onto a substrate and then sintered at a high temperature, are combinations of noble metals and glass frit. Therefore, they behave as semiconductor materials. Under certain conditions, Lane discovered, resistors made of these materials conduct better in one direction than in the other. The result, says Lane, is a diode.

The diode doesn't have a single fabricated junction. Instead, many junctions are formed randomly by the intimate contact of the different granules distributed in the paste, the net result being a preferential direction to form one equivalent junction.

In the lab. It's not practical to make diodes this way yet, says Lane, but he has printed experimental diodes, using conventional thick-film processes that have about a 10-to-1 ratio of reverse resistance to forward resistance. Lane is confident that this ratio can be improved upon, and his company, which makes resistor and conductor pastes, is continuing to investigate the conductance phenomenon.

Meanwhile, a printed thermistor has been added to the list of passive elements that can be designed into hybrid thick-film circuits. A thermistor is a nonlinear resistor that has a large negative temperature coefficient of resistance and exhibits an exponential change in resistance versus temperature.

Conventionally, when a circuit needs a thermistor—say for temperature compensation—it is added as a discrete element. Now, says Lane, the new thermistor paste made by his company can be printed and fired like resistor pastes. Thermistor material resistivities range from 300 ohms per square per mil of thickness to 10 megohms per square per mil. Temperature coefficient of resistance depends on the material, and is about −0.5% per degree centigrade.

Manufacturing

Controlled charge

Depending on the function of the device, interface charge can be a boon or a bane in metal-nitride-oxide semiconductors. In a digital integrated circuit made by the MNOS process, for example, the charge is highly undesirable because it makes the threshold voltage unstable. In an MNOS memory, on the other hand, interface charge is the mechanism by which data is stored.

A semiconductor manufacturer obviously would find knowledge of the factors that affect this charge and a means of varying it a great help. At Fairchild Semiconductor's R&D Laboratories, two scientists—Valentine Rodriguez and Dov Frohman-Bentchkowsky—have shown that the charge can be controlled by varying the composition of the silicon nitride layer. Rodriguez and Frohman-Bentchkowsky have established relationships among interface charge, electronic conductance, and deposition conditions. They've also studied charge and discharge times as a function of voltage and temperature.

Charged. Silicon nitride, of course, has attracted attention as a substitute for silicon dioxide insulating layer in IC's and discrete devices; Si_3N_4 resists contamination much more effectively than SiO_2, and reduces threshold voltage [*Electronics*, March 31, p. 117]. The problem is that an uncontrollable charge is trapped at the interface of the nitride and the silicon substrate when a voltage is applied to a metal-nitride-semiconductor transistor.

The solution was to thermally grow SiO_2 on the silicon before depositing the nitride—in other words, using an MNOS structure. This circumvents the unstable metal-nitride interface charge, but unfortunately—or fortunately, depending on what the device is expected to do—another charge comes into play at the interface of the oxide and the nitride.

This interface charge is a result of the difference in electronic conductance between SiO_2 and Si_3N_4 (it would, in fact, occur with any two insulating materials). When a voltage is applied to the MNOS structure, a minute current flows through the insulating layers—on the order of 10^{-11} or 10^{-12} amperes. Since SiO_2 tends to have a much higher conductance than Si_3N_4, it draws more current, and this excess current is stored as charge at the interface.

Inching along. Through an etching experiment, Rodriguez and Frohman-Bentchkowsky showed that the stored charge is located at the nitride-oxide interface. They made an MNOS structure with aluminum as the metal and silicon as the semiconductor; nitride and oxide each were 1,000 angstroms thick. The Fairchild researchers applied a voltage to the structure to create the stored charge. Then they etched into the insulating layers in steps of 200 Å, and measured the charge at each etch increment. Only when they got within 200 Å of the nitride-oxide interface was a significant charge observed.

The next step was to determine how the relative conductances of the two layers could be varied to either enhance or diminish the storage of charge. The oxide layer in an MNOS structure is thermally grown from the silicon substrate; since the silicon is of a fixed composition, the conductance of the oxide can't be varied. But the nitride can be deposited by the decomposition of a mixture of silicon tetrachloride and ammonia, and the proportions of the mixture—which can be easily varied—can have a strong effect on the conductance of the resulting nitride.

The nitride conductance can be varied over "several orders of magnitude" according to Rodriguez, with a similar effect on the interface charge.

As for plans to exploit conductance control commercially, there's still much work to be done. "We haven't explored all the possibilities," Rodriguez says. "Long-term behavior remains a big question." How long will a charged or discharged interface retain its state? "Days, months, or years," Rodriguez replies.

It's in the bag

What happens when a manufacturer tests its resistors 100% and knows they're all good before they're shipped, then the customer tests them 100% and finds they're not all good?

Angstrohm Precision Inc., the manufacturer, and Standard Elektrik-Lorenz of West Germany, the customer, found themselves in this position when 2.4% of a shipment of 5,000 resistors unaccountably flunked their incoming inspection. The units were 1/20 watt metal film resistors with a $\pm 0.1\%$

resistance tolerance.

Angstrohm shipped the resistors to TRW Systems, which transshipped them to Standard. Three months later, Standard reported that 119 resistors were out of tolerance, and rejected the shipment.

Cultivated fields. TRW and Angstrohm then attempted to duplicate the conditions the resistors were subjected to from the time they left the manufacturer until they arrived at Standard. The culprit: plastic bags in which TRW shipped the resistors. The combination of vibration and low humidity on the plane that carried the resistors to Germany created high-voltage electrostatic fields on the bags, and these fields caused a permanent change in resistance values.

The TRW-Angstrohm failure analysis showed that there was no detrimental effect on temperature coefficient or long-term stability, but the change in resistance was serious enough to eliminate plastic bags unless they're antistatic or foil-lined. What's more, the resistance change isn't limited to units of Angstrohm manufacture, that company found; thin-film metal resistors produced by Nepco and IRC showed the same tendency when subjected to high electrostatic fields in Angstrohm's failure analysis.

For the record

Lab deal. EDP Technology, a Washington, D.C., software firm, will buy Cornell Aeronautical Laboratory for $25 million—if. The big if is the lifting of a temporary injunction obtained by the State of New York barring Cornell University from selling the Ithaca, N.Y., facility. Cornell and EDP have asked for an early trial on the issue. Another problem could be staffing the lab. While its full complement is 1,500, including 630 scientists and engineers, the announced intention of the university to sell it hasn't discouraged anyone from leaving. The question is just how many stayed. The prospective purchaser specializes in developing systems for education, business, health, and community planning.

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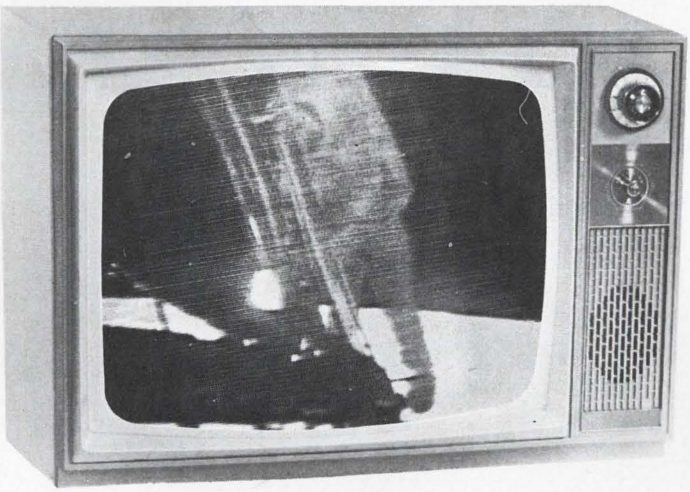

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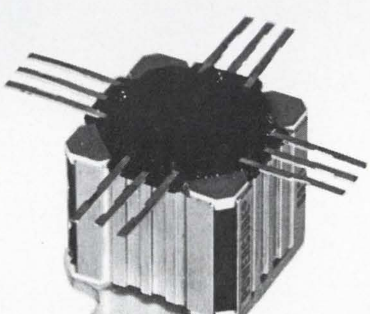

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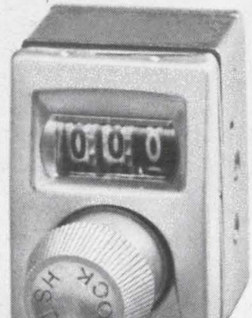

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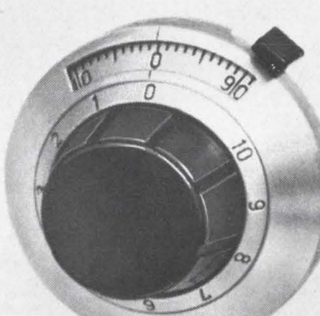

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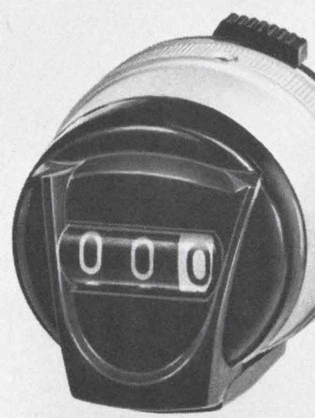

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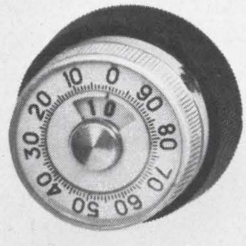

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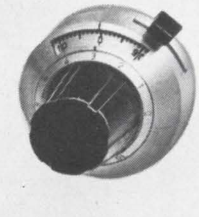

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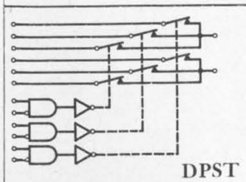
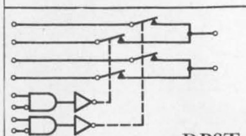
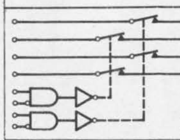
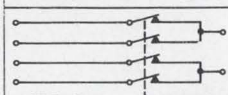
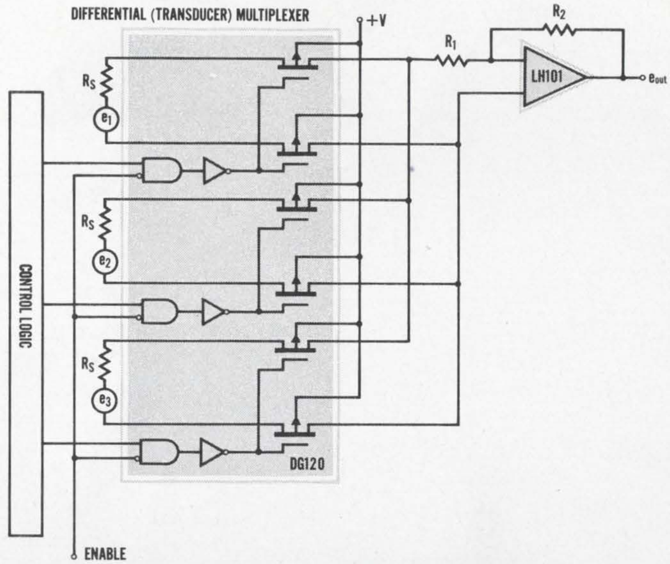
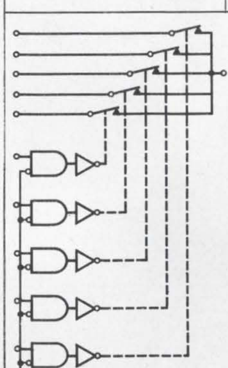
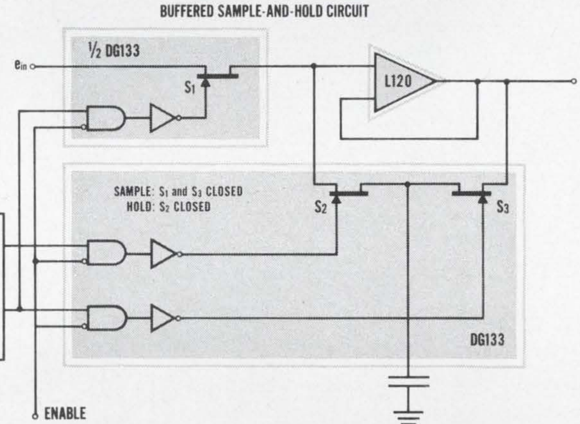
Here are two more examples that illustrate the versatility of Siliconix driver/FET switch packages in data transmission systems.

Functional Description	Channels	Type	Max. $r_{DS\,(ON)}$ (ohms)	Switch Type
 DPST	3	DG120 121	600 600	PMOS PMOS
 DPST	2	DG122 132	600 600	PMOS PMOS
 DPST	2	DG126 129 140	80 30 10	N N N
 SPECIAL FUNCTION	1	SI3001	600	PMOS

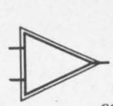
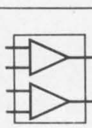


This three channel version of a transducer-multiplexer uses a single DG120 along with an LH101.

Functional Description	Channels	Type	Max. $r_{DS\,(ON)}$ (ohms)	Switch Type
 ENABLE DG123	2	DG110 111 112 133 134 141 147 148	600 600 600 30 80 10 600 40	PMOS PMOS PMOS N N N PMOS PMOS
	4	DG116 118	600 600	PMOS PMOS
	5	DG123 125	600 600	PMOS PMOS



Low input leakage of the L120 OP AMP makes it ideally suited for sample-and-hold circuits. Two channels of this circuit require only three DG133s and one L120. An alternative approach would require two DG129s and one L120 for two channels.

SILICONIX OP AMPS	Max. input offset voltage −55 to +125°C	Max. input current	Min. open loop gain	Output voltage swing	Slew rate	
 LM 101 LH 101 (Internally compensated)	6 mV	200 nA	50K	±12V	0.25V/μsec.	• Operation from ±5 to ±20V power supplies • Low current drain • Continuous short circuit protection • Same pin configuration as 709 amplifier
 L 120	200 mV	50 pA	100	±12V	20V/μsec.	• Low input leakage • High slew rate • Unity gain stable • Ideal for sample and hold, integrating and fast voltage comparisons

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Circle 75 on reader service card

Washington Newsletter

October 27, 1969

Response pours in on wafer LSI for Navy's AADC

More than 40 companies already are interested in developing modules to package LSI in full wafer configurations for the Advanced Avionic Digital Computer (AADC). The Naval Air Systems Command expects to choose "several" development contractors from the response to its **request-for-proposals that's coming out in November.**

Navy program managers insist there is **no preferred approach for packaging LSI at this point,** despite their acknowledged interest in a Hughes Aircraft LSI interconnect method called pad relocation [*Electronics*, Oct. 13, p. 44] that the Navy feels has potential for "great cost savings" in large production runs of wafers.

AADC is backed by $1 million in fiscal 1970 money that has been obtained in a year when most new military starts are dying of economic starvation. Despite the hooker that any potential contractor must agree to permit the Navy to distribute any or all of its technological inputs to other companies on a "need-to-know" basis [*Electronics*, Sept. 29, p. 73], the list of companies interested in the Naval airborne computer project reads like a "who's who" of the electronics industry.

Army tightens purse strings for new technology

Count on a tough effort to get the Army Materiel Command to spend money on developing or building state-of-the-art equipment, or gear that hasn't been proven operationally. Congress has been "disenchanted with our progress," admits Gen. Ferdinand Chesarek, AMC commander, who indicates the command is playing it cool on new technology after the problems it encountered with such programs as the Cheyenne helicopter.

New equipment will have to be proven elsewhere, even by commercial users, before the Army will consider gear based on new technology, Chesarek indicates, citing such examples as Precision Instrument's laser mass memory and IBM's 360/195 giant processor. The Army's problem, he says, is to devise appropriate uses for such systems as the laser memory, which stores a trillion bits in 26.5 square feet at relatively low cost. As for the 360/195, the AMC commander says the Army has "major problems to resolve" before it can use such a system.

Go-ahead likely for Comsat on domestic satellite . . .

The Nixon Administration, under increasing pressure to get started on a domestic communications satellite system for television relay, is likely **to flash the green light on an experimental pilot system soon—perhaps in November.** Presidential advisers shortly are expected to echo a September recommendation of the President's Task Force on Telecommunications: give Comsat the responsibility to build and operate a pilot domestic system. If the Administration goes along, then the final step is approval by the FCC.

There was nothing new in the proposal made by CBS this month that the tv networks set up their own satellite relay system. ABC made much the same pitch four years ago, and GE earlier this year made a detailed domestic satellite proposal. Comsat, which presented its domestic satellite plan to the FCC in 1966, wants to discuss its latest plan with the three tv networks. **Only difference between the two is that Comsat would retail its satellite services directly to users, eliminating common carriers, notably AT&T.**

Washington Newsletter

. . . as first contract for ground stations is readied . . .

While the Administration tries to decide who should build the pilot domestic communications satellite system, **Comsat—Nixon's likely choice —is going ahead with what will be the first hardware contract.** Comsat shortly will announce the winner of the award for three transportable ground terminals, which will be prototypes for small stations in the domestic system.

Eight companies bid on the contract, which will be worth around $1 million. Though Comsat denies it, sources say it has narrowed the field to four finalists: **Collins, Hughes, Motorola, and Raytheon.** Those cut were Page, Nippon Electric, Radiation Systems, and Sanders. The last stage of the bidding was described as a Chinese auction in which the company that takes the biggest loss will get the award. So far, **with a possible 200 to 300 ground stations at stake, none of the four finalists is shirking.** One finalist already is getting quotes from subcontractors for gear to equip up to 30 stations, anticipating an award for that many by early November.

The transportable terminals will use cooled parametric amplifier front ends to meet bandwidth and noise figure requirements.

. . . and Alaska puts heat on Nixon to get ball rolling

Some of the strongest pressure exerted on the White House to get going on the pilot domestic communications satellite program is coming from Alaska. In fact, Alaskan leaders assert there's a "very real possibility" that **the 50th state will turn to Canada's domestic satellite system when it becomes operational in 1972.**

Sen. Mike Gravel (D., Alaska), says **the problem is Comsat,** which he calls "unmanageable in its present form with industrial competitors on its board." He's pushing his bill (S. 2928), now before the House Commerce Committee, which would amend the Communications Satellite Act to permit ground-station ownership by states or entities designated by them.

Color-tv fire probe doesn't worry EIA

The electronics industry apparently isn't too concerned over the latest Government probe into tv-set safety. "Anything that plugs in the wall will cause a fire sometime," says Jack Wayman, EIA vice president, in dismissing the National Commission on Product Safety's investigation into reports that some color-tv sets have caught fire spontaneously. Wayman calls the ratio of sets reportedly catching fire "infinitesimal"—only hundreds out of the 85 million tv sets across the country.

Mike Lemov, attorney for the commission, won't identify the manufacturers of the color tv sets reportedly causing all the trouble, maintaining it might create an "unfair competitive advantage" to other makers.

The commission, meanwhile, has sent inquiries to some 15 set makers asking if they had reports of fires on their sets.

Addendum

Cutler-Hammer's AIL division is now promoting its AN/TPX-42 ground-based processing and display system to the FAA. However, sources at the agency, which is having its troubles with Raytheon's display consoles for the National Airspace System (See p. 54), say the **AIL system can't be considered as a replacement for Raytheon's hardware since the latter is designed for a capacity of three to four times that of the TPX-42.** The AIL system's 128-target capability limits it to low-density terminals in civilian applications.

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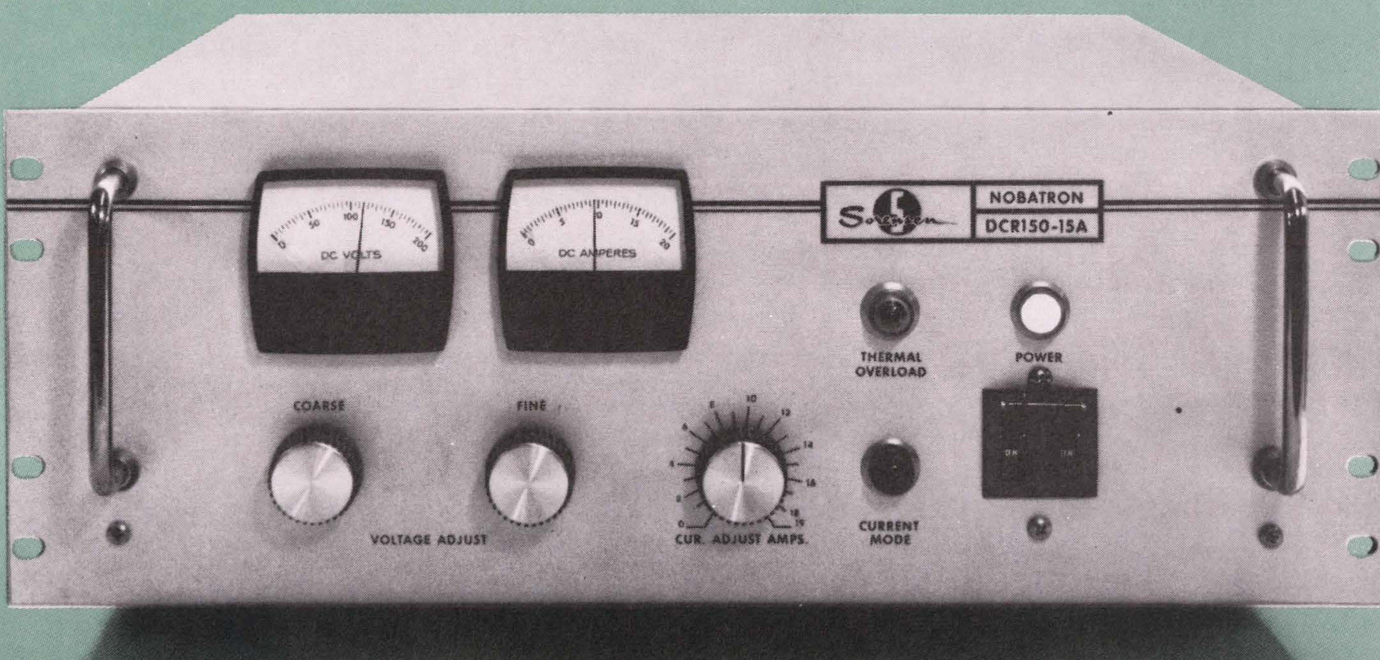

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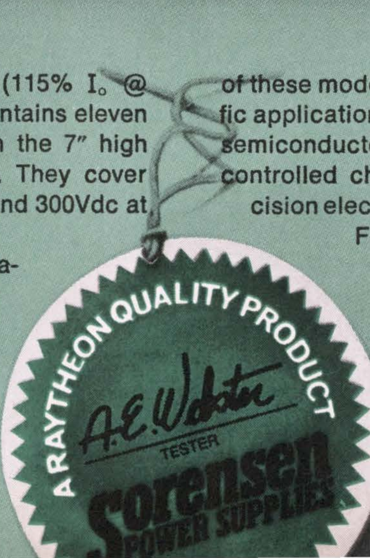

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Dual-25	MM400	−55°C to +125°C
	MM401	−55°C to +125°C (Internal 20K pull-up resistor)
	MM500	−25°C to +70°C
	MM501	−25°C to +70°C (Internal 20K pull-up resistor)
Dual-50	MM402	−55°C to +125°C
	MM403	−55°C to +125°C (Internal 20K pull-up resistor)
	MM502	−25°C to +70°C
	MM503	−25°C to +70°C (Internal 20K pull-up resistor)
Dual-100	MM406	−55°C to +125°C
	MM407	−55°C to +125°C (Internal 20K pull-up resistor)
	MM506	−25°C to +70°C
	MM507	−25°C to +70°C (Internal 20K pull-up resistor)
Dual-64	MM410	−55°C to +125°C
Accumulator	MM510	−25°C to +70°C
Triple-60+4	MM415	−55°C to +125°C
Accumulator	MM515	−25°C to +70°C
STATIC		
Dual-16	MM404	−55°C to +125°C
	MM504	−25°C to +70°C
Dual-32	MM405	−55°C to +125°C
	MM505	−25°C to +70°C
8-bit	MM408	−55°C to +125°C
Serial to Parallel	MM508	−25°C to +70°C
8-bit	MM409	−55°C to +125°C
Parallel to Serial	MM509	−25°C to +70°C
Dual-32	MM419	−55°C to +125°C
Split clock	MM519	−25°C to +70°C

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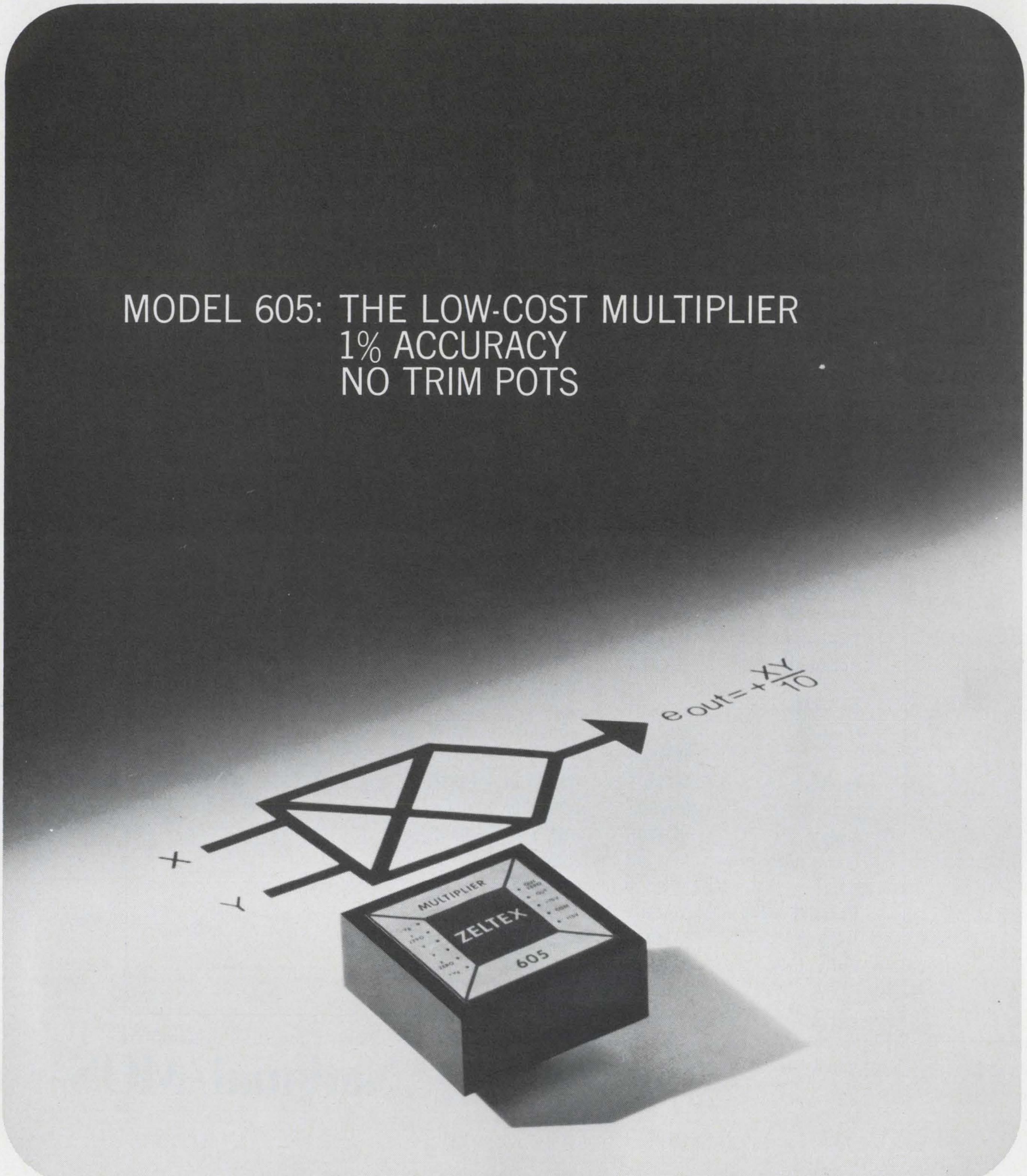
Circle 81 on reader service card



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Other key specifications include:

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

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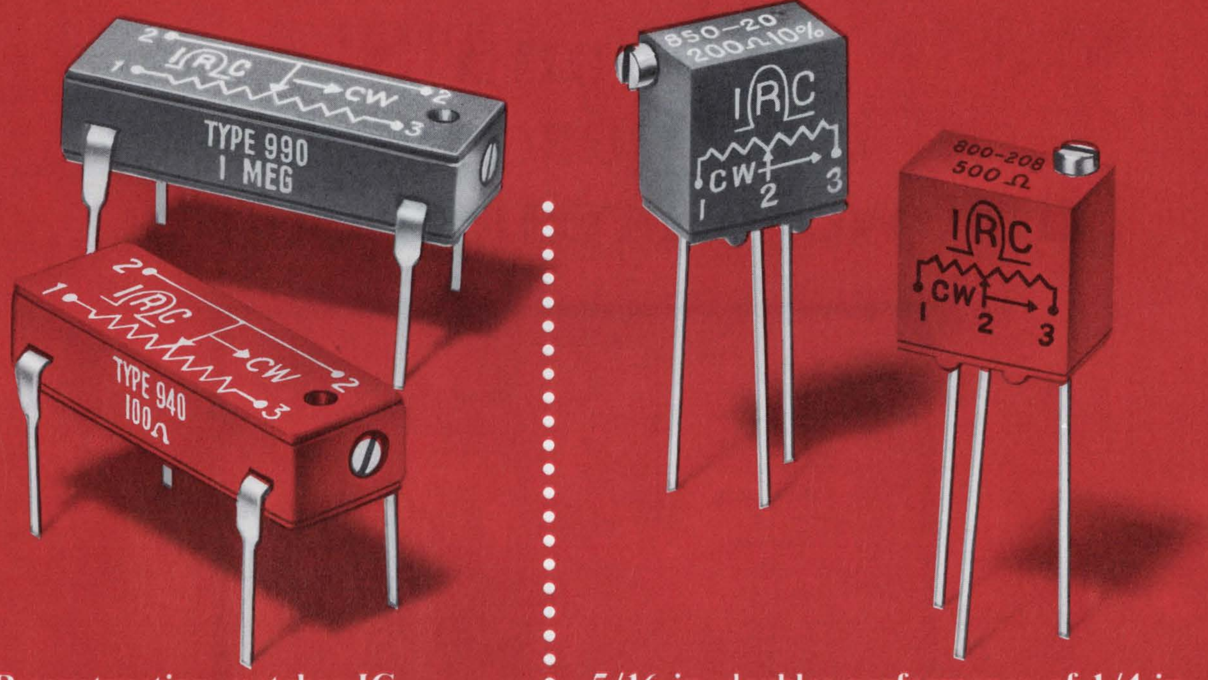
Space-saving trimmers



DIP construction matches IC size. Cuts assembly costs.

5/16-in. doubles performance of 1/4-in. trimmer—cuts cost almost in half.

These new IRC precision trimmers in dual-in-line packages simplify PC board layout. Only .200-in. high, their pin spacing is the same as the TO-116 size integrated circuit. It is fully compatible with high-speed automatic inserting equipment.

Pin spacing of these IRC 5/16-in. square trimmers matches the 1/4-in. square unit. Only .031-in. larger on each side, they can cut your cost almost in half and give you three times the power rating of the 1/4-in. and 40% better resolution.

Both DIP and 5/16-in. are available with precision wirewound and infinite resolution Metal Glaze elements. All units are fully sealed and impervious to common industrial solvents because of a silicone rubber shaft seal and epoxy bonding at all seams.

These units, like all IRC Metal Glaze trimmers, have a maximum guaranteed TC of ±150ppm/°C over the entire resistance range, with typical TC being ±100ppm/°C, and at no added cost. For complete technical information and prices, contact your IRC Industrial Distributor or write IRC St. Petersburg Division of TRW INC., 2801 72nd St., North, St. Petersburg, Florida 33733.

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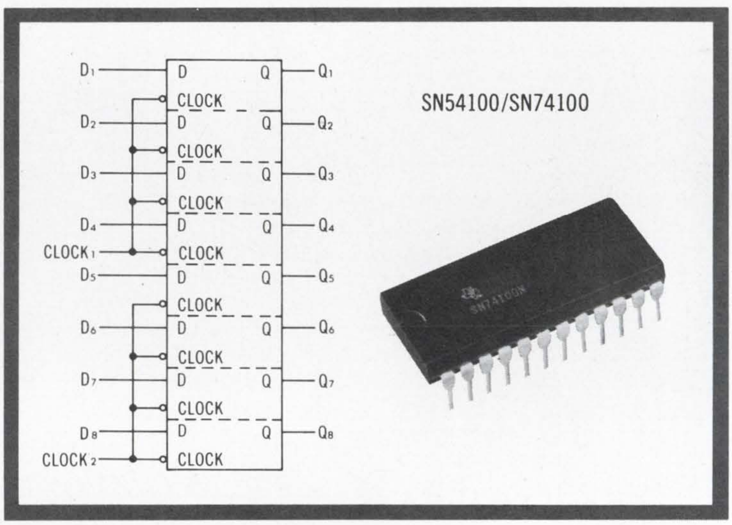
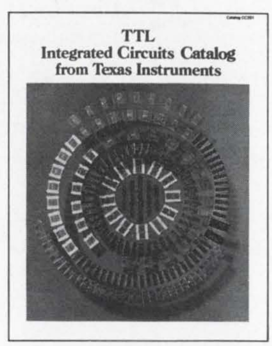


$7.42 from TI—your first source for TTL.

If the cost of temporarily storing 8 bits is more than you really like to pay, then TI's new MSI dual quad latches (SN54100/SN74100) will please you.

For example, the SN74100N, in 100-999 quantities, is a cost-conscious $7.42.

These new MSI functions combine two independent quadruple latches in a single, 24-pin dual-in-line plastic package. Typical power dissipation is 40 mW per latch. And the SN54100/SN74100 are fully compatible with TI's other TTL and DTL integrated circuits.



As attractive as the price is, you'll want more details before you buy. Our new 424-page TTL catalog contains a data sheet on these dual quad latches as well as sheets on all TI Series 54/74 circuits. Circle 255 on the Reader Service Card, or write Texas Instruments Incorporated, P. O. Box 5012, M.S. 308, Dallas, Texas 75222. Or call your authorized TI Distributor.

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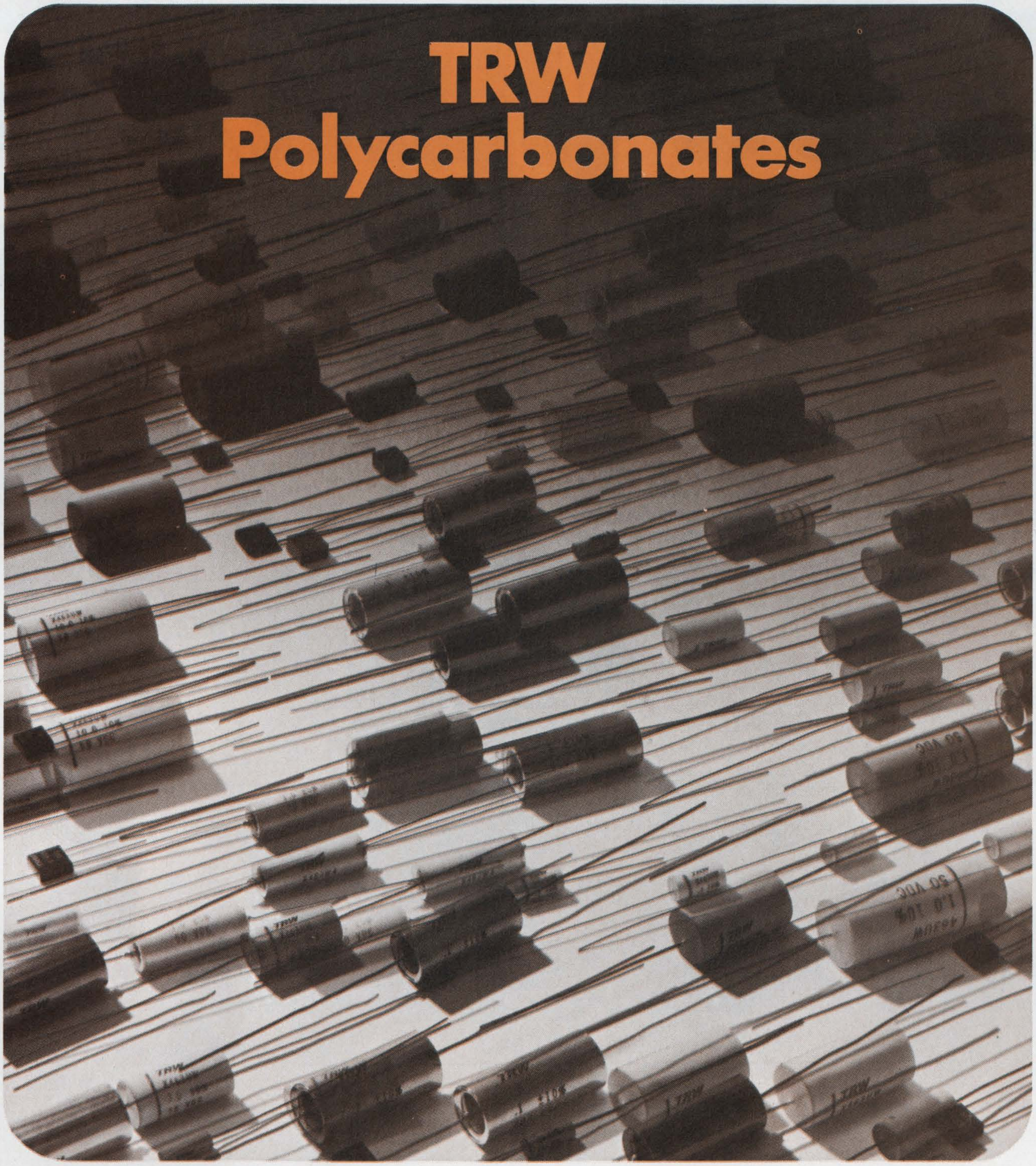

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Technical Articles

Boosting reliability of disk memories
page 88

Unless there is a good mechanical design, even the best of electronic designs can't guarantee a relatively high level of reliability. A good example of how much mechanical design counts is a new disk memory. Maximum reliability as well as maximum performance stems in large part from a rather unusual mechanical design. Air bearings are used instead of the usual ball bearings, fluidics control the mechanical motion, and a sealed enclosure stores the disks.

Multiplexers double as logic circuits
page 100

It's now possible to perform any kind of combinational logic function—including NAND, AND, NOR, exclusive OR, and compare—with a single universal logic circuit, a digital multiplexer that's fabricated on a single chip. The designer thus reaps the benefits of medium-scale integrated circuitry—small size, high speed, easier layout design, and better reliability. And he avoids the expense of custom design every time he wants circuits to perform different combinational logic functions. All that's required is the application of standard logic design principles involving truth tables and Karnaugh maps.

Active filters: part 13
Narrowing the choice
page 106

Because several circuits, such as gyrators and negative-impedance convertors, are available for active filter design, it's difficult to judge at first glance which is best for a particular application. Five circuit techniques are examined—a single operational amplifier, negative-impedance converter, integrator and lag, triple op amp, and the gyrator.

Air traffic control: Girding for the 1980's
page 127

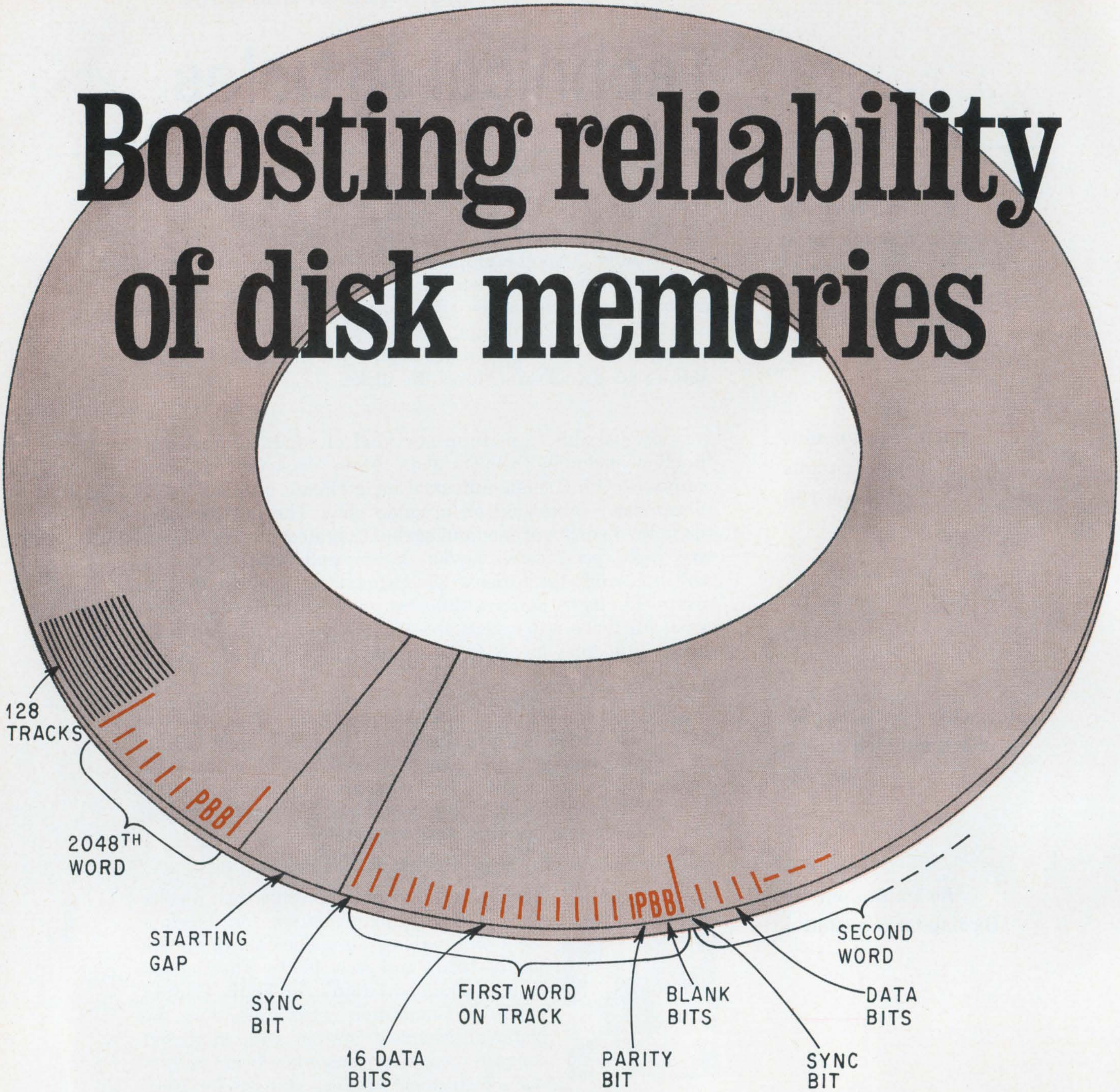
Technological evolution, rather than revolution, is the recommendation for development of a national air traffic control system for the 1980's and early 1990's. The Department of Transportation's Air Traffic Control Advisory Committee urges upgrading the National Airspace System with increased computer capacity; scanning beam microwave instrument landing systems for landing and terminal navigation; the use of dual-lane runways and intermittent positive control; a ground-based collision-avoidance system, and with both improved accuracy vhf omnirange and higher-capacity distance-measuring equipment. A post-1995 system would employ communications and navigation satellites in a highly automated network.

Coming

Microsound: Tomorrow's signal processing

An emerging technology that uses surface acoustic waves has the potential of replacing practically all the signal-processing circuits found in today's radar, navigation, and communications systems. An article by J. H. Collins and P. J. Hagon of Autonetics will point out the techniques that are involved and the devices that are emerging.

Boosting reliability of disk memories



One in twenty. A synchronizing bit signals the beginning of every 16-bit word, of which 2,048 are recorded in each track; a parity bit and two blank bits follow the data. A gap 1/60th of a revolution in length separates the last word in a track from the first; but the 128 gaps don't actually line up in a pie-shaped sector as depicted in this diagram. Rather, because each track has its own read-write head, and because the heads are arranged in eight groups of 16 around the supporting casting, the gaps are also distributed around the disk.

Sound electronic design isn't enough by itself; good mechanical design can make the big difference, according to *Roland Boisvert* and *S. A. Lambert* of Digital Information Storage Corp.

● Mechanical design often has been ignored in electronic design, only to turn out to be the keystone without which otherwise technically sound and reliable equipment collapses. But if mechanical considerations in an electronic product are given very high priority, and are considered along with the design of the electronics, as in a new digital disk recorder with removable disks, the goal of high total reliability can be achieved:

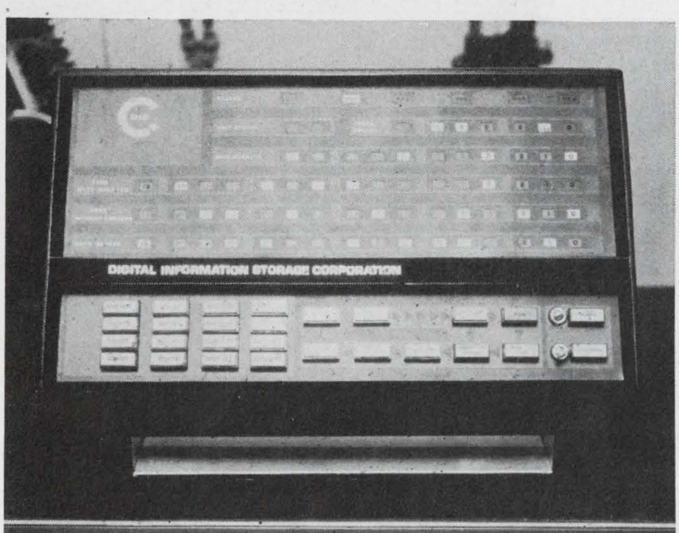
- Timing reliability is high because read-write timing is controlled by synchronization bits interspersed among the data bits—and with only one sync bit in every 20 bit positions on the disk, against one in four or even one in two in some systems.
- Mechanical reliability is high because all major bearing surfaces run on air bearings rather than ball bearings, while the drive's mechanisms are controlled by fluidic logic instead of relays and solenoid valves.
- Data reliability is high because the disks are stored in sealed cartridges. From these they are loaded into the drive without being exposed to the dirt in room air.

Significantly, a major byproduct of the quest for mechanical reliability in the new recorder—Digital Information Storage Corp.'s DDR-1—is the first combination of effectively infinite storage capacity with fast access time. Removable disks provide the capacity, limited only by shelf space available for disk storage. Fast access results from having a read-write head for every track. These two features, a giant bonus when combined in one machine, are made possible by the air bearing's intrinsic self-centering property, which permits the disk to be accurately positioned relative to the heads, even as it spins at up to 3,600 revolutions per minute.

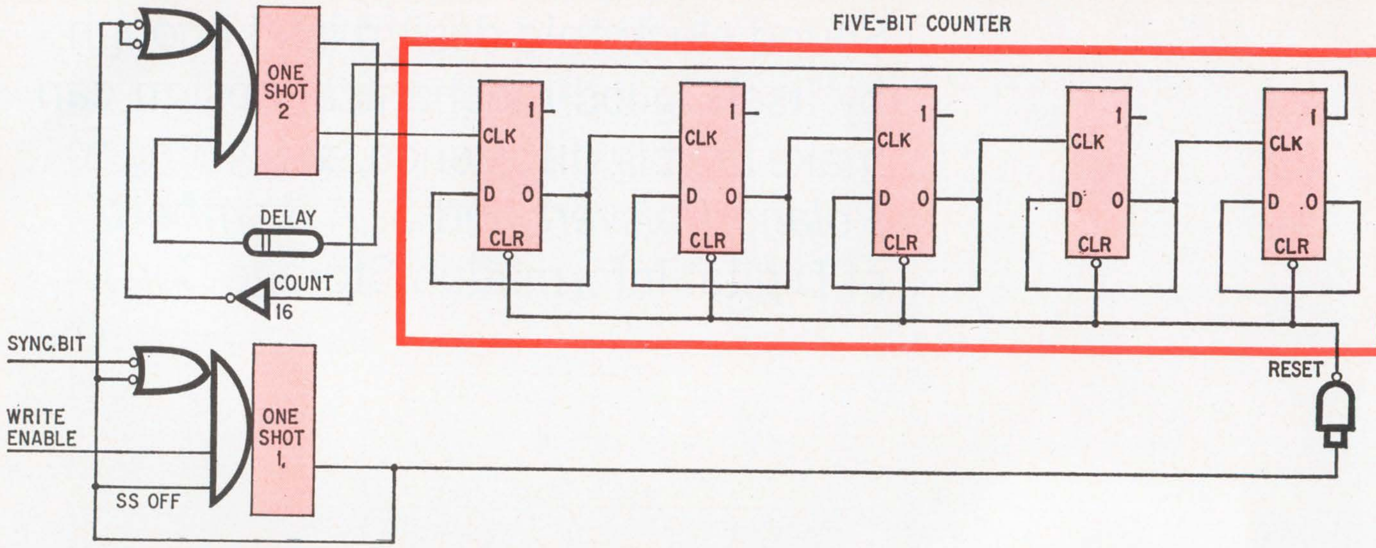
To permit a large quantity of data to be stored on each disk, some single-disk systems are arranged with storage surfaces on both sides of the disk. If the unit is removable, the two-sided arrangement requires read-write heads to be retracted during loading and unloading. But a head-retracting mechanism with one head per track would be so cumbersome as to be uneconomic, so these systems also require the heads to move from track to track preceding most reading and writing operations.

On the other hand, recording data on only one surface of the disk requires very small spacing between tracks. This can be close enough to cause crosstalk between tracks, and other problems, on disks using iron oxide coating; but when the magnetic recording medium is the nickel-chromium material that has become increasingly popular, these problems aren't serious. Nickel-chromium also permits tight packing of bits within a track. But close track-spacing means that the heads must be very accurately positioned over the tracks.

Accurate positioning, up to now, has precluded a removable disk. Enter the head-per-track approach—which has the added advantage of sharply reducing access



Simple. This view of the DDR-1's front panel also shows the slot through which disks are loaded into the machine from their storage cartridge, which is called a DISClosure. Here the machine appears on a table top, requiring the air compressors to be placed under the table or nearby. A stand is available that conceals the compressors in its base.



time. Thus a command from the computer to read or write data in a particular location on a particular track is delayed only by the time required for the location to come around under the head—at most one revolution of the disk—avoiding the additional delay for the track-seeking motion, which can be up to 10 times the rotational lag.

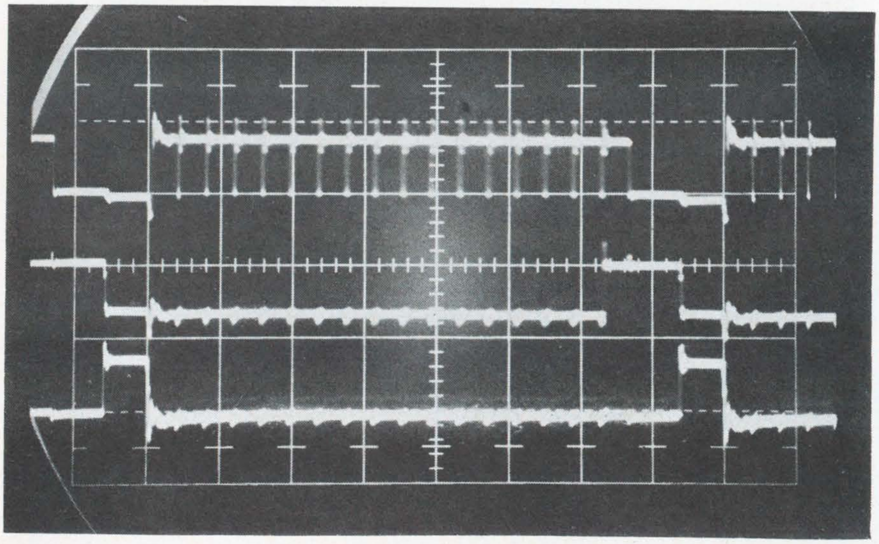
On many older fixed-disk storage units, synchronizing pulses are obtained from one of several timing tracks when writing or reading data in other tracks. But at high recording densities, the tolerances in these timing tracks become very critical. For example, the disk shows gyroscopic behavior under even slight external shock, causing a slight precession of the disk; or, under certain circumstances, it can set up a standing wave in the disk. Both the data and timing heads are mounted on flexible supports to ride out such disturbances, but they may ride in opposite directions and upset the phase relationship between the timing and data pulses.

These considerations—and a great many more—have forced designers of removable-disk systems to incorporate timing into the data tracks. These sync pulses necessarily somewhat dilute the density of the recorded data—sometimes to a very great extent, as when every other pulse is a sync pulse. But since in the DDR-1 only every 20th pulse is a sync pulse, dilution of the data density is almost negligible. It works because of a highly reliable method of clocking the data following every sync pulse, and because of the machine's mechanical design details.

The reliability factor in the air bearing enters the picture here. For one thing, it tends to cushion external shocks, so that they are reduced in severity, if indeed they reach the disk at all. For another, because the air bearing is self-centering, it automatically compensates for any changes in the rotating mass comprising the disk, the supporting hub, the shaft, and the motor rotor as a result of external shocks or just ordinary wear and tear. Electronic engineers may not always realize the complexities involved when something spins in the presence of external forces. For example, the axis of rotation presumably passes through the center of mass—but not when the mass is unbalanced or when it is precessing gyroscopically.

Another detail is mounting of the read-write heads. In some systems, for example, they ride out transient disturbances in the disk because they sit on short horizontal arms that rotate a few degrees in a vertical plane around a support. The sideways component introduced by this rotation is only a tiny fraction of the vertical motion. But at high densities even that tiny fraction may be all or a large part of the distance between two bits, disrupting the timing of both read and write operations.

The DDR-1's heads are mounted on spring brackets secured against lateral motion at each end; the heads are free to move up and down as necessary, but can't move



Word timing. These three signals generate all internal timing in the DDR-1. The top trace goes positive when the sync bit is read, and goes negative 17 times at 800-nsec intervals while reading or writing one word. The middle trace, rising 100 nsec after the 16th negative pulse, signals parity time; the bottom trace is the start signal for the next word.

Timing generator. Two single-shots and a five-stage counter control the DDR-1's timing. The circuits, made to military specifications, are affected only negligibly by long-term drift.

Bits, words, tracks

Bits per word	16 plus parity and sync
Words per track	2,048
Data tracks	128
Words per disk	262,144 Expandable to 1,048,576 via three slave units
Average access time	16.67 msec (8.33 msec available)
Bit frequency	1.25 Mhz (2.5 Mhz available)

at all in a lateral direction.

When the DDR-1 receives a read or write command from the computer, it first selects the proper head for the desired track. Then it waits for the desired word to arrive under the head. A continuously running counter keeps track of the word that is coming up next, and when the counter matches the requested address, data transfer begins to or from the computer.

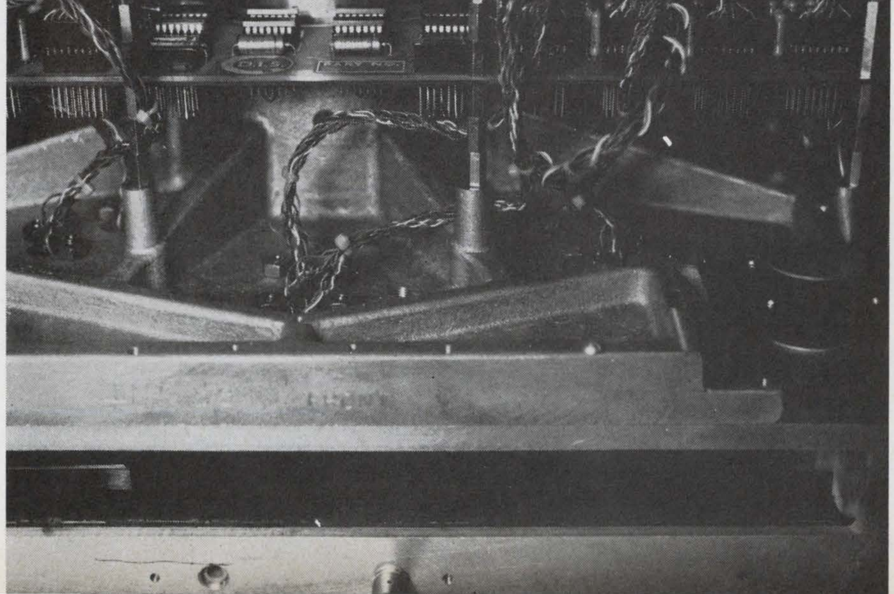
At this point, the DDR-1 sends an interrupt signal to the computer to request data for writing, or to indicate that the data is forthcoming on a read command. All disk storage units do this. But the DDR-1 also sends an early warning signal 16N + 5 microseconds before the desired word is located; N is the number of words between the two interrupts. This number is wired into the machine; usually it's 4, but it depends on the user's requirements.

This early warning permits the computer program to finish an operation before attending to the disk; to start a routine to hold the computer's status while the disk operation is in progress; or perhaps to avoid starting a new task that it will have to discontinue shortly.

Each word stored on a DDR-1 disk begins with a sync bit, as shown on page 88, followed by 16 data bits, one parity bit, and two binary 0's that serve as a marker between words, for a total word length of 20 bits. There are 2,048 of these words in a single track, plus a gap of about 550 microseconds to indicate the starting point. At the start of a read or write operation with an address less than the wired-in value of N, the early warning signal occurs at the beginning of this gap.

Coding is NRZI, a non-return-to-zero function, with change on ones; this is a common technique in which the disk coating always is magnetically saturated, and in which a 1 is represented on the disk by a flux reversal from saturation in one direction to saturation in the other. Successive 1's are thus depicted by flux reversals in opposite directions, whereas a 0 is represented by the absence of a reversal. As seen by the sense amplifier, therefore, the absence of a pulse shows a 0, and successive 1's, whether separated by 0's or not, are represented by pulses of opposite polarity generated by the alternating flux reversals. Parity is even—the parity bit insures that the number of bits in each word, including the sync bit, is even.

Timing depends on two single-shots and a five-stage binary counter, as shown at the top of page 90. One of the single-shots, when off, holds the counter in its reset state. At the end of the 550-μsec gap, the Enable line turns on, and the following sync pulse turns on the first single-shot, releasing the reset. It stays on for about 15 microseconds, long enough for the entire word to be written, then shuts off. But while on, it opens a gate to the second single-shot, which drives itself through a delay line and the same gate, and therefore oscillates at



Spaced out. The read-write heads are assembled into a single head pad; 16 pads are mounted as eight pairs spaced around a supporting casting. This arrangement minimizes the lead length from the heads to the sense amplifiers, which are on the nearest circuit board eight inches away.

. . . the whole disk-loading procedure is carried out by pneumatic and fluidic equipment; there isn't a single ball bearing anywhere in the business end of the machine.

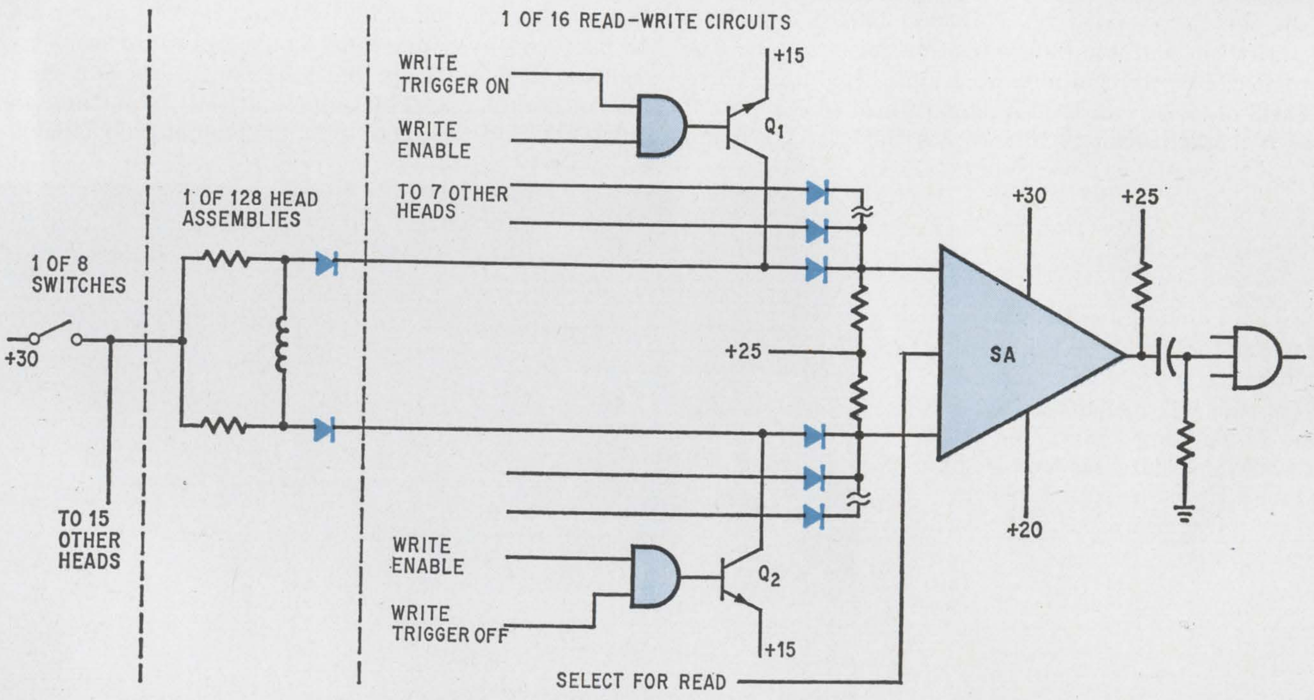
Diode decoupling

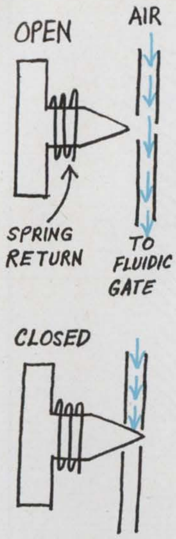
A reasonably straightforward circuit, but one believed to be unique, shown below, decouples the sense amplifier from the write circuits, It begins with a write trigger (not shown in the diagram) which changes state whenever a 1 is to be written; the trigger's change turns on one of the two write transistors Q_1 and Q_2 and turns off the other, reversing the current through the winding in the head. This current originates at the +30-volt supply, and passes through switches in the selection matrix; it divides into two nearly equal parts to pass through matched resistors connected to the two ends of the head winding, whose resistance is much lower than that of the resistors. One of the currents passes through the head winding; they recombine and go to whichever of the two write transistors is conducting. When these transistors change state and reverse the current through the winding, the matched resistors damp the inevitable inductive kick, an improvement over a common design that has a center-tapped winding and no return path for inductive currents. Reversing the current in the winding reverses the saturation in the disk's surface according to the NRZI encoding.

Because the write transistors are connected to +15 volts, the diodes between their collectors and the sense amplifier are reverse-biased, so that the amplifier is decoupled from the write circuits.

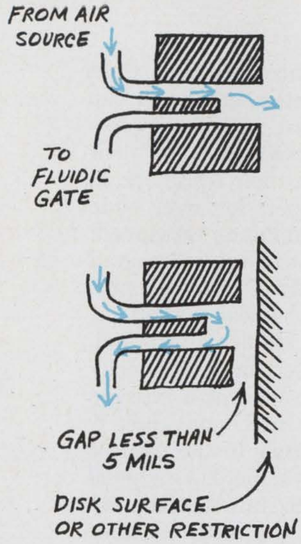
When reading, both write transistors are turned off because the Write Enable line is off; the +30 volts in the matrix selection thus forward-biases the diodes and admits read signals in the millivolt range, riding on the large d-c bias, directly to the sense amplifier, which is floating at +25 volts. A capacitor at the amplifier's output blocks direct current, but passes data to the logic circuits.

This read-write circuit design carries with it a bonus: it can switch from write to read, or vice versa, in 350 nanoseconds. This permits the DDR-1 to read a word immediately before or after writing in the adjacent location on the same track. There is no waiting for a full disk revolution, as in most disk storage units.





Gadgets. Fluidic manual switches (left) are made from standard electric pushbuttons with electrical parts removed and tubing connections added. Fluidic proximity detectors (right) control the logic as mechanical motions are initiated or completed.



1.25 megahertz. Its oscillations drive the binary counter, an array of five flip-flops—each a standard off-the-shelf product. The flip-flops actually are six three-input NAND gates on a chip, interconnected to act like a flip-flop; when the 0 output is connected to the data input, the circuit acts like a binary flip-flop, changing state with every positive shift of the clock input. This same 0 output is connected to the clock input of the following stage to produce the binary counting action.

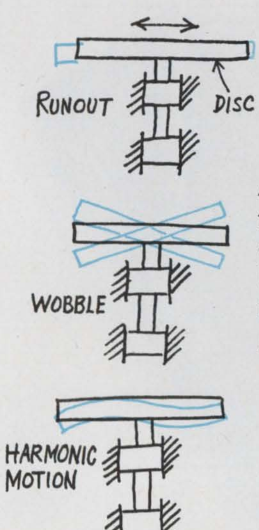
The binary unit counts up to 16, then shuts off the oscillator. At that moment the second single-shot is on; when it turns off, it steps the counter again. The 17 pulses from the single-shot synchronize the writing of the 16 data pulses and the parity bit. Immediately after the 17th pulse, the first single-shot turns off, signaling the end of the word. The next sync pulse starts the process again, whether data is being transferred or not.

To interchange disks, the DDR-1 takes advantage of mechanical design ideas unique to disk storage units. First, disks not in use are kept in sealed cartridges. When a disk is to be loaded, the operator places one edge of the cartridge in a slot at the front of the machine. The mechanism opens the cartridge seal and a similar one on the machine, reaches into the cartridge, hooks onto the hole in the center of the disk, and pulls it into position underneath the motor shaft. At this point the operator must remove the cartridge, which recloses both seals; then the motor shaft picks up the disk, accelerates it to the proper speed, and brings it up under the read-write heads. When the disk is unloaded, the sequence is reversed: the mechanism pushes the edge of the disk to get it into the cartridge, and reseals both the cartridge and the machine before the operator can remove the cartridge.

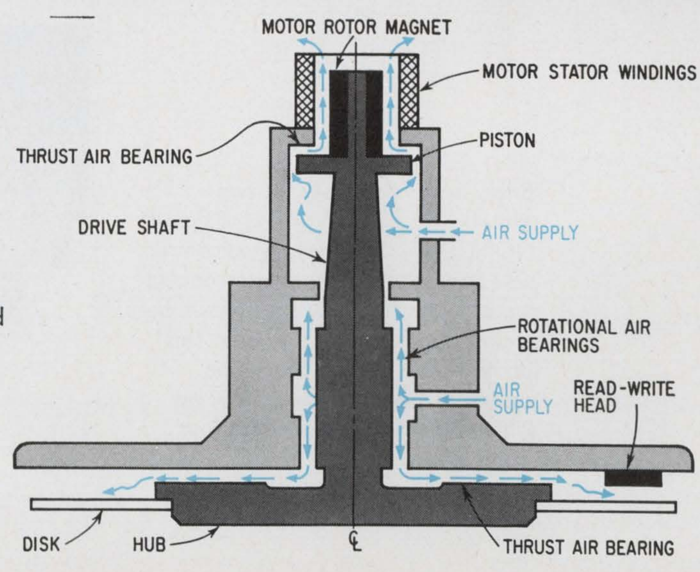
What's extraordinary is that the whole procedure is carried out by pneumatic and fluidic equipment; there isn't a single ball bearing anywhere in the business end of the machine.

Ball bearings have serious drawbacks in a disk storage unit. The disk must be capable of axial and rotational motion; ordinary ball bearings support only rotation, while specialized adaptations would require multiple bearings. Also, ball bearing wear subjects a rotating disk to undesirable motions, or even to development of a harmonically curved surface resulting from vibrations that are even multiples of its angular frequency of rotation as at left below. Lubrication doesn't always avert the problems, and the lubricant could pollute the magnetic recording surface.

These difficulties were averted with air bearings. Because air's fluid nature tends to equalize the pressure in any given mass of air, and because any off-center motion of the shaft tends to vary this pressure, the air bearing is intrinsically self-centering. And it's so friction-free that



Anti-wobble. The undesirable motions that can occur with ball bearings (left) are avoided in the DDR-1 with air bearings, shown at right. The shaft spins in a rotational bearing, and the hub and piston bear upward against thrust bearings, all films of air under pressure.

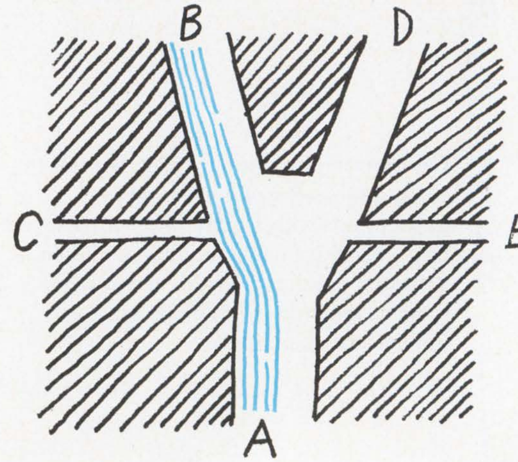


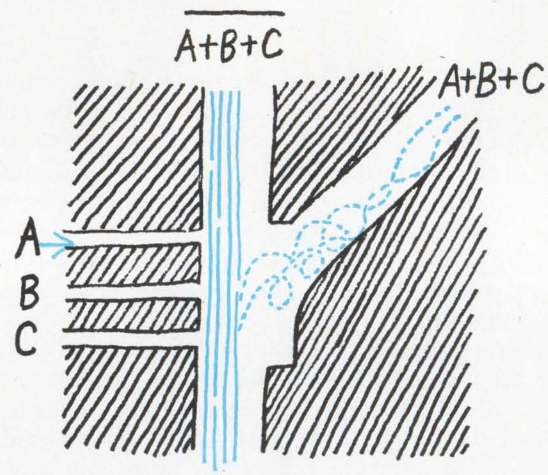
Fluidic logic

Air or any other compressible or incompressible fluid passing through pipes, jets and interaction chambers can be made to perform logic functions just as well as electronic circuits. In some way fluidic devices surpass their electronic counterparts—for example, in their resistance to nuclear radiation or their continued operation over wide temperature ranges. The principal limitation is speed; switching functions occur at speeds ordinarily measured in milliseconds, and at best in hundreds of microseconds. But in controlling relatively gross mechanical operations, as in the DDR-1, speed isn't critical and fluidics fill the bill.

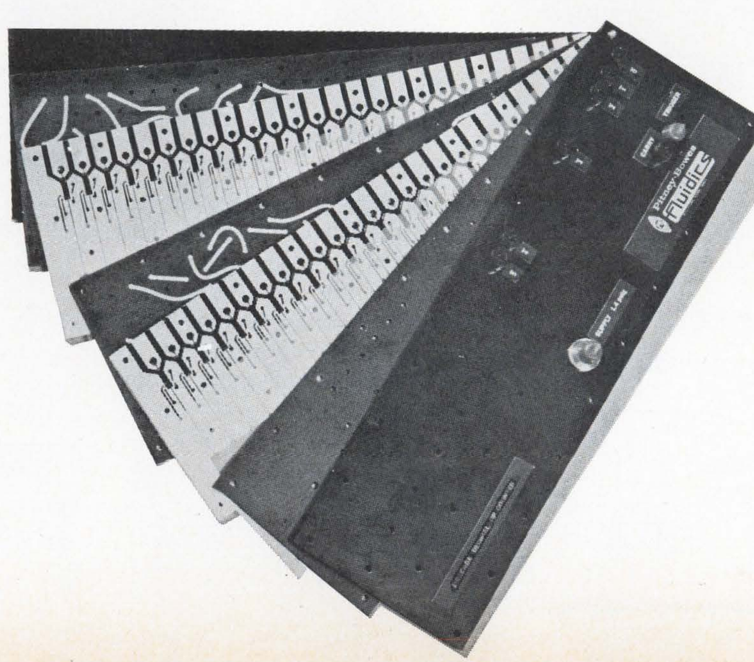
Operation of fludic logic devices is based on the tendency of a jet of fluid flowing parallel to the wall of a passage to adhere to that wall. A jet emerging from input duct A in the diagram, once it has attached itself to the wall of the left-hand outlet, as illustrated, stays there; nearly all the fluid volume exits through duct B. But a relatively small control jet at duct C can detach the main jet from its wall and force it against the opposite wall, where it remains after the control jet turns off. Now the major portion of the fluid exits through duct D. Another control jet appearing at E can switch the main jet back to its original position. This configuration behaves exactly the same as an electronic flip-flop; it has two stable states and remains in either state indefinitely unless it is switched to the other by a relatively small control signal.

A somewhat similar configuration implements the familiar NOR function in fluidics. Here the basic element, instead of being Y-shaped like the flip-flop, has one output leg in a straight line with the input and the other at a somewhat sharper angle than the flip-flop outputs. A laminar stream of fluid, flowing into the interaction chamber, continues straight through and attaches itself to the wall of the output leg in the absence of any control inputs at the side of the interaction chamber. Fluid emerging from this output represents the 1 state of the circuit. But a small control signal entering the interaction chamber through any one or more of the control input ducts can break this wall attachment and divert the jet to the other leg. Because of the relatively sharp turn from the input to the new output, the flow becomes turbulent and the jet doesn't attach to the wall—when the control signal turns off, the jet returns to the straight-through path. Thus the circuit is an implementation of the NOR logic function. Its operation as part of a larger logic array assumes that the 0 output, in which the flow is initially turbulent, is long and straight before feeding any other logic block, so that the flow again becomes laminar.

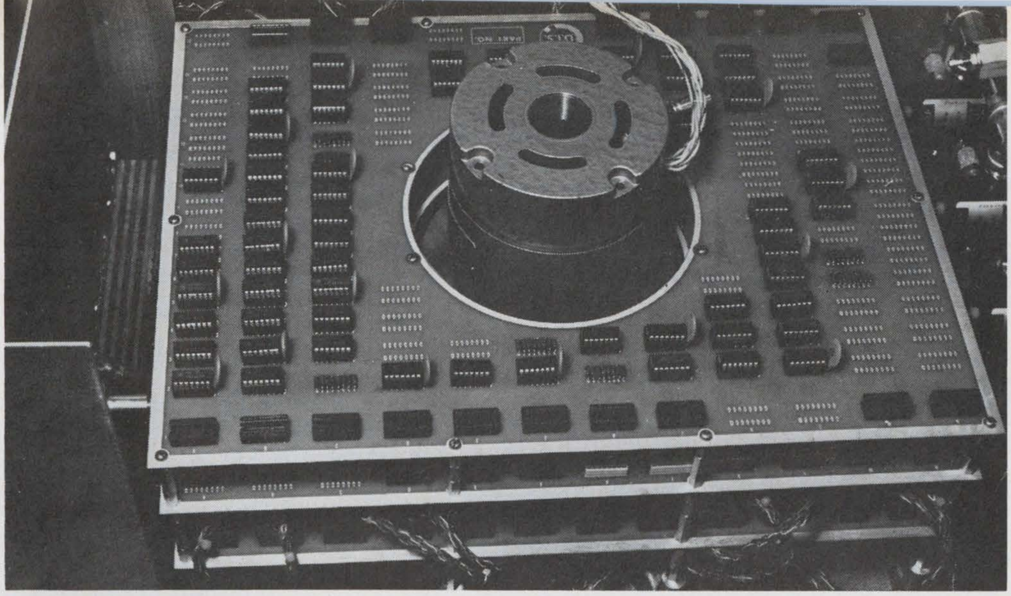




One of the benefits of fluidics is the ease with which fluidic large-scale integrated circuits can be put together. Almost all of the fluidic controls in the DDR-1 are built on a single lump of plastic about the size of an ordinary brick; "worm holes" in the brick are the passageways and chambers in which the fluidic logic functions are implemented. The fluidic brick isn't really as solid as it looks—it's made up of several layers of plastic, some with convoluted grooves and some with holes for connecting grooves in different layers.



Brick. In this assembly the two white layers contain arrays of fluidic NOR blocks; the other layers contain holes and channels that interconnect the blocks, when the "fan" shown here is closed and riveted together. This photo is of a dummy block; the assembly made for the DDR-1, by Pitney-Bowes Corp., contains four white layers.



Three layers. All electronic components are mounted on three 12-by-16-inch printed-circuit boards. Two boards carry the electronics common to all machines; the top board is tailor-made for a particular computer. Large center holes permit all three boards to fit over the housing for the floating piston and shaft.

it requires only a fraction of the torque a conventional bearing demands from the hysteresis-synchronous motor. And the air bearing, unlike the ball bearing, inherently permits axial motion.

Three air bearings are used: a rotational bearing surrounding the shaft that connects the drive motor to the hub supporting the disk; a thrust bearing above a floating piston that raises the shaft, hub, and disk into position for reading and writing, and another thrust bearing above the hub itself.

The floating piston, shaft, and hub [see p. 93] are cast as a unit; the motor rotor, which is a permanent magnet, is press-fitted onto the top of the shaft and becomes permanently a rigid part of the casting. After the disk has been mechanically latched onto the hub, air pressure on the piston raises it, together with the disk and the rotor. When the rotor enters the rotating magnetic field of the motor stator, the shaft begins to turn; by the time the shaft has reached its uppermost position, it is almost at its maximum speed.

At this point the piston is almost in contact with the bottom of the motor shell and the hub carrying the disk is almost in contact with the bottom of the shaft housing. In both places, a thrust air bearing is established—at the top by the air that pushes the piston up, at the bottom by air escaping from the shaft's air bearing. The differential pressure between each of these two thrust surfaces and the supply pressure controls the disk position with respect to the read-write heads with an accuracy of a few parts in 100 million, or a few hundredths of 1% of the nominal spacing between the disk surface and the read-write heads.

Since air already was available for the DDR-1's bearings, it was logical to use air in fluidic devices for controlling the recorder's mechanical motions.

In fluidics, as in electronics, a NOR gate is one of the simplest logic elements; from an array of NOR gates, logic functions of any desired complexity can be constructed [see "Fluidic logic," p. 94]. These NOR gates, combined with a very simple proximity detector control, for example, removal of a disk from its cartridge provided the cartridge is in place and another disk isn't already in the machine.

Most of the air flows from the fluidic logic vents into the space around the electronic circuitry in the recorder, keeping the components cool. Then it recycles through a duct at the back of the cabinet to the blower at the bottom. A small part of the fluidic logic air, and all of the air from the bearings, pressurizes the interior of the compartment containing the disk loading mechanism and the read-write heads. As a result, when the seals on the compartment and on the disk cartridge open for loading or unloading, air flows out, keeping the interior of the compartment free of contamination. ●

Circuit design

Designer's casebook

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

Sighting irregularities in small shafts

By George S. Lehsten

Col-Nic Industries, Naperville, Ill.

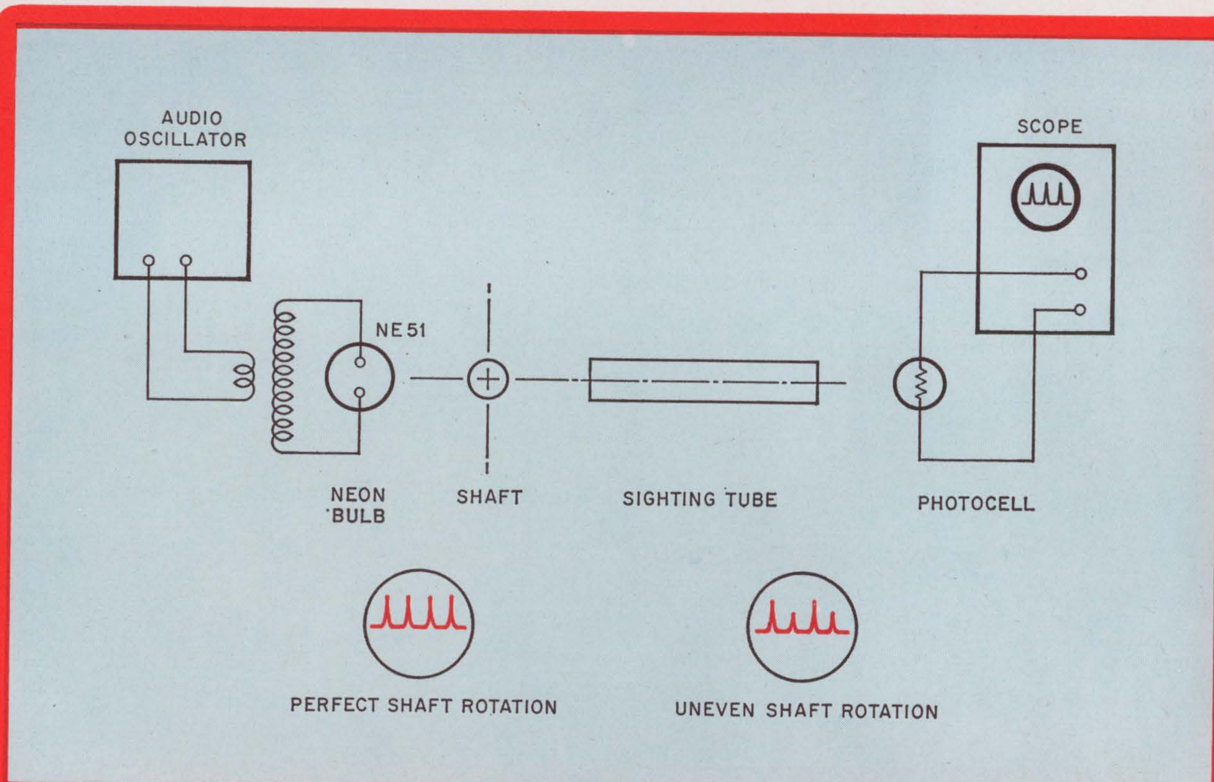
A wobbling high-speed shaft may need new bearings, but it's not easy to measure the wobbles if they're only fractions of an inch off center. Now, a simple setup consisting of a neon lamp excited by an audio oscillator, a sighting tube, and a photocell can display shaft irregularities on an oscilloscope. It's then easy to determine where undesirable movements occur along the shaft.

The sighting tube, which is slightly larger than the shaft's diameter, is directly aligned with the neon lamp's electrodes so that light from the lamp just passes over the shaft's surface through the tube. If the shaft is smaller than the spacing between the lamp's electrodes, the neon lamp can be rotated to compensate. For larger shafts two neon bulbs can be combined using one electrode from each bulb and inserting a diode in each line so the photocell only sees one electrode at a time.

An audio oscillator's frequency is synchronized with the speed of the shaft and excites the neon lamp's electrodes. The resultant light pulses travel down the sighting tube to a photocell. The photocell converts the light energy to electrical pulses which are displayed on the oscilloscope.

If the shaft's rotation is uneven, less light reaches the photocell and the pulses on the scope are alternately shorter than they would be had the shaft been perfect.

The amount of shaft movement is measured by comparing the variation of the shorter pulses with a reference full scale pulse measured without any shaft. Also, the position of the irregular shaft areas can be determined by adding paint to the area and observing the effect in the pulse heights on the scope.



Insight. An audio oscillator excites the electrodes of a neon lamp at the same frequency as the shaft rotates. The light pulses from the lamp travel down the sighting tube and are detected by the photocell. The photocell displays these pulses on a scope; the height of which determines the amount of shaft irregularity.

Monitor guards three ways against power failures

By Darold K. Smith

General Dynamics Corp., San Diego, Calif.

Equipment operating from three-phase power sources can be damaged if there is a loss of one phase, or if the line voltage rises above or falls below safe operating levels. Protection against these power failures can be insured by a circuit that monitors and compares the sum of the three-phase line voltages with a regulated supply voltage and removes power from the equipment in the event of a power loss or an overvoltage.

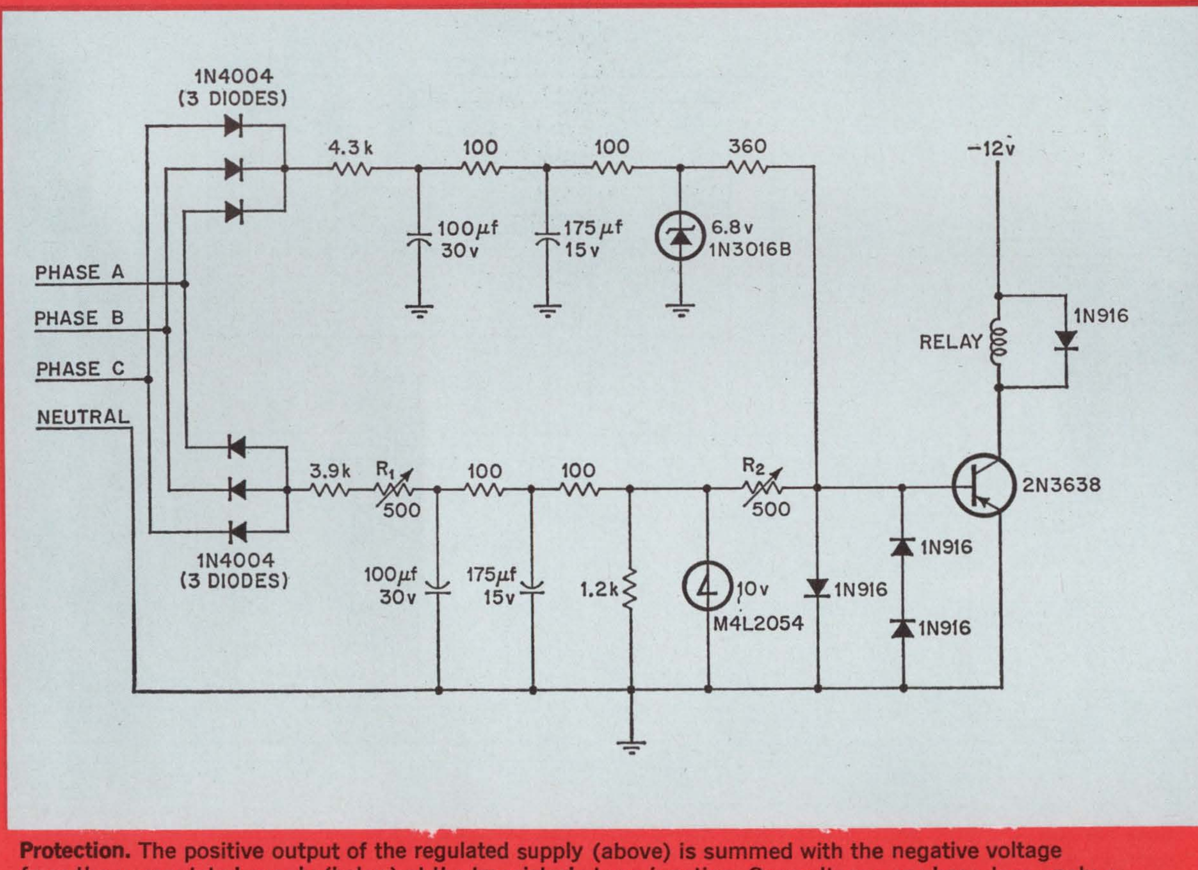
The regulated supply shown above consists of three rectifier diodes, a two-section RC filter and a zener diode. The unregulated supply below, in addition to the diodes and filter, contains a 1.2-kilohm load resistor and a four-layer diode.

At normal line voltages the unregulated supply's output voltage is slightly larger than the regulated output which applies a negative voltage to the transistor's base. The transistor conducts and operates the relay which in this application closes the main three-phase power supply contactor.

Now suppose that the input line voltage increases above a certain desired maximum voltage. The four-layer diode at the output of the unregulated supply breaks down when a voltage greater than its breakover voltage is applied across it; this breakdown effectively clamps the transistor's base to ground turning it off. The control relay opens which in turn opens the main power supply contactor. To reactivate the relay, the power at the input must first be removed.

If the line voltage falls below normal, a net positive voltage is applied to the transistor's base because the 1.2-kilohm resistor at the unregulated supply's output lowers its voltage more than the positive supply's output. The transistor, therefore, cuts off and opens the relay. Also, if one of the three phases is lost, the effect is similar to the case for the low line voltage.

The over and undervoltage trip points can be adjusted by potentiometers R_1 and R_2. Increasing



Protection. The positive output of the regulated supply (above) is summed with the negative voltage from the unregulated supply (below) at the transistor's base junction. Overvoltages or phase loss apply a net positive voltage to the transistor's base to open the control relay.

R_1's resistance, raises both the over and undervoltage trip points while decreasing R_1 lowers both trip points. Increasing R_2 lowers the overvoltage trip point, but increases the undervoltage trip point and vice versa.

To allow for momentary voltage drops in the power lines without activating the contactor control circuitry, the capacitor values shown in this circuit add a 0.2-second delay to the input signal.

The circuit can be used for single phase operation by removing two of the diodes at each input. The 3.9- and 4.3-kilohm input resistors, however, should be replaced with 1.5- and 2-kilohm resistors, respectively.

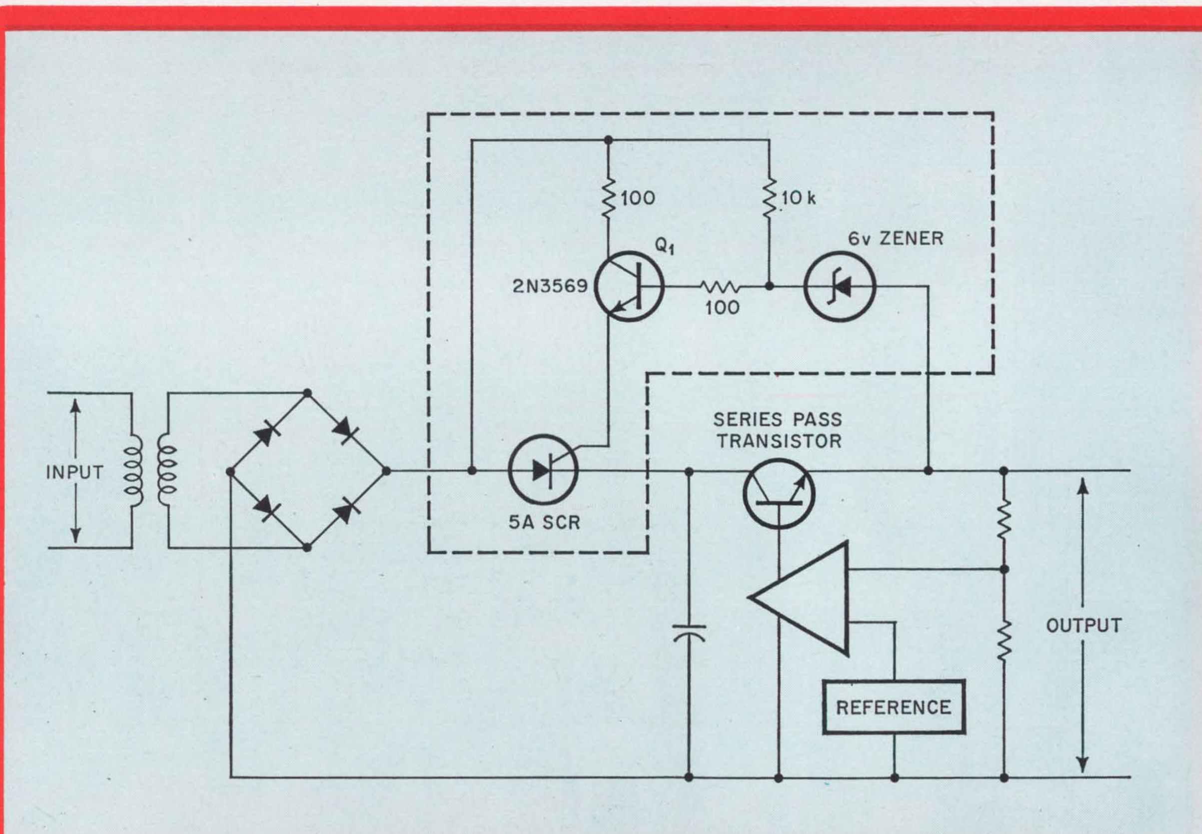
Zener in preregulator limits series transistor dissipation

By Peter Pohl

Institute of Nuclear Sciences, New Zealand

The series pass transistors in regulated power supplies are the source of much unwanted heat. The silicon-controlled rectifier preregulator when added to the power supply decreases the heat dissipation of the pass transistor and thus a large heat sink isn't necessary for the transistor. In addition, the preregulator is easy to hook up since it doesn't need the external triggering or added voltage lines other circuits have.

As long as the voltage across the pass transistor is less than the zener breakdown voltage, the silicon-controlled rectifier conducts and the capacitor charges. If the power supply voltage exceeds the zener breakdown voltage, the SCR cuts off. The average power dissipation of the pass transistor is thus the product of the current drawn and the zener voltage.



Easy hookup. The SCR preregulator shown boxed easily can be connected to conventional power supplies and reduces the heat dissipation in the series pass transistor. The average heat dissipation generated across the series transistor is the product of the current and the zener voltage.

Circle 99 on reader service card→

Multiplexers double as logic circuits

Capable of performing combinational-logic functions for any number of variables, digital multiplexers can replace interconnected packages and thus lower costs

By James L. Anderson
Fairchild Semiconductor, Mountain View, Calif.

Combining many logic functions in a single package is always attractive to a designer of combinational logic. However, most of the time this means custom-design which leads to expense and difficulty in making design changes once the masks are made. But now, a digital multiplexer offers complexity—many gates on a single chip—along with the ability to perform just about all the logic functions of the single packages. Moreover, the unit is an off-the-shelf item.

Depending on how logic-level inputs are applied externally, the multiplexer can perform any kind of combinational logic function, including NAND, AND, NOR, exclusive OR, and compare. It is actually so versatile that it takes on the aspect of a universal logic circuit.[1]

And, compared with the interconnected packages, the multiplexer, because it is contained on a single chip, offers higher speed, better reliability, easier design, and simplified printed-circuit board layout. These improvements are the reason why medium scale integration is used to place complete functional logic circuits such as shift registers, counters, and decoders on single chips. It is also easier to stock one type of multiplexer rather than several types of gates.

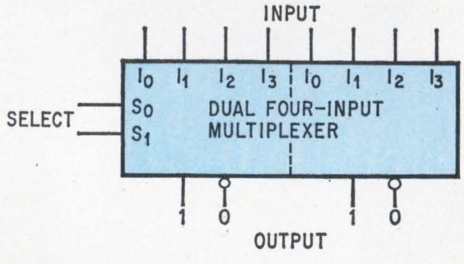
Combinational logic functions have been performed using two types of Fairchild Semiconductor multiplexers—the dual, four-input 9309 and the eight-input 9312, as shown schematically below. While these units are fabricated with transistor-transistor micrologic, the principles for implementing the functions are the same for any type of device technology, whether diode transistor logic or whatever. These principles can be understood by first reviewing how multiplexers operate.

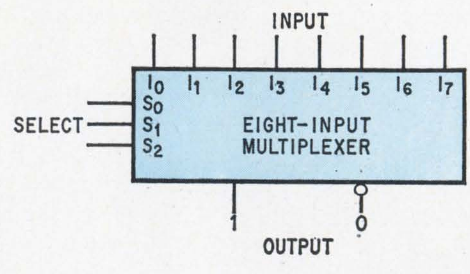
Essentially, they are electronic switches sequentially connecting input-data lines to a single output. In a standard multiplexing application, digital signals are connected to the multiplexer's input terminals (I_0, I_1, I_2. . . .), and binary control signals are fed to the select terminals (S_0, S_1 . . .). For example, to connect I_0 to the output on a dual, four-input unit, a 0 is applied to both select lines, and each combination of select-line signals corresponds to one of the four inputs.

On the dual, four-input unit, the two select lines are common to both halves of the multiplexer so that it behaves like a two-pole, four position switch. On the eight-input multiplexer, three select lines control the eight input lines, and the device resembles a single-pole, eight-position switch.

Applied as a universal logic circuit, the four-input multiplexer can handle as many as three variables—two are applied to the select terminals, and the fourth variable or its complement goes to each of the input lines.

Any of the possible functions of three variables





Anything goes. Dual, four-input multiplexer, left, and eight-input unit, right, are used as universal logic circuits. Binary signals on the select lines determine which input line is tied to the output.

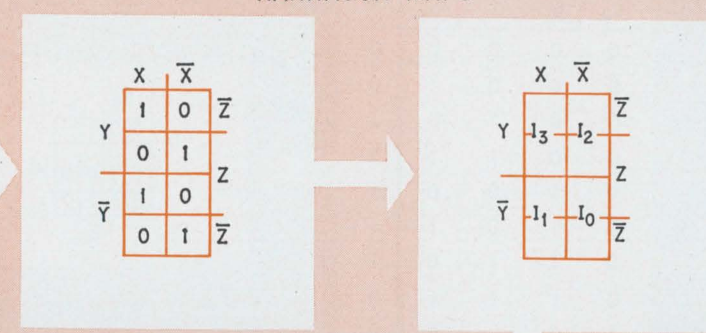
FUNCTION

$$F = XY\overline{Z} + \overline{X}YZ + X\overline{Y}Z + \overline{X}\overline{Y}\overline{Z}$$

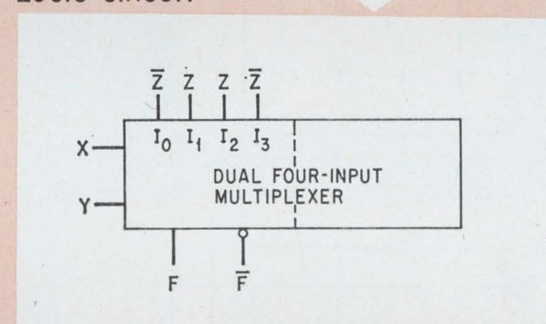
TRUTH TABLE

X	Y	Z	F
0	0	0	1
0	0	1	0
0	1	0	0
0	1	1	1
1	0	0	0
1	0	1	1
1	1	0	1
1	1	1	0

KARNAUGH MAPS



LOGIC CIRCUIT



Try it with three. Even-parity function of three variables is implemented with one-half of a dual four-input multiplexer, right. A truth table is written first, then a three-variable Karnaugh map is made. Each of the four multiplexer inputs is allotted a map area. The signals applied to the input lines are found by inspecting the I's and 0's contained in the cells of the areas.

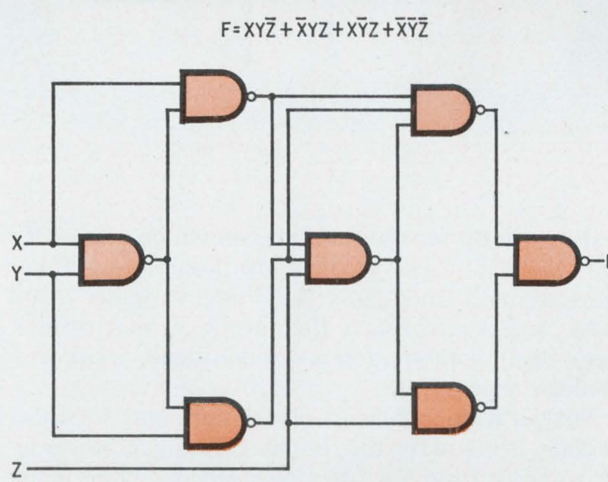
—there are 256—can be generated with one-half of the dual, four-input multiplexer. And any of the possible functions of four variables—which amount to a prodigious 65,536—can be handled by just one, eight-input unit.

The best way to illustrate how a given function is implemented with the multiplexers is by working out examples. Suppose a logic function must produce an output every time any two of three variables, X, Y, and Z, are 1. Expressed in Boolean form, this function, F, is

$$F = XY\overline{Z} + \overline{X}YZ + X\overline{Y}Z + \overline{X}\overline{Y}\overline{Z}$$

This is an even-parity function, commonly used in digital circuitry to check whether an error has crept into the combination of ones and zeros making up a digital word. It does this by counting the number of 1's in a word. An even number would, for example, mean the word code is correct.

From the Boolean expression, a truth table is



The old way. Implemented with discrete NAND gates, the even-parity function requires five, two-input and two, three-input gates packages.

FUNCTION

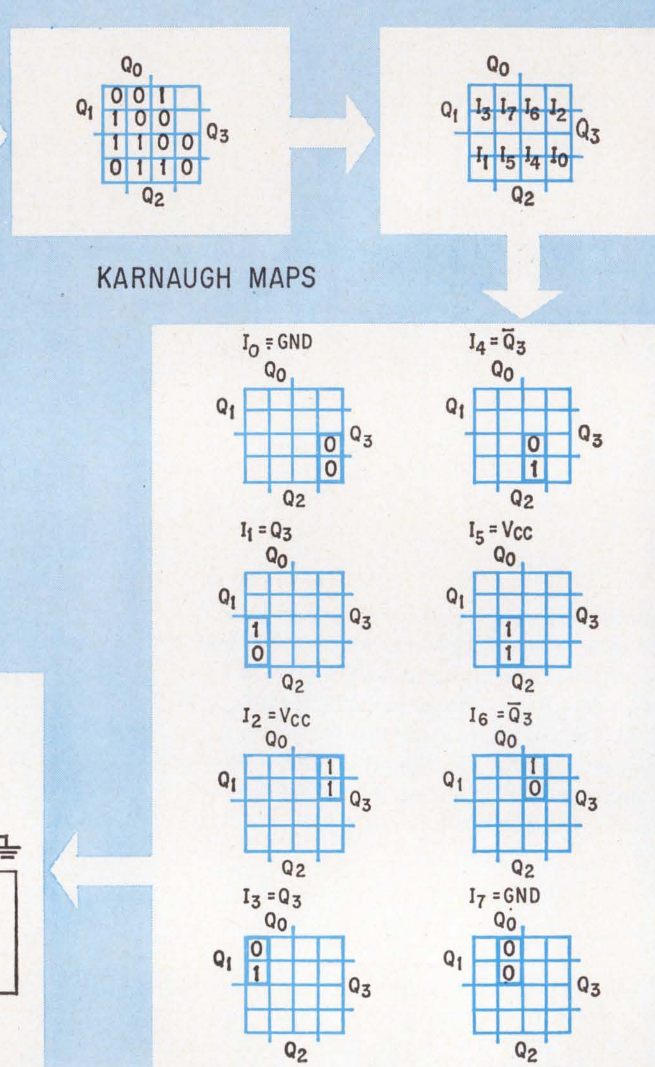
$$F = Q_0\bar{Q}_2Q_3 + Q_0\bar{Q}_1Q_3 + \bar{Q}_1Q_2\bar{Q}_3 + \bar{Q}_0Q_1\bar{Q}_3 + \bar{Q}_0Q_1\bar{Q}_2$$

Four of a kind. The procedure for implementing a function of four variables is the same as for three, although an eight-input, instead of a four-input, multiplexer is used. A truth table, left, is made and then the Karnaugh maps, below. Values of Q_3 to be applied to the input lines of the multiplexer, I_0 to I_7, are found from the areas in the maps alloted to each line.

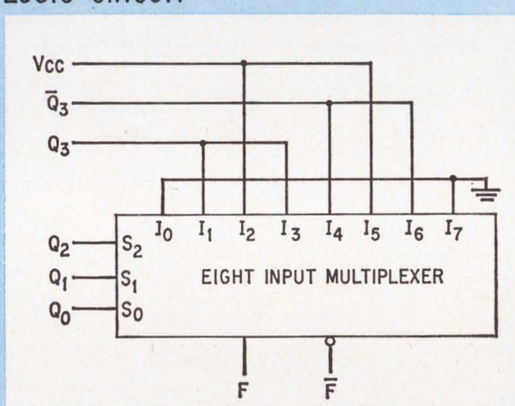
TRUTH TABLE

Q_0	Q_1	Q_2	Q_3	F
0	0	0	0	0
0	0	0	1	0
0	0	1	0	1
0	0	1	1	0
0	1	0	0	1
0	1	0	1	1
0	1	1	0	1
0	1	1	1	0
1	0	0	0	0
1	0	0	1	1
1	0	1	0	1
1	0	1	1	1
1	1	0	0	0
1	1	0	1	1
1	1	1	0	0
1	1	1	1	0

KARNAUGH MAPS



LOGIC CIRCUIT



first drawn up for the function, shown on page 101. This table shows all of the eight possible combinations of ones and zeros the three variables may have. And it also shows the output, F, that results from each combination as determined from the Boolean expression.

Next, a Karnaugh map containing eight squares, or cells, is made for the function. This can be made by working from the function itself or, which may be easier, by working from the truth table. Either the truth table or the map can be used to determine how to connect the three variables to the multiplexer. Generally, it's easier to use the map when the function contains more than three variables. In either case, first choose two of the three variables—let's say X and Y—to feed the two select terminals. The remaining variable, Z, or its complement, $\overline{Z}$, will be connected to the input terminals, I_0, I_1, I_2, and I_3.

Indicates connections

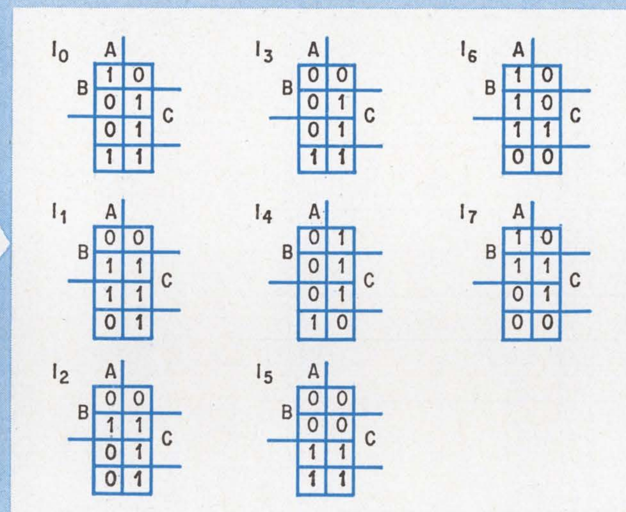
The truth table shows that when X and Y are 0, the output, F, is the complement of Z, and F is 1 when Z is 0, and 0 when Z is 1. This means that $\overline{Z}$

TRUE COMBINATIONS

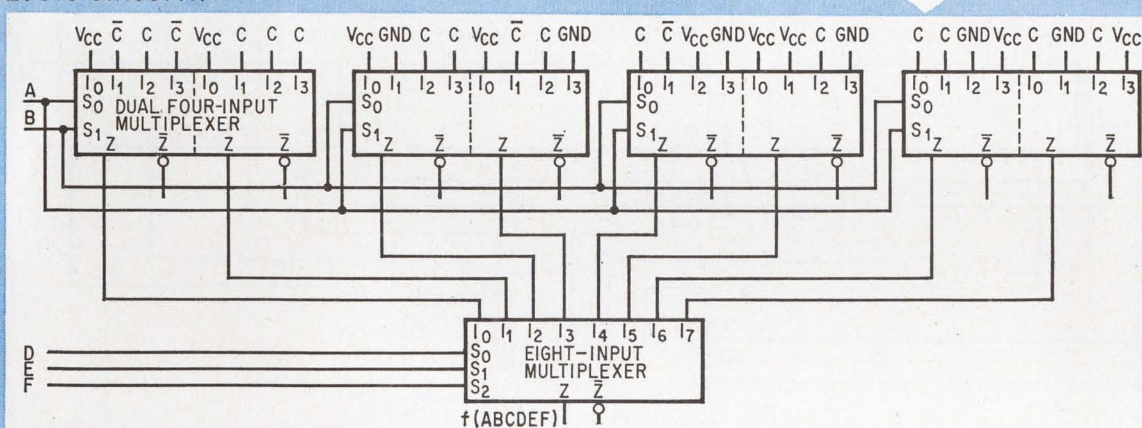
ABC	INPUT	DEF
000	I_0	000
001		000
011		000
100		000
110		000
000	I_1	100
001		100
011		100
101		100
111		100
000	I_2	010
001		010
011		010
111		010
000	I_3	110
001		110
011		110
100		110
001	I_4	001
010		001
011		001
100		001
000	I_5	101
100		101
001		101
101		101
011		101
001	I_6	011
101		011
110		011
111		011
100	I_7	111
001		111
011		111
111		111

Six pack. A function of six variables must be divided into two parts, ABC and DEF, resulting in two levels of logic implementation. The table of true combinations, left, lists the conditions when an output must occur. The table is divided into the eight possible binary combinations of D, E, and F. Input signals to the first level logic are found using Karnaugh maps for variables A, B, and C, below. The output from each first-level multiplexer feeds an input line of the second-level multiplexer implementing the D, E, and F combinations.

KARNAUGH MAPS FOR FIRST LEVEL



LOGIC CIRCUITRY



must be connected to I_0. When X is 0 and Y is 1 —select code 01—the multiplexer's internal gating is such that input I_1 is connected to the output. In this instance the truth table indicates that the output, F, will be 1 only when Z is 1. Hence, the variable Z itself must be connected to the input I_1. If this procedure is followed for the remaining two possible combinations of X and Y, it's found that Z should be connected to I_2 for input select code 10, and $\overline{Z}$ to I_3 for input select code 11.

If the Karnaugh map is used to figure out what to connect to the input terminals, an intermediate step is needed. The map's eight cells must first be divided into four, two-cell areas—each containing a cell for Z and one for its complement $\overline{Z}$. Each area is allotted to one of the four, input terminals, as shown at the top of page 101.

Each area will contain any of the four possible combinations of 1's and 0's—00, 10, 01, or 11. But the way the binary digits are located determines the signal that must be obtained at the multiplexer output and, hence, the signal to be applied to the corresponding input terminal.

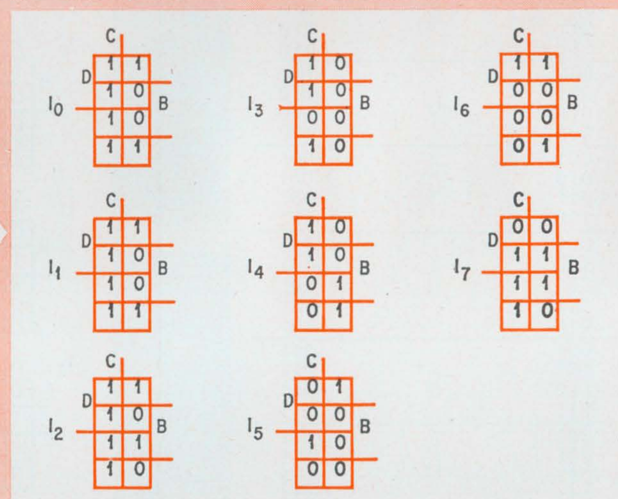
Thus, if an area has two 1's, the output must

Different packaging. Logic implementation can be simplified if the variables are grouped more carefully, as is done for the same six-variable function, f(ABCDEF), shown on the preceding page. One dual, four-input multiplexer is eliminated if the variables are grouped by CDB and EFA. This is because second-level terms I_0 and I_1 turn out to be identical, and I_7 is the complement of I_6.

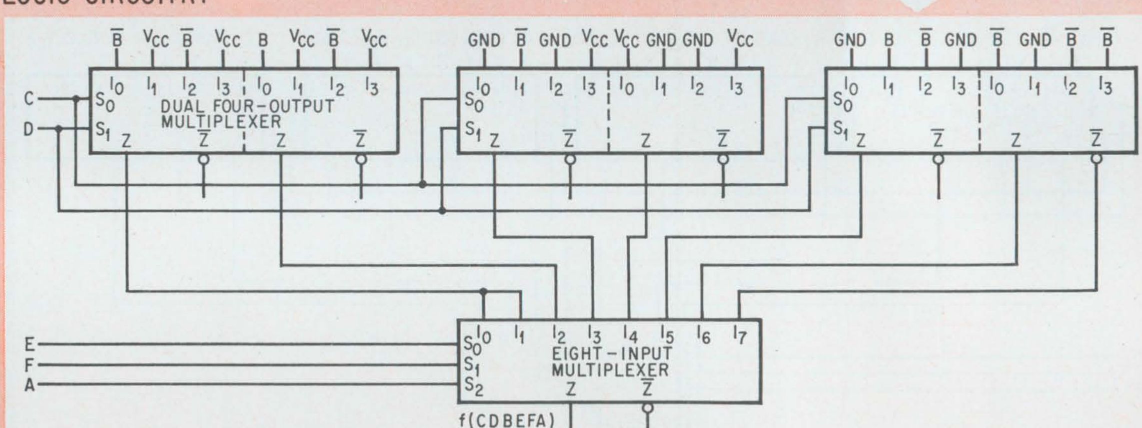
TRUE COMBINATIONS

f(CDB)	INPUT	f(EFA)
000	I_0	000
100		000
010		000
101		000
110		000
111		000
000	I_1	100
100		100
010		100
101		100
110		100
111		100
100	I_2	010
010		010
110		010
001		010
101		010
111		010
100	I_3	110
110		110
111		110
000	I_4	001
110		001
001		001
111		001
010	I_5	101
101		101
000	I_6	011
010		011
110		011
100	I_7	111
001		111
101		111
011		111
111		111

KARNAUGH MAPS FOR FIRST LEVEL



LOGIC CIRCUITRY



always be 1. It is sufficient to apply a constant voltage, V_{CC}, equal to the voltage value of 1, to the corresponding input.

On the other hand, if an area has two 0's, the output will always be 0, and the constant voltage level for 0, or ground, must be applied to the corresponding input.

A combination of 1 and 0 in an area indicates that the output signal will change. But how it will change depends on whether the 1 is in the Z or in the complementary portion, $\overline{Z}$, of the Karnaugh map. If the 1 lies within the four cells assigned to Z on the map, then the output will vary with Z, and Z itself must be applied to the corresponding input terminal. If the 1 lies within the four cells assigned to $\overline{Z}$, then $\overline{Z}$ must be applied to the corresponding input.

Steps to take

It turns out that for this example only the values of Z and $\overline{Z}$ must be supplied to the input terminals, as shown in the schematic of one-half of the dual, four-input multiplexer on page 101. It's possible to summarize the procedure to be followed in determining the connections to be made to the multiplexer in a series of steps:

- Draw a truth table for the three variables. Determine the values of the third variable—Z, and $\overline{Z}$, or the constant condition of 0 or 1—that are to be applied to the input lines.
- Construct a Karnaugh map.
- Allot areas of the map to inputs I_0, I_1, I_2, and I_3.
- With two of the variables applied to the select lines of the multiplexer, determine the values of the third variable—Z, $\overline{Z}$, 0 or 1—that are to be applied to the input lines from the location of 1's and 0's in the alloted areas.

To get some idea of the advantages of using the universal logic circuit, compare its simplicity with what is required to implement a three-variable function using the minimum possible number of discrete standard NAND gates, shown on page 101. The logic was designed with the following typical constraints: maximum inputs per gate is three, and any gate may drive three other gates.

Five, two-input and two, three-input gates, available in a minimum of two packages, are needed. By contrast, only half of the dual four-input multiplexer is needed to generate the same function. Moreover, the universal logic circuit not only carries out the function faster (25 nanoseconds compared with 43 nsec), but also requires less power, fewer connections, and provides true and complementary outputs. And in addition, the remaining portion of the multiplexer is available to generate another logic function.

The approach to implementing a universal logic circuit for three variables can be extended to four variables with the eight-input multiplexer. Again, the best way to proceed is by working out an example.

Suppose the truth table for the function to be implemented is as shown on page 102. The function simplifies to

$$F = Q_0\overline{Q_2}Q_3 + Q_0\overline{Q_1}Q_3 + \overline{Q_1}Q_2\overline{Q_3} + \overline{Q_0}Q_1\overline{Q_3} + \overline{Q_0}Q_1\overline{Q_2}$$

As before, a Karnaugh map is made. Then, an area on the map is alloted to each of the eight input terminals of the multiplexer. The required input connections are found as before by examining the cells in the map and seeing whether they contain the combinations 00, 01, 10, or 11. Thus, referring to the figure the input connections are

$I_0 =$ ground	$I_4 = \overline{Q_3}$
$I_1 = Q_3$	$I_5 = V_{CC}$
$I_2 = V_{CC}$	$I_6 = \overline{Q_3}$
$I_3 = Q_3$	$I_7 =$ ground

When five or more variables must be handled, more than one level of universal logic circuits are needed. That is, one set of logic circuits feeds another. For example, a general six-variable universal logic implementation requires eight four-input universal elements—contained in four packages—in the first level and a single eight-input multiplexer circuit in the second.

When a particular function of six variables f(ABCDEF) must be generated, it is first divided into two parts—ABC and DEF. This simplifies the functional implementation. Instead of a six variable problem it is now two three-variable problems, and is solved as follows:

- Factor out each combination of D, E, and F and obtain the function of the other three variables, f(ABC), associated with each combination.
- Collect all terms of f(ABC) corresponding to each unique input combination of D, E, and F.
- Implement each function of ABC as a function of three variables as described earlier. This yields first level outputs.
- Feed the first level outputs into an eight-input universal logic circuit that is controlled by the combinations of D, E, and F, which are applied to the select lines.

The steps involved in implementing a six-variable function are shown on page 103. Instead of expressing it in Boolean form, the function is presented in a table of its true combinations. (This table shows only the combinations of variables that cause an output; it does not show all the possible combinations that a complete truth table does.)

Make the map

From the information in this table, Karnaugh maps are made for the three variables A, B, and C. This is done by first dividing the table into the eight possible 1 and 0 combinations of D, E, and F. The variables A, B, and C feed each of these combinations. So the next step is to make a three-variable map for A, B, and C. As before, A and B are arbitrarily applied to the select terminals, C, $\overline{C}$, O, or 1 to the input terminals of the multiplexer.

Four dual four-input multiplexers make up the first logic level. The output of each feeds an input terminal, $I_0, I_1 \ldots I_7$, of the second-level universal logic circuit consisting of a single, eight-input multiplexer.

It's possible to simplify the implementation by carefully selecting the variables to be included in the first-level functions. In general, select variables for first-level functions that are either identical or the inversion of one another; they reduce to the fewest variables.

Thus, the function f(ABCDEF) can be implemented by transforming it into a first-level function f(CDB) and a second level combination, E, F and A. This partition makes use of the helpful facts that f(CDB) is identical for second-level terms I_0 and I_1, and that the second-level term I_7 is the complement of I_6. The result, shown opposite, is that fewer packages can implement the function. ■

References

1. S.S. Yau and C.K. Tang, "Universal Logic Circuits and Their Modular Realization," Proceedings of the 1968 Spring Joint Computer Conference, p. 297.
2. C. Maley and J. Earle, "The Logic Design of Transistor Digital Computers," Prentice-Hall, 1963, pp. 300-317.

Active filters: part 13 Narrowing the choice

Selecting one of the many active filter designs available can be puzzling; five common ones are compared to help choose the best for a specific task

By Michael Hills

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Choice, not chance is the goal of the designer seeking the right active filter circuit for his specific application. Since the engineer must know how to design, for example, circuits using only one operational amplifier, or how to maintain component sensitivity levels with two op amps, the problem of selection becomes more intricate. Adding to the difficulty is the necessity of minimizing the number of components.

Five circuit choices—single-operational amplifier, negative-impedance converters, integrator and lag method, triple op amp, and the gyrator—are examined here. The techniques are compared on the basis of sensitivity to active and passive parameter variations, number and complexity of active elements, and their component values.

In nearly all, component sensitivity—the effect of a 1% change in an element's value on the filter's response—is a major problem. The filter's response is proportional to the component's sensitivity and to the network's Q. A 1% change in a component's value will cause at least a 10% change in a pole location in a network whose Q = 10. This is especially critical in a multipole filter produced by cascading several second-order circuits. For example, if a four-pole network is built with only one active device, the sensitivity will be proportional to the product of the Q's of each conjugate pole. The transfer function of a typical second-order filter can be expressed by

$$H(s) = \frac{V_{out}}{V_{in}} = \frac{K}{1 + dTs + T^2s^2} \qquad (1)$$

where d is the damping factor, and $\omega_o = 1/T$ is the cutoff frequency. The steeper the response curve, Q large, the smaller d must be. The circuit Q is related to d by $Q = 1/d$.

Since any active filter is a combination of an active device with an RC network, it's useful to review the principals of RC theory. The simplest RC circuit that produces a second-order transfer function is a two-section network. In terms of its component values, the transfer function of the low-pass circuit shown at bottom of facing page is written as

$$\frac{V_{out}}{V_{in}} = \frac{1}{1 + (C_1R_1 + C_2R_2 + C_2R_1)s + C_1R_1C_2R_2s^2} \qquad (2)$$

Setting $C_1R_1 = T_1$ and $C_2R_2 = T_2$ simplifies the form of equation 2 to

$$\frac{V_{out}}{V_{in}} = \frac{1}{1 + (T_1 + T_2 + \lambda T_1)s + T_1T_2s^2} \qquad (3)$$

where $\lambda = C_2/C_1$.

For a normalized cutoff frequency of unity, let $T_1T_2 = 1$. Equating like coefficients of the middle terms in equations 1 and 3 yields

$$\begin{aligned} d &= T_1 + T_2 + \lambda T_1 \\ &= (1 + \lambda)\, T_1 + 1/T_1 \end{aligned}$$

Since $T_1T_2 = 1$, the minimum value of d occurs when $T_1 = 1\sqrt{1+\lambda}$ and is $d_{min} = 2\sqrt{1+\lambda}$. Since λ is a positive number, the minimum value, d_{min}, would occur when $\lambda = 0$. The value would be $d_{min} = 2$.

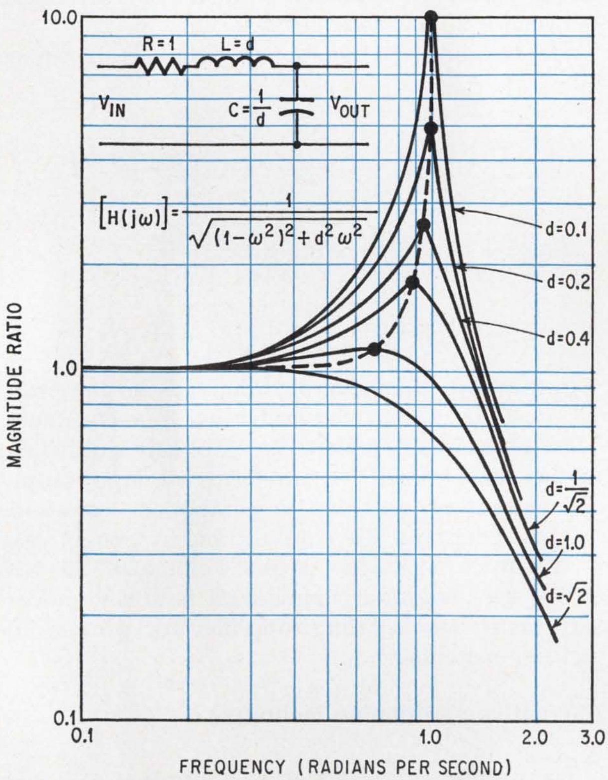
Because it's not physically possible for λ to be zero, the range of the filter response curve is limited. Consequently, the best that can be achieved is a value of $d = 2$, obtained at the expense of $\lambda = 0$; this would require very large ratios of capacitor and resistor values.

Multipole filters require two or more RC circuits separated by a unity-gain voltage amplifier for isolation. The transfer function in this case is given by

$$\frac{V_{out}}{V_{in}} = \frac{1}{1 + (T_1 + T_2)s + T_1T_2s^2} \quad (4)$$

For $T_1T_2 = 1$ then, $d = T_1 + 1/T_1$, so $d_{min} = 2$ for $T_1 = T_2 = 1$. In this case the two capacitors may have any values, provided $C_1R_1 = C_2R_2 = 1$.

To produce more complex characteristics without inductors, the active filter techniques depend on feedback circuits. The transfer function of a feedback circuit as shown at top left of page 110, is



Frequency response. Voltage transfer function for a simple RLC passive network is plotted for six damping factors. As d is made smaller the typical second-order response peaks sharply.

$$H(s) = \frac{V_{out}}{V_{in}} = \frac{AB}{1 - \beta A} \quad (5)$$

where $V_1/V_{in} = B$ is the voltage transfer function of some passive RC circuit at the input, $\beta = V_2/V_{out}$ is the feedback ratio, and A is the gain of the active element.

For instance, a low-pass Sallen and Key[1] circuit shown on page 109 can be considered in this form.

Since the output impedance of the amplifier ideally is zero, C_1 is grounded with respect to the input circuit. The input resistor, R_1, is grounded via the input voltage source. Hence the circuit shown in the table may be considered to be equivalent to that at the top right of page 110.

The input RC circuit introduces a frequency dependent loss, B, where

$$B = \frac{V_1}{V_{in}} = \frac{1}{1 + (T_1 + T_2 + \lambda T_1)s + T_1T_2s^2} \quad (6)$$

The voltage-feedback ratio, β, is given by

$$\beta = \frac{V_2}{V_{out}} = \frac{sT_1}{1 + (T_1 + T_2 + \lambda T_1)s + T_1T_2s^2} \quad (7)$$

The effective gain of the amplifier portion with feedback is

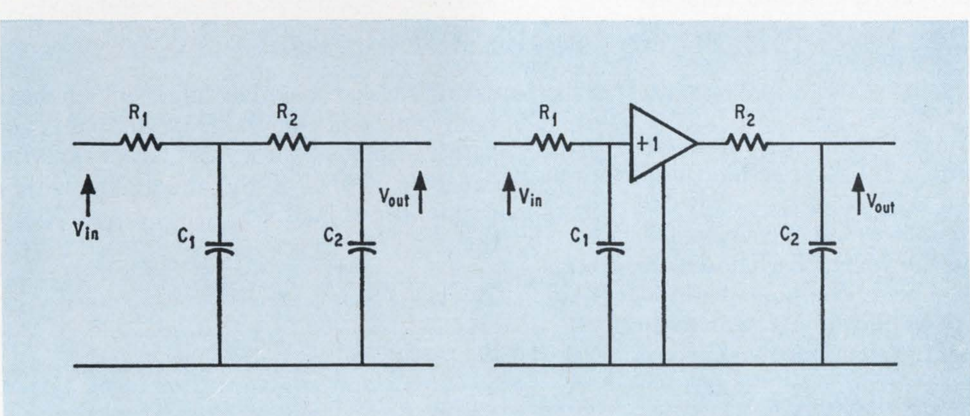
$$A' = \frac{A}{1 - \beta A}$$

Thus the effect of frequency-selective feedback is to tailor the gain of the stage to achieve the desired filter function. For low d values, βA must be close to unity. Since small changes in component values result in large changes in the filter's response, the value of βA must be set tightly.

The overall filter characteristic of the circuit is now expressed by

$$H(s) = \frac{AB}{1 - \beta A} = \frac{h}{1 + ds + s^2} = \frac{N(s)}{D(s)} \quad (8)$$

so, putting



Low-pass filter. Simple RC network at left generates a second-order frequency response but requires a large resistor and capacitor ratio to achieve a minimum sensitivity. By adding a unity-gain voltage amplifier the ratio problem is circumvented.

$$B = 1/D(s) \quad \text{and}\ \beta = sT_1/D(s) \tag{9}$$

then

$$\frac{A}{D(s) - AsT_1} = \frac{h}{1 + ds + s^2} \tag{10}$$

Because the numerator does not effect the pole locations, variations of A in the numerator of equation 10 will not effect the overall response as much as in the denominator. Therefore, the designer must find a technique for partitioning the denominator on the left-hand side of equation 10 to find the smallest d value. This can be achieved with the Horowitz[2] technique of negative-impedance converter synthesis.

For the second-order case, Horowitz shows that the optimum partitioning is given by, $1 + ds + s^2 = D(s) - b_o s = (1 + s)^2 - b_o s;\ b_o = (2 - d)$.

Hence, the optimum Sallen and Key circuit is obtained for $D(s) = (s + 1)^2$. For the RC circuit under consideration, this may be achieved only for $T_1 = T_2 = 1$ and $\lambda = 0$; $A = (2 - d) = h$.

The minimum d value requires an infinite capacitor and resistor ratio. For a value of d other than minimum, tables are handy. Such a guide appears on page 109.

To observe the effect of a varying component parameter the designer should write the transfer function for the optimum circuit in terms of the circuit elements. Thus

$$\frac{V_{out}}{V_{in}} = \frac{1}{1 + (T_1 + T_2 - AT_1)s + T_1T_2s^2}$$

Hence

$$d = \frac{T_1 + T_2 + AT_1}{\sqrt{T_1T_2}} = (1 - A)\sqrt{\frac{T_1}{T_2}} + \sqrt{\frac{T_2}{T_1}} \tag{11}$$

Since A is the gain, it is an important factor in producing an accurate filter response. Any deviation in component value will have lesser influence because they are ratios. If $A > 1 + T_2/T_1$, then an unstable system will be produced.

Economy is goal

If the filter is constructed with integrated circuits, or in thin-film form, a large, open-loop gain amplifier can be obtained economically—but it will be difficult to obtain accurate R and C values. The component values may, however, be chosen to minimize the effect of passive component variations, but at the expense of the filter's sensitivity to the variations of the active components. The circuit with the least passive component variation occurs for a unity-gain amplifier, and the corresponding sensitivities are given in the table.

One active-filter scheme that relies on a positive feedback amplifier is the negative-impedance converter. Any impedance placed across the input terminals will appear as the negative of that impedance when observed at the output. The circuit is shown at bottom, page 110, where A is the gain of an ideal voltage amplifier. If the input voltage to the amplifier is E_1, the output is AE_1, so the current I_1 must be $(E_1 - AE_1)Z$. The input impedance thus is $E_1/I_1 = Z/(1\text{-}A)$; hence, for $A>1$, a negative impedance will occur. For $A = 2$ the input impedance is $-Z$.

The ideal negative-impedance converter in the table is redrawn at bottom right, page 110; this circuit exhibits the required transfer characteristics between terminals 1-2 and 3-4.

The transfer function of this circuit is expressed by

$$\frac{V_{out}}{V_{in}} = \frac{(A-1)}{1+S[T_1+T_2+(1-A)C_2R_1]s+s^2T_1T_2} \tag{12}$$

$$\text{Hence } d = \frac{T_1 + T_2 + (1 - A)C_2R_1}{\sqrt{T_1T_2}}$$

$$= [1 + \lambda(1 - A)]\sqrt{\frac{T_1}{T_2}} + \sqrt{\frac{T_2}{T_1}}$$

In this case, the value of d depends on the product AC_2R_1 as well as the individual time-constants. Thus this circuit, which is completely equivalent to the conventional NIC in terms of input-output behavior, is as sensitive to component variations as the Sallen and Key circuit, and is not as easy to construct. Since the output voltage of the NIC circuit goes across a capacitor, it is always necessary to use an isolating amplifier for proper impedance matching.

Alternative partitioning technique

The partitioning of equation 8 into that of 9 may also be done with an inverting amplifier as follows:

$$\text{Let}\quad A = \frac{-1}{s(s + d)},\quad B = 1,\quad \beta = 1 \tag{13}$$

then

$$\frac{AB}{1 - \beta A} = \frac{-1}{1 + ds + s^2}$$

This leads to a class of active filters which have an integrator and a lag in the forward path, and 100% negative feedback, since β is chosen as unity.

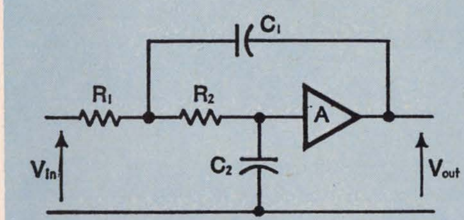
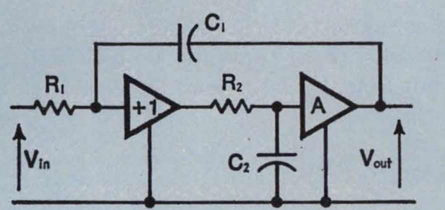
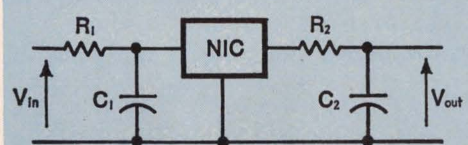
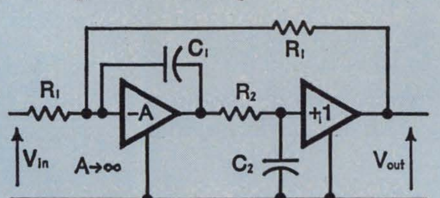
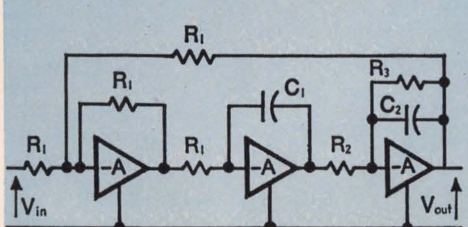
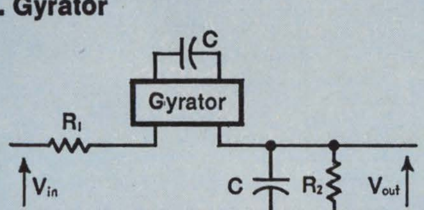
The transfer function of the integrator with a finite-gain amplifier of A is

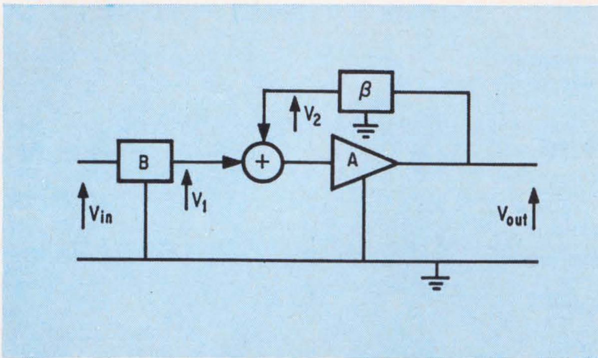
$$V_2 = \frac{-1}{T_1[(1 + 1/A)s + 2/AT_1]} \tag{14}$$

and the RC circuit is

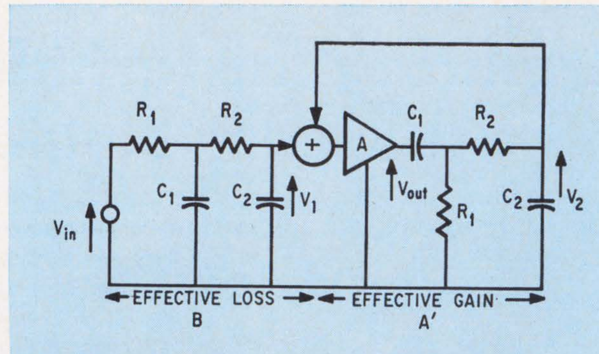
$$\frac{V_2}{V_o} = \frac{1}{1 + T_2s}$$

Comparing the techniques

Technique	Design procedure	S_R	S_C	S_A	S_f	S_β	Remarks
1. Sallen and Key (single amplifier) 	a) For minimum active sensitivity $\lambda = C_2/C_1$ as small as possible. $T_1 = 1/\sqrt{1+\lambda}$, $A = 2(1+\lambda) - d\sqrt{1+\lambda}$	-1	-1	-2	4	1	Low output impedance, $R_2/R_1 = 1 + 1/\lambda$
	b) For minimum passive sensitivity $\lambda = \frac{1}{4}d^2$, $A = 1$, $T_1 = 2/d$	0	$-\frac{1}{2}d$	$-2/d$	$2/d$	0	Low output impedance, $R_2/R_1 = 1$ but very small λ needed
	c) For minimum passive sensitivity but $\lambda_{min} > \frac{1}{4}d^2$ $A = 1 + \lambda - \frac{1}{4}d$, $T_1 = 2/d$	0	$\frac{1}{2}\lambda d$	$2/d$	$2/d$	$2\lambda/d$	Low output impedance, $R_2/R_1 = 1$
2. Sallen and Key (double amplifier) 	a) For minimum active sensitivity $A = 2 - d$, $T_1 = 1$	-1	-1	-2	6	1	Low output impedance, $R_2/R_1 = C_1/C_2$ arbitrary value
	b) For minimum passive sensitivity $A = 1 - \frac{1}{4}d^2$, $T_1 = 2/d$	0	0	$-2/d$	$4/d$	$\frac{1}{2}d$	Low output impedance, the positive gain is now less than unity, so this requires potentiometer after the + 1 amplifier
3. Negative-impedance converter 	Minimum active sensitivity (Horowitz decomposition) $K = 1$, $\lambda = 2 - d$, $T_1 = 1$	-1	$+1$	-2			Output across capacitor, so isolating amplifier necessary. S_A refers here to converter ratio error.
4. Integrator and lag 	$T_1 = d$	$\frac{1}{2}d$	$\frac{1}{2}d$		$2/d$		Low output impedance, $R_2/R_1 = \frac{1}{4}d^2\, C_1/C_2$ so large ratios needed. Sensitivities similar to 1(b) and 2(b).
5. Integrator loop 	$T_1 = 1$, $R_3/R_2 = d$	d	0		2		S_R refers to coefficient of $(R_3 - R_2)$. Low output impedance, bandstop and bandpass outputs available simultaneously. Active and passive sensitivities simultaneously low.
6. Gyrator 	$R_2 = (d/2 - d)R_1$, $1/C = \sqrt{\frac{1}{2}d}\,R_2$, $L = R_1/\sqrt{\frac{1}{2}d}$	$\delta d = \frac{1}{2}d\,(R_1 - R_2)$					Best performance since first-order behavior is governed only by R_1 and R_2. May be used in cascaded circuits but greatest circuit complexity.



General network. Feedback circuit represents a typical model for an active filter. Network B is coupled to an operational amplifier of gain A that contains a feedback loop of gain β.



Partitioning. The Sallen and Key active filter can be divided into two basic parts—effective loss and gain. The input network introduces a frequency-dependent loss, and the feedback proportions the gain.

For large A, the $1 + 1/A$ term in equation 14 may be taken as unity; hence the overall transfer function becomes

$$\frac{V_{out}}{V_{in}} = \frac{-1}{1 + (T_1 + 2T/A_g)s +_2 T_1T^2s} \qquad (15)$$

Hence for this system

$$d = \frac{T_1 + 2T_2/A}{\sqrt{T_1\,T_2}}$$

Since d is an algebraic sum it is not possible to make its value too small, unless a large A is selected. For large A and $T_1T_2 = 1$ the designer may assume $d = T_1$ for a first approximation. The actual d will be

$$d' = d + \frac{2}{Ad} \qquad (16)$$

Because A is a large value the circuit cannot become unstable since the pole positions remain in the left-hand side of the s-plane. Thus this circuit seems less sensitive to component changes in the active and passive parameters, but when these sensitivities were computed it was found[5] that they were virtually the same as for the unity-gain Sallen and Key circuit, but that the latter circuit uses one less resistor.

Integrator-loop filters

Another active filter replaces the passive RC lag-circuit by its active equivalent; this effectively removes the need for a large ratio of component values. Another sign-inverting amplifier is necessary, as shown in the table. The transfer function of the circuit is

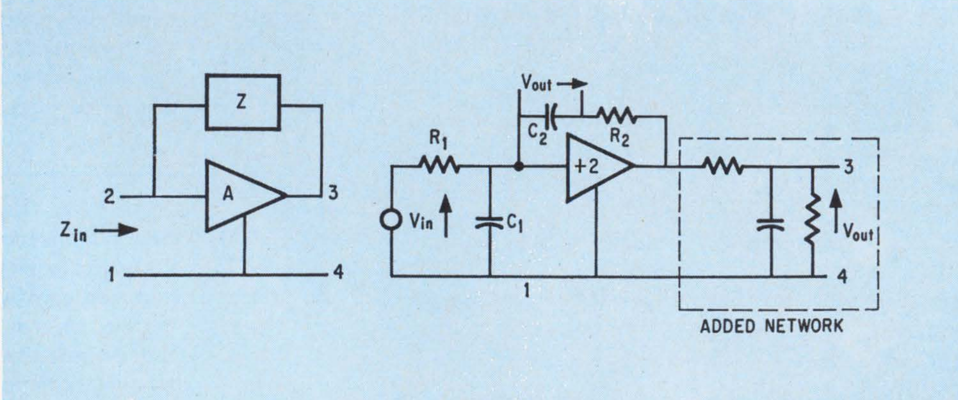
$$\frac{V_{out}}{V_{in}} =$$

$$\frac{1}{1+[(R_3/R_2+1/A)\,T_1+/AT_2\,]\,s+s^2T_1T_2} \qquad (17)$$

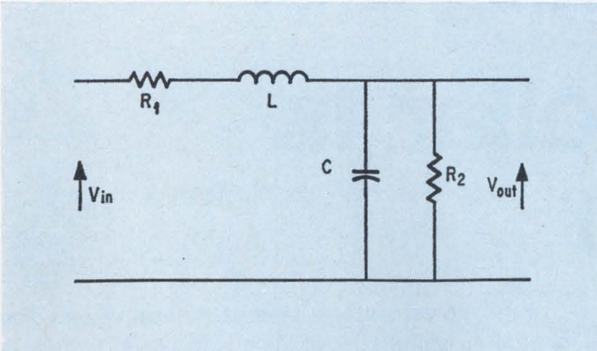
Hence for a normalized cutoff frequency $T_1 = T_2 = 1$ and $R_3/R_2 = d$, and A, large, then

$$d' = d + 2/A \qquad (18)$$

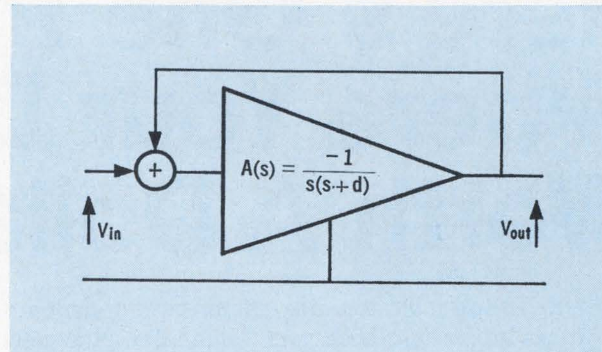
and the error term is reduced by a factor of $1/d$ from the two-amplifier version. This circuit has



NIC. Ideal feedback amplifier, left, is used in the negative-impedance converter, right, to produce a desired transfer function.



Low pass. RLC filter is insensitive to 1% changes in L. However, the main drawback to an active filter equivalent is that it requires many components.



Special class. By using an operational amplifier whose gain is $-1/s(s+d)$, the designer obtains a circuit that has an integrator and a lag in the forward path.

low passive and active sensitivities simultaneously. It's possible to fabricate a two-amplifier version, but since additional RC's are needed more component-sensitivity results.[7]

The gyrator

The conventional application for a gyrator is to employ a capacitor across one port to produce the terminal properties of an inductor across the other port.[8, 9] The engineer starts designing an active filter with a gyrator by drawing the passive RLC circuit that gives him the desired response. He then replaces the inductors by gyrator-capacitor combinations. Any change in the parameters of the gyrator produces a change in the equivalent inductor value. Thus, the circuit's sensitivity may be examined by finding the component change of the original passive circuit to an inductance value change.

One such RLC network example is the low-pass filter shown directly above. For this second-order circuit the voltage transfer function is given by

$$\frac{V_{out}}{V_{in}} = \frac{R_2}{R_1 + R_2} \cdot \frac{1}{1+\left[\dfrac{L+CR_1R_2}{R_1+R_2}\right]s+LC\left[\dfrac{R_2}{R_1+R_2}\right]s^2} \qquad (19)$$

where $LC\left[\dfrac{R_2}{R_1+R_2}\right] = T^2$

and

$$d = \frac{1}{\sqrt{R_1+R_2}}\left[\sqrt{\frac{L}{CR_2}} + \sqrt{\frac{CR_1}{C}}\right] \qquad (20)$$

Now if L changes by a small amount, δL, then T is only slightly affected and the change in d is expressed by

$$d = \frac{1}{\sqrt{R_1+R_2}}\left(\sqrt{\frac{L}{CR_2}} - \sqrt{\frac{CR_1}{L}}\right) \qquad (21)$$

This term may be made zero by a suitable choice of component values. Use the table to help select these values for a known d value.

The gyrator filter has the best sensitivity behavior of all those considered here, but it's only slightly better than the integrator loop for the second-order case. The advantages of this filter are even greater for higher-order networks because inductors are directly replaced by gyrators and not by cascading second-order RC sections. The main drawback is that it requires the largest number of passive components in simulating the gyrators, especially if the inductors in the equivalent LCR filter are ungrounded, as is usual for low-pass filters.

Sensitivity values given in the table are coded as follows: S_R for resistors, S_C for capacitors, S_A for the Sallen and Key amplifier, $S\int$ for the integrator-lag amplifier, and S_β for the feedback network. The values that are given in each case are based on the design procedure. ■

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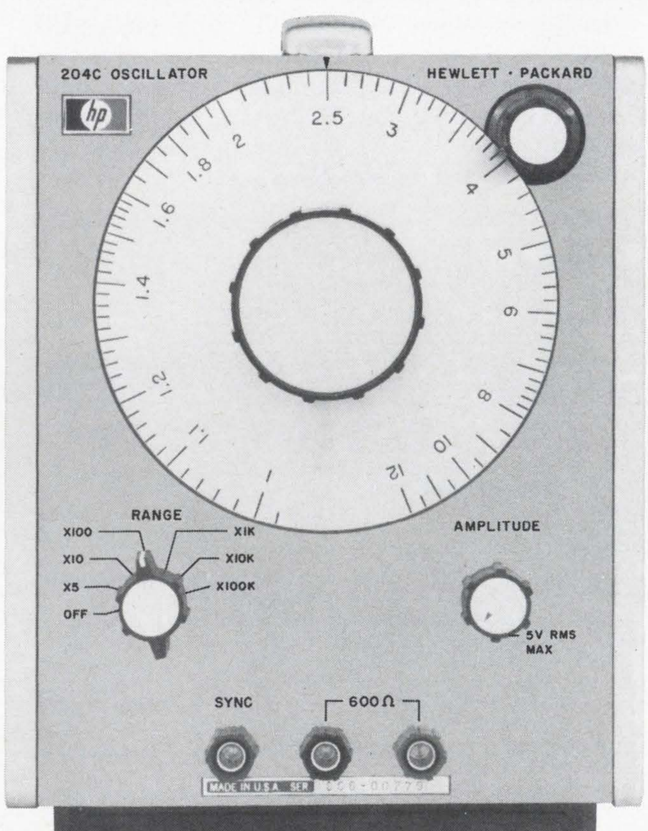
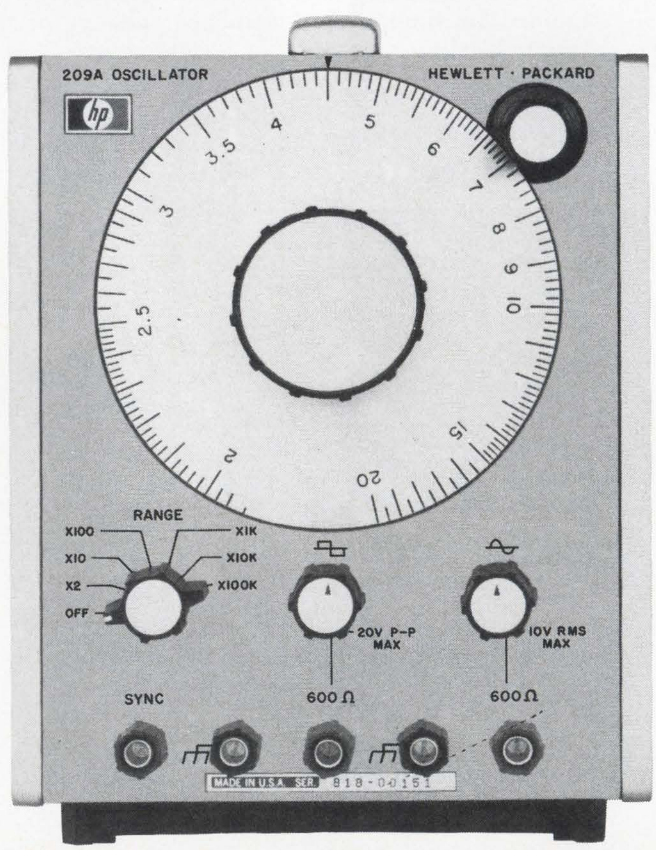




Growing silicon on spinel adds up to high isolation, fast switching in IC's

Spinel, a silicon-compatible crystal structure, has a distinct edge over both bulk silicon and sapphire as a substrate material in MOS devices for high-performance applications

By Heinrich Schlötterer
Siemens AG, Munich

True isolation—that is, electrical isolation—is wellnigh impossible in a conventional monolithic integrated circuit. Because of the silicon substrate's conductivity, there is always some interaction of the circuit elements on the chip, causing parasitic capacitive and resistive coupling.

In applications where high frequency response, fast switching, or low leakage current is essential, air-isolation IC's—using a highly insulating substrate—can do the trick. And spinel is one of the most promising materials for the substrate.

These IC's can be made by depositing a thin film of single-crystal silicon on the substrate, etching the film to make islands of silicon, and then using conventional photolithographic techniques to diffuse an active or passive component in each island.

The silicon-on-spinel technique requires careful sawing and cutting of the spinel, and it's more expensive than usual IC fabrication processes. But, in critical applications, its advantages are well worth the expense. In fact, Siemens AG is experimenting with the technique to make metal oxide semiconductor IC's—including complementary MOS—with one-third the switching time of the conventional bulk devices. Moreover, these newer devices have negligible leakage current. In discrete silicon-on-spinel transistors, switching times of less than 1 nanosecond have been realized.

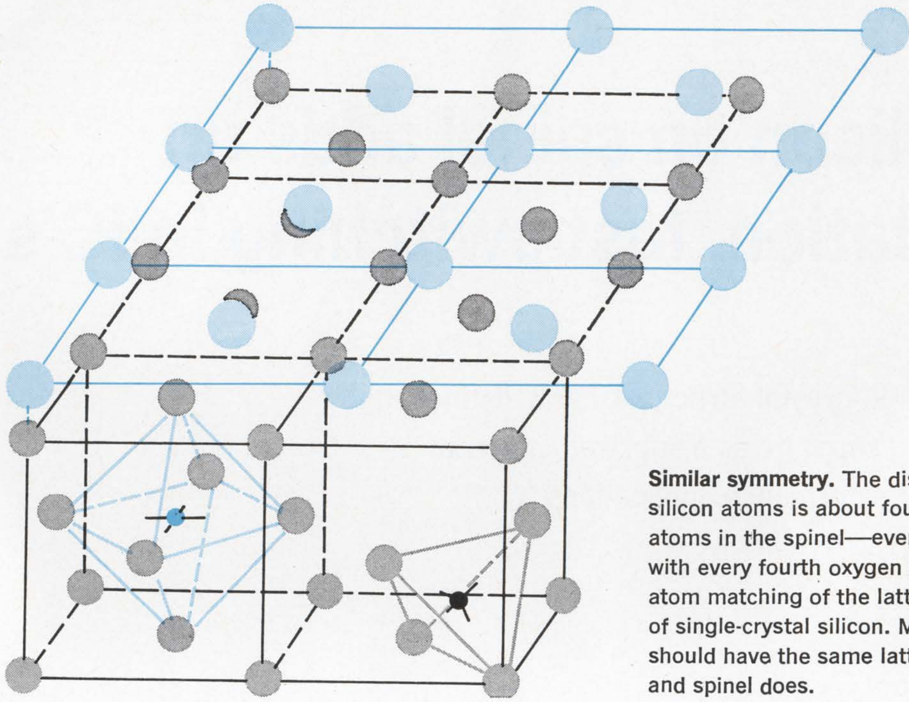
Spinel is the generic name for a family of crystalline materials in which oxygen ions form a close-packed cubic lattice structure with tetrahedral and octahedral interstices, as on next page. The interstices can hold metallic atoms. The general formula for spinel is AB_2O_4, where A is the metal in the tetrahedral interstices and B is the metal in the octahedral ones.

Silicon-on-spinel IC's are only one of many possible film-on-insulator devices. Other semiconductors, such as germanium, gallium arsenide, and cadmium sulphide, could be used as thin-film material. Siemens started with silicon as the thin-film semiconductor material because it's so well understood and easy to use. The other materials, however, are promising and could open the way to new thin-film devices and IC's. To qualify as insulating substrate, a substance should have the same crystal symmetry as the thin film, and should be resistant to high process temperatures—during deposition of silicon films the substrate is exposed to reactive gases at 1,200°C. Quartz, calcium fluorite, beryllium oxide, and silicon carbide have been tried as substrates for silicon at some companies, but only spinel and sapphire have so far been used successfully.

Siemens favors spinel over sapphire because it offers significant advantages—among which, its crystal structure is more compatible with that of silicon, and it causes less unwanted doping of the silicon. Siemens uses the magnesium-aluminum spinel: magnesium is the A metal; aluminum is the B metal.

Significant symmetry

The crystal-lattice diagram on next page shows the big advantage of spinel as a substrate material. Both spinel and silicon have cubic symmetry; thus, regardless of the crystal orientation of the spinel substrate, an epitaxial, single-crystal film of silicon can be grown on it. Sapphire, on the other hand, has rhombohedral symmetry, and since silicon can be grown only on certain lattice planes, surface preparation of sapphire is considerably more critical



Similar symmetry. The distance between two adjacent silicon atoms is about four-thirds that of two oxygen atoms in the spinel—every third silicon atom coincides with every fourth oxygen atom. Fortunately, atom-for-atom matching of the lattice is not necessary for growth of single-crystal silicon. More important, the substrate should have the same lattice symmetry as silicon—and spinel does.

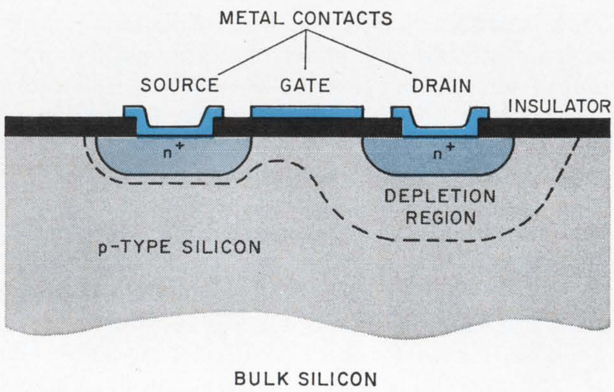
and complicated.

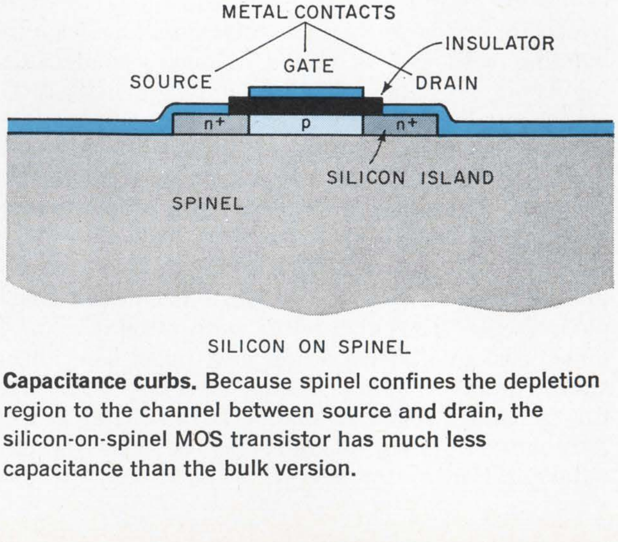
Spinel's symmetry advantage is important, since single-crystal films of silicon are essential in any film-on-insulator device. Polycrystalline films are easier to deposit. But the boundaries between adjacent crystals seriously impede the flow of charge carriers through the polycrystalline film—carrier mobility is reduced to unacceptable levels. The mobility of an n-type single-crystal thin film of silicon in the 1-0-0 orientation can be as high as 600 centimeters^2/volt-second, whereas in polycrystalline films, mobility is only 10 cm^2/volt-sec.

Another problem with polycrystalline devices is stability: parameters tend to vary with time and temperature more than in single-crystal devices.

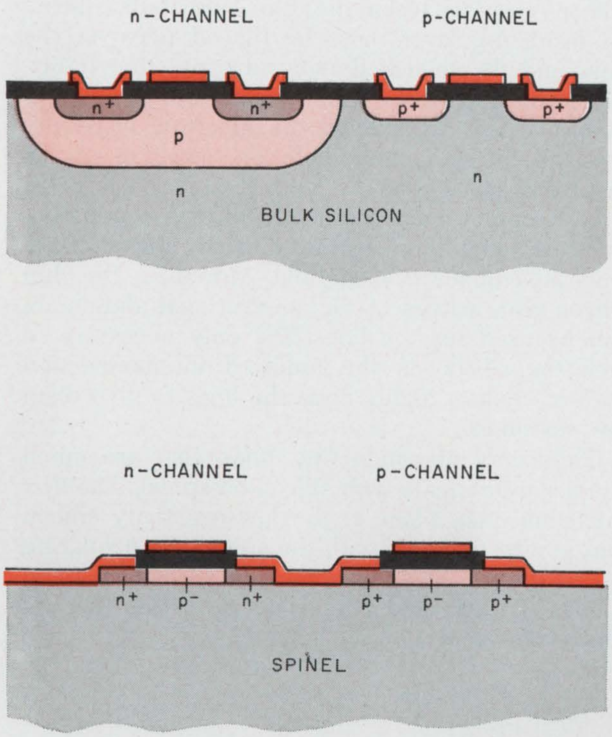
Although they're vastly superior to polycrystalline silicon, single-crystal silicon thin films don't do so well against bulk materials. Heteroepitaxial growth (growth on a substrate composed of a different material) causes crystal defects in the single-crystal silicon film. Also, the silicon film shows much greater expansion with temperature than the substrate. Since the film is deposited at high temperature, it is strained under high compressive stress at room temperature. But the thermal mismatch is much smaller with spinel than with sapphire.

The combination of crystal defects and the piezoelectric effect of the compressive stress keeps the mobility of single-crystal, thin-film silicon lower than the maximum attainable in bulk silicon (about 1,500 cm^2/volt-sec). Fortunately, this doesn't seriously affect the characteristics of silicon-on-spinel MOS devices. Transconductance and channel mobility are just a bit lower than in bulk devices, while the big improvement in switching speed and parasitic capacitance in the thin film devices more

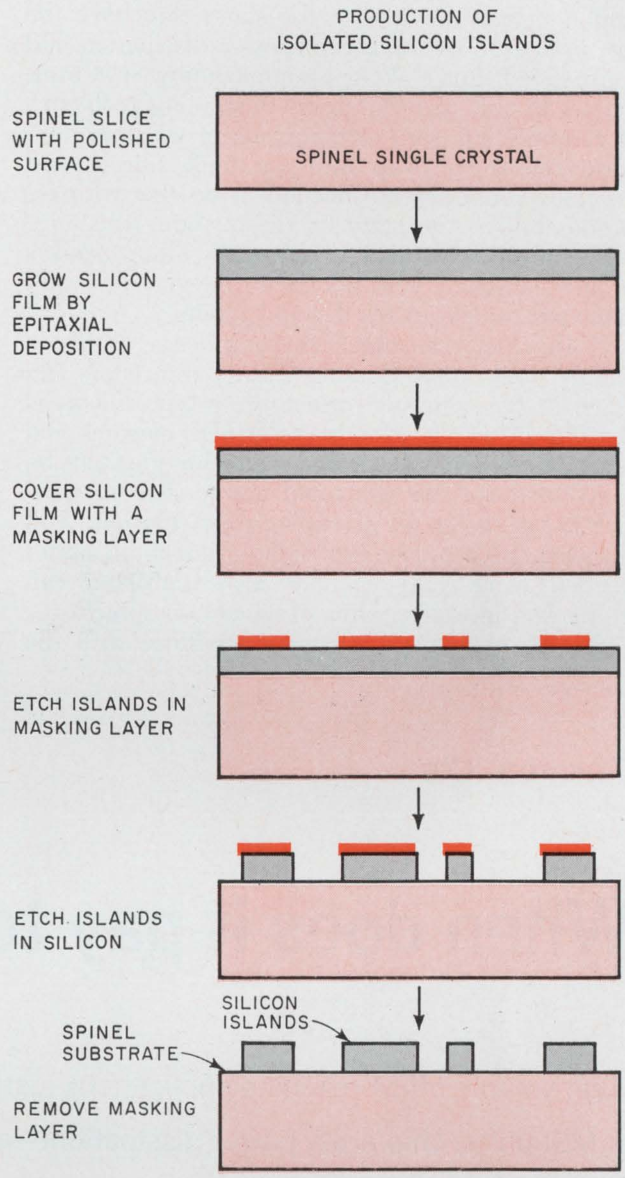




Capacitance curbs. Because spinel confines the depletion region to the channel between source and drain, the silicon-on-spinel MOS transistor has much less capacitance than the bulk version.



Complements of MOS. Formation of p-channel and n-channel transistors on the same substrate requires elaborate and critical processes in bulk-silicon IC's; in one such process, a p region must be diffused deep into the silicon to provide isolation. But in silicon-on-spinel IC's the islands provide their own isolation. In the p-channel silicon-on-spinel transistor, the thinness and high resistivity of the p region give it a high ohmic value, but when a voltage is applied it becomes highly conductive.



Isolation. Circuit elements in a silicon film on a spinel substrate are isolated from each other by etching into islands. Then, transistors, diodes, resistors, and capacitors are formed in the islands by conventional methods.

than compensates.

A potential hazard in silicon thin-film growth is called autodoping—aluminum from the substrate passes into the silicon film, where it acts as an acceptor. Fortunately, autodoping from spinel almost always is negligible, and under similar growth conditions, spinel's autodoping level is about 10 times lower than sapphire's.

Silicon isles

The silicon film must be divided into islands to achieve isolated devices. This is done by photolithographic masking and etching, as shown above right. A special etchant, which attacks silicon much faster than the photoresist or silicon dioxide, is used. The silicon islands then can be made into circuit elements by conventional masking, oxidation, and diffusion techniques.

Siemens has concentrated on MOS devices rather than bipolar units. MOS transistors made of thin-film silicon switch much faster—by a factor of three or more—than those made of bulk silicon, because drain-source capacitance is proportionally lower in the thin-film version. In the bulk MOS transistor, when a voltage is applied to the drain and gate, the space-charge region deeply penetrates the bulk material, as shown at bottom of opposite page. In the thin-film MOS transistor, however, the active region is confined to the channel between drain and source by the spinel substrate, drastically reducing parasitic capacitance.

The only path

Furthermore, leakage currents are very low in silicon-on-spinel devices because the only path between components other than intentional connections is through the spinel, which has extremely high resistance.

In active memories, complementary p-channel and n-channel devices in the same chip have the advantage of low quiescent power dissipation and high speed. But making complementary MOS transistors in bulk material poses processing problems. It requires diffusion of p regions of medium, uniform resistivity deep into the bulk silicon, and complex processes are needed to do this with reproducibility. Alternatively, the medium-resistance p region can be formed by epitaxially filling grooves in an n substrate with p silicon—but growth conditions are critical under this technique.

With silicon-on-spinel, these process problems simply don't arise. Complementary transistors can be made by using high-resistivity p-type silicon as the film. After the islands are etched, conventional photolithographic and diffusion techniques can be used to make the n-channel and p-channel transistors, as shown on preceding page, top left. And because space-consuming isolation junctions aren't needed, more complementary MOS transistors can be packed in a given area of silicon on spinel.

It's easier to deposit conduction lines with the silicon-on-spinel technique, too. With bulk silicon, an insulating layer must be placed between the lines and the semiconductor substrate. Inevitably, this leads to parasitic lead capacitance, the magnitude of which depends on the substrate resistivity and the thickness and dielectric constant of the insulating layer.

With spinel, on the other hand, the conducting lines can touch the substrate directly, and parasitic lead capacitance is negligible. Moreover, the thin silicon film, instead of the conventional aluminum, can be used for the lines. It's only necessary to etch the silicon in the required interconnection pattern, then to highly dope the lines to give them low resistance.

Crossovers of conducting lines also are much simpler to fabricate with silicon-on-spinel. The first interconnection plane is the low-resistivity silicon film in direct contact with the spinel. An insulating silicon-dioxide layer is grown on the silicon, and a metal is deposited directly on the oxide to form the crossover. ■

German IC's

When does it pay to customize IC's?

High-volume office-machine applications justify mix-and-match approach in MSI units; chip area, power dissipation—and costs—are reduced

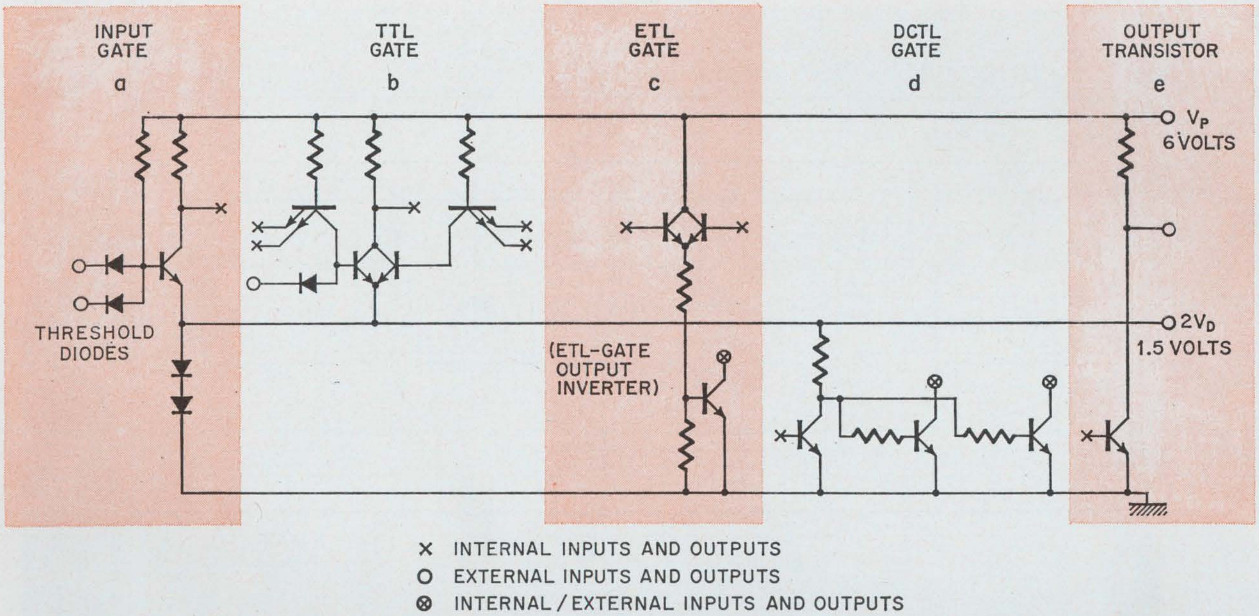
By Uwe Bertram, Hans Hoffmann, and Hans-Wilhelm Neuhaus

Philips Zentrallaboratorium GmbH, Hamburg

Off-the-shelf integrated circuits aren't necessarily the most economical answer in high-volume office-machine applications. In the long run, designers who invest a little extra time and money to customize their IC's ultimately can realize a net saving through reduction of both chip area and power dissipation.

Philips Zentrallaboratorium GmbH has designed several medium-scale integrated circuits for office equipment under the specialty policy. These IC's primarily employ diode-transistor logic, which is ideal for office machines—it's inexpensive, and although not the fastest logic form, speed is fully equal to the application.

But the cells used in the MSI circuits aren't exclusively DTL: internally almost anything goes—transistor-transistor, emitter-transistor, or direct-coupled transistor logic—as long as the input and output levels are DTL-compatible. The result: a reduction in the number of transistors, diodes, and isolation islands, and in the total value of resistors. In a 1-bit arithmetic unit, for example, these reductions effected a 30% shrinkage in chip area; in a one-out-of-10 decoder, the area reduction was even greater. At the MSI level of complexity, many of these gates don't fan out to the external pins of the package. Therefore, only external gates must be compatible with the other circuits in the system and, in this case, operate at the 6-volt supply used for the Philips DTL series.



Basic cells. Specialized design approach permits use of various logic-gate configurations inside the chip, even though external voltage and current levels conform to DTL standards. All cells, however, are made by the standard DTL process.

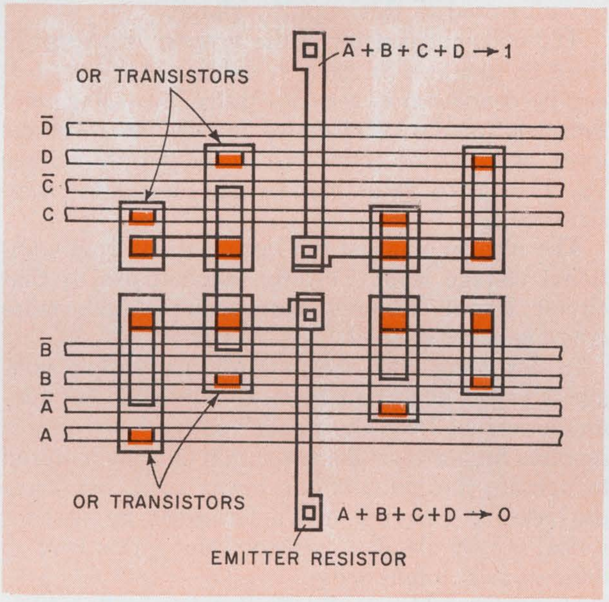
Designing internal gates for lower operating voltage will cut power dissipation, and the level of integration for a given power consumption can therefore be increased. By adding an additional internally generated voltage level, a fraction of the current into the device can be used twice.

The basic gates at the top of this page were designed for Philips MSI circuits for office machines. The input gate (a) has two common threshold voltage diodes connected to the emitters of the inverter transistors. For a circuit with many inputs, this arrangement reduces the number of shifting diodes and base resistors.

Multiple-emitters

For the internal TTL gates (b), the supply voltage (8 volts maximum) is lowered by two diode drops, but still permits use of multi-emitter transistors. Internal gates can be coupled directly, without using shifting diodes, since a lower signal-to-noise ratio is tolerable inside the chip. To allow an additional internal input, a collector-base diode is provided at the collector of the multi-emitter transistor of internal gates.

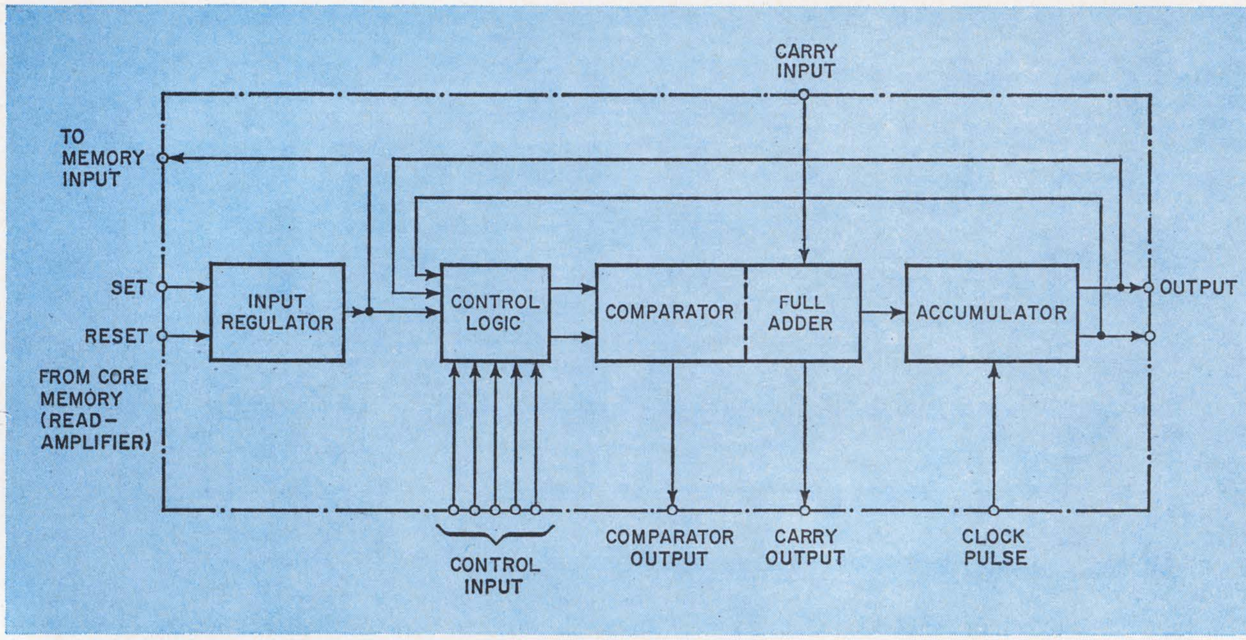
For the inverter transistors in both the input gate and the TTL gate, the voltage corresponding to a logic zero is $2V_D + V_{CE(sat)}$, the sum of the two diode voltage drops and the collector-emitter saturation voltage. Since this is not the standard DTL logic zero, the ETL gate (c) is provided for controlling output inverters. In fact, in the Philips circuits ETL cells—which have a power-speed product comparable to that of DTL—are used to perform as many logic functions as possible, particularly since all the OR transistors can be placed in a common isolation region (the resistor diffusion) to save space on the surface of the chip.



Middle of the road. ECL circuitry for decoding can be located at regular intervals under the information lines, considerably easing circuit layout.

The output level of the ETL cell is the same as the standard DTL output, but its current is too low for adequate DTL fan-out. A high fan-out can be achieved by adding a direct-coupled inverter.

This gate design (a,b) insures that a certain minimum current flows through the two threshold diodes. Only a fraction of this current is needed to maintain the threshold; the remainder can drive gates in the voltage level between ground and $2V_D$, which is approximately 1.5 volts. The DCTL cell (d)



Partitioning. By dividing the circuit functions so that each bit is completely processed on a single chip, four identical circuits, instead of several different ones, can be used to make a four-bit arithmetic unit.

is well suited to this supply voltage.

The collector resistor of the inverter transistor of the ETL gate can be used in either of two ways. It can be connected to the $2V_D$ threshold voltage and thus control the DCTL gates in the lower voltage level, or it can be connected to the supply voltage V_P. The DCTL gates can switch the output transistor (e).

The disadvantage of the introduction of an additional voltage level, $2V_D$, for internal use, is that circuit layout becomes more complicated; more crossovers are needed.

In designing with the new internal supply voltage it's also important to make sure that the minimum current from the upper voltage level always remains higher than the maximum current required to operate the gates in the lower level. But since the relative currents are determined by resistor ratios, not by absolute resistor values, this isn't as difficult as it might seem.

Using these basic cells, Philips has built—with a standard DTL process—a one-out-of-10 decoder and a one-bit arithmetic unit.

The decoder converts the binary-coded-decimal code into the decimal code. It's intended for decimal-oriented machines—a printer, for example—and for directly controlling the drive transistors for ferrite-core memories. For the latter, the first three input terminals are used for coding and the fourth is employed for the read or write pulse.

One big problem in designing a decoder is laying out a crossbar system to distribute the eight information lines to the 40 inputs of the decoder gates. Fortunately, the ETL cells provide a simple solution in the Philips decoder because the transistors can use the same isolation region. The eight information lines, divided into two groups of four lines each, shown on preceding page, control 10 ETL gates, each with four emitter-follower transistors in parallel to perform the OR function.

The special merit of this arrangement is its regularity. All the ETL-OR circuitry is located under the information lines, which are tapped by connecting to emitters directly underneath. The OR-functions are performed in the space between the two groups of information lines, and the OR signals are passed under the information lines to the inverters via the emitter resistors.

The only limitation on the size of the OR transistors is the process technology, so they can be made very small indeed. The collectors are connected to the upper supply voltage by the buried layer. The inverter of the ETL gate uses the current from the four-input double inverters to yield a large fan-out. The regularity of the cross-bar system allows an easy adaptation to any desired code.

The arithmetic unit even more clearly illustrates the advantages of the Philips tailored-design approach. For this application, in which the machine processes four bits in parallel, if the arithmetic unit were partitioned into the usual subfunctions—full adder, register, and accumulator—several distinct circuits would have to be designed, each of which could only be used once in each office machine. But by designing the MSI circuit to completely process a single bit, as shown above, the same circuit can be used four times in each machine.

This circuit has many input and internal gates, and only few outputs, so the cells shown on page 117 can be utilized to particular advantage. The accumulator flip-flop is built up from the DCTL basic cell. ■

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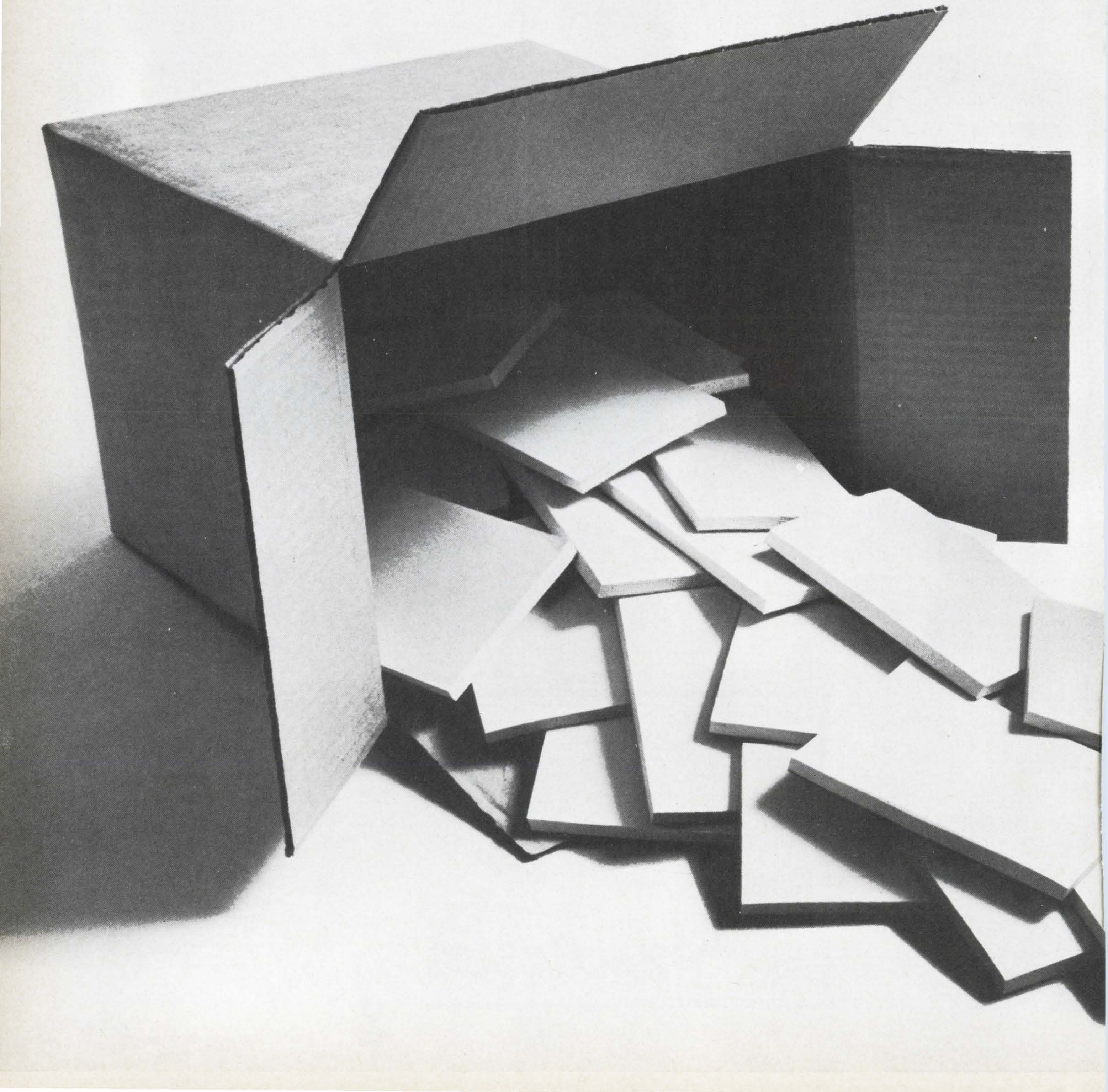

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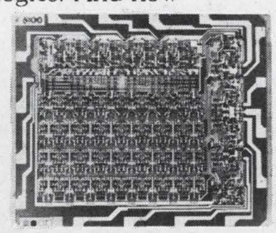

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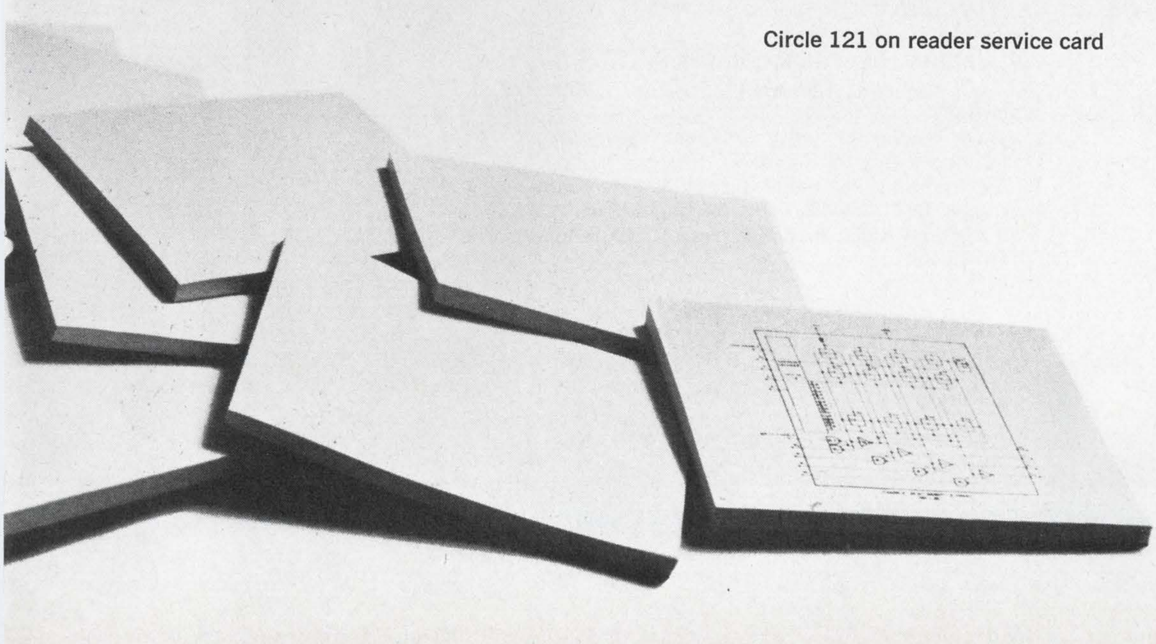

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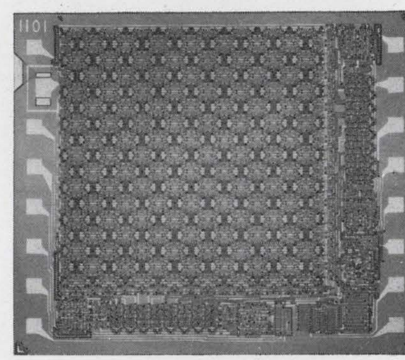

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Read cycle	1.1 μsec typ. 1.5 μsec max.	5v input pulse. 10 nsec rise and fall.1.5v reference level. Load is 1 TTL gate.
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(At $T_A = 25°C$, $V_{CC} + 5v$, $V_{DD} = -7v$, $V_D = -10v$)

Test	*Limit*	*Conditions*
Input load current	500 nA max.	$V_{in} = 0v$
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Input "low" voltage	$-10v$ to $+0.5v$	
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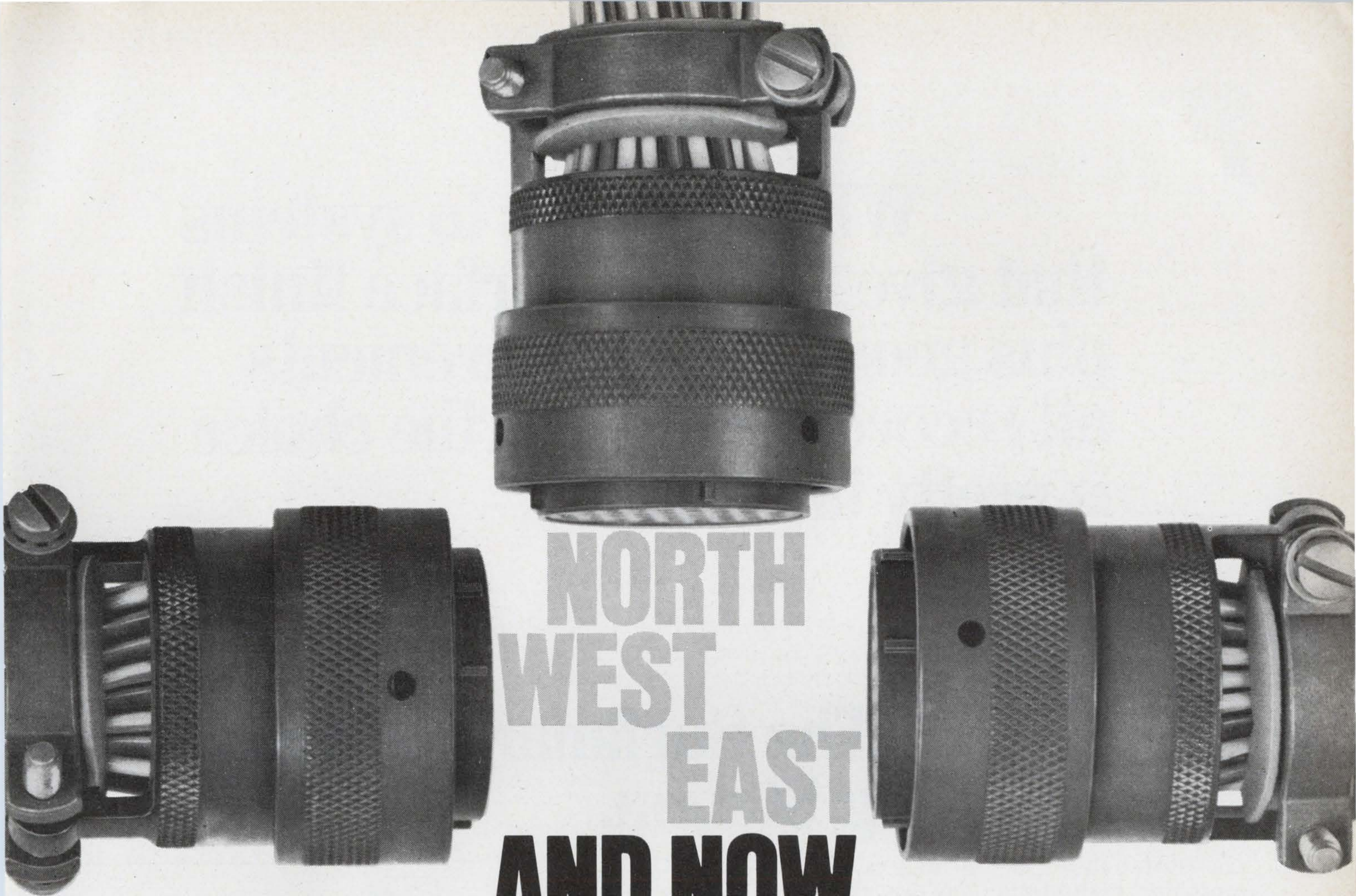

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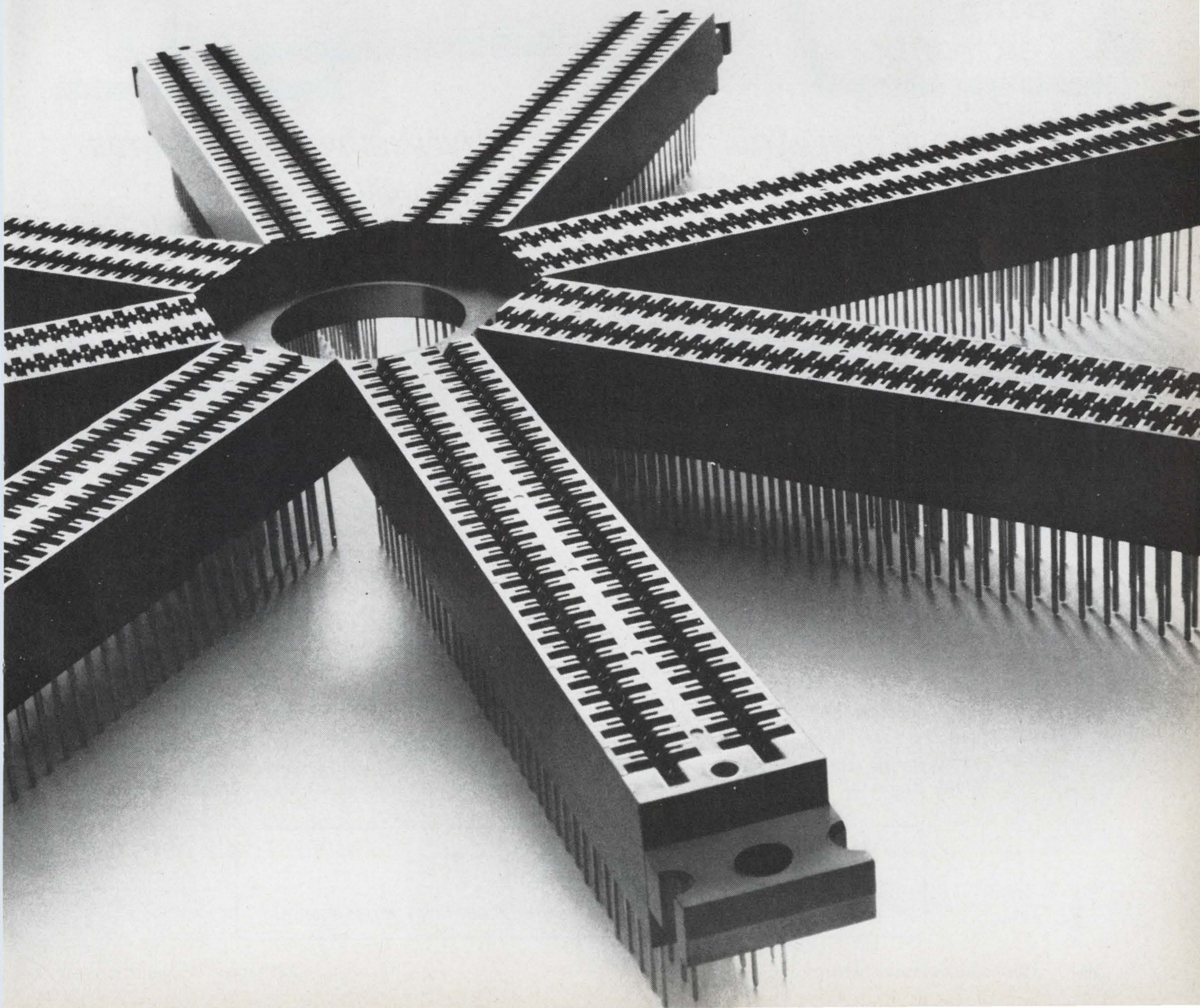

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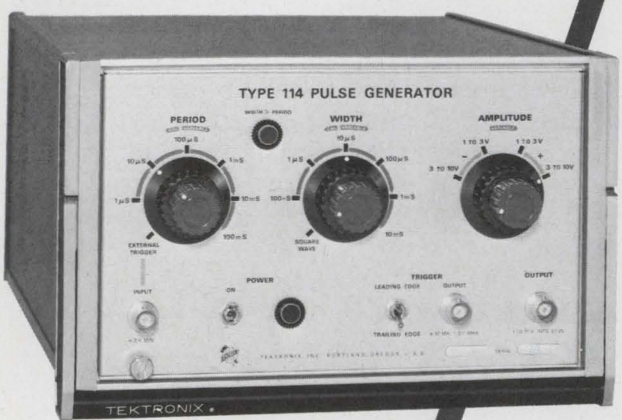

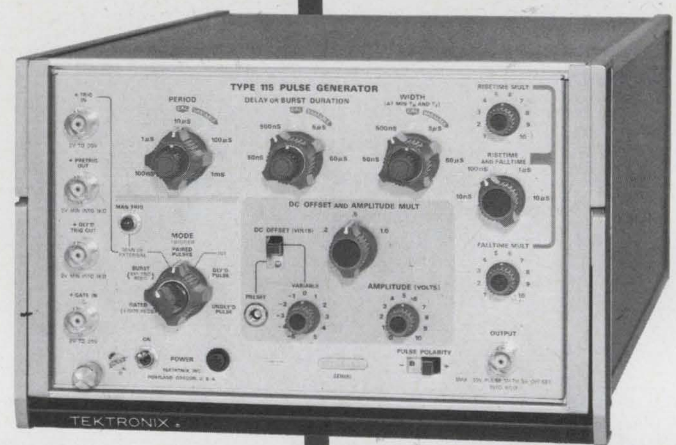

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Air traffic control for the 1980's: Survival to cost billions of dollars

ATC group sees wider computer role, scanning beam microwave ILS as essential components in upgrading the National Airspace System

By Ray Connolly

Associate editor

If today's air traffic control is in a state of crisis, what will be the picture 10 years from now when air traffic is expected to be doubled? The Federal Aviation Administration, which is having trouble just improving the present National Airspace system (see p. 54), needs to begin work now on developing the next-generation system to meet the 1980-and-beyond requirements.

This call for top national priority is sounded in a report to the Department of Transportation from the Air Traffic Control Advisory Committee. Contents of the report are being disclosed publicly at the IEEE Electronic and Aerospace Systems Convention and Exposition (Eascon) in Washington this week.

The study spells out requirements for, among other things, the hardware that needs to be developed and built for the proposed system—work that would require billions of dollars to be spent with the electronics industry.

Should the Administration fail to assign a high national priority for upgrading the National Airspace System, there will "10 midair collisions a year" involving commercial air carriers and general aviation aircraft by 1980, predicts Lawrence A. Goldmuntz, executive secretary of the ATC Advisory Committee.

The chairman of the ATC Advisory Committee, Ben Alexander, who is chairman of General Research Corp., extrapolated the data on 1968 near midair collisions, and came up with the same kind of grim prediction. Alexander's committee predicts collisions between air carriers and general aviation craft at nine in 1980, rising to a phenomenal 41 by 1995, if work doesn't get under way on the new system soon.

Though by 1980 U.S. aviation activity is expected to be at least double the 1968 rate, and to double again by 1995, the projected collision rate will rise much more rapidly. Moreover, says Alexander, "The demand for ATC service is estimated to almost treble by 1980 and to treble again by 1995."

The committee "strongly and unanimously recommended a program starting immediately to selectively upgrade the National Airspace System beyond 1995.

Components of an upgraded NAS system would include: scanning beam microwave instrument landing systems for landing and terminal navigation; major additional computer capacity; a discrete addressed ATC radar beacon system, including an air-ground data link of varying sophistication depending on the aircraft; provisions for intermittent positive control (IPC) where justified by traffic congestion to reduce the midair collision threat; and improved accuracy for vhf omnirange (VOR) and higher-capacity distance measuring equipment (DME). Further, airports would be designed and instrumented for higher capacity by increasing use of parallel runways, and halving separation between them and approaching aircraft as well. Achieving the latter, however,

A near miss—this time!

depends on successful development of scanning beam microwave ILS, precise monitoring and data-linked commands.

Future caveats. For 1995 and beyond, the committee warned that "some caution is in order" even though its space and computer studies were encouraging. Reliability, they contend, is the key to both techniques since "they must perform virtually without outages." Further, it is not yet known if the fully automatic controller can work its way out of emergency situations safely, while a satellite system

(continued on p. 129)

Collision avoidance: Cockpit or on the ground?

The concept of intermittent positive control (IPC) using a ground-based computer for aircraft collision avoidance appears at first glance to be one of the most controversial recommendations of the ATC Advisory Committee. U.S. air carriers, working through the Air Transport Association, are in the midst of flight testing independent airborne systems that use competing hardware developed by McDonnell Douglas, Bendix, and the team of Sierra Research and Wilcox Electric.

But the Lambda Corp. of Rosslyn, Va., which studied IPC feasibility under a six-month, $20,000 FAA contract, doesn't see the concept as competitive with the cockpit systems now being tested. Instead, Lambda's Ken Willis sees IPC as a more sophisticated, parallel system for the 1980's and beyond, when an upgraded National Airspace System (NAS) and air terminal system could become operational. Further, says Willis, IPC would only be used as a backup to a primary air traffic control system.

A cockpit system, which will prevent collisions of comparably equipped aircraft, is expected to be available to airlines next year.

Under the IPC concept, aircraft would be equipped with a simple ground-to-air data link and display in addition to an ATC radar beacon transponder. The suggestion that an IPC data link and display could be integrated with a beacon transponder is already generating concern within the aviation community as to costs associated with redesign and installation.

Limiting commands. Lambda's concept, aimed at preventing pilots from being overwhelmed by commands from an IPC system as well as limiting memory requirements for a ground-based computer, calls for dividing the airspace and putting this information in a computer memory in numbered cells. The dimensions of these cells would correspond with the distance an aircraft could cover in 40 seconds at a speed of 300 knots. As one of its six-to-eight functions, says Willis, a ground computer such as the Univac 1320, which probably will be used in the air terminal system, would reserve one or more words for each cell in memory—a technique Lambda calls implicit geometric filtering.

An aircraft's identity would be stored in the cell through which it is passing. In the event an attempt was made to place another aircraft in an occupied cell, a warning would be flashed immediately to the pilot. [See diagram describing cell approach on p. 129]. The computer would issue positive commands via the data link directly to the pilot display without intervention of a human controller. Lambda asserts that if the commands were followed—whether delivered by a computer in a terminal area, or one at an en route control point—safe separation distances could be maintained between aircraft.

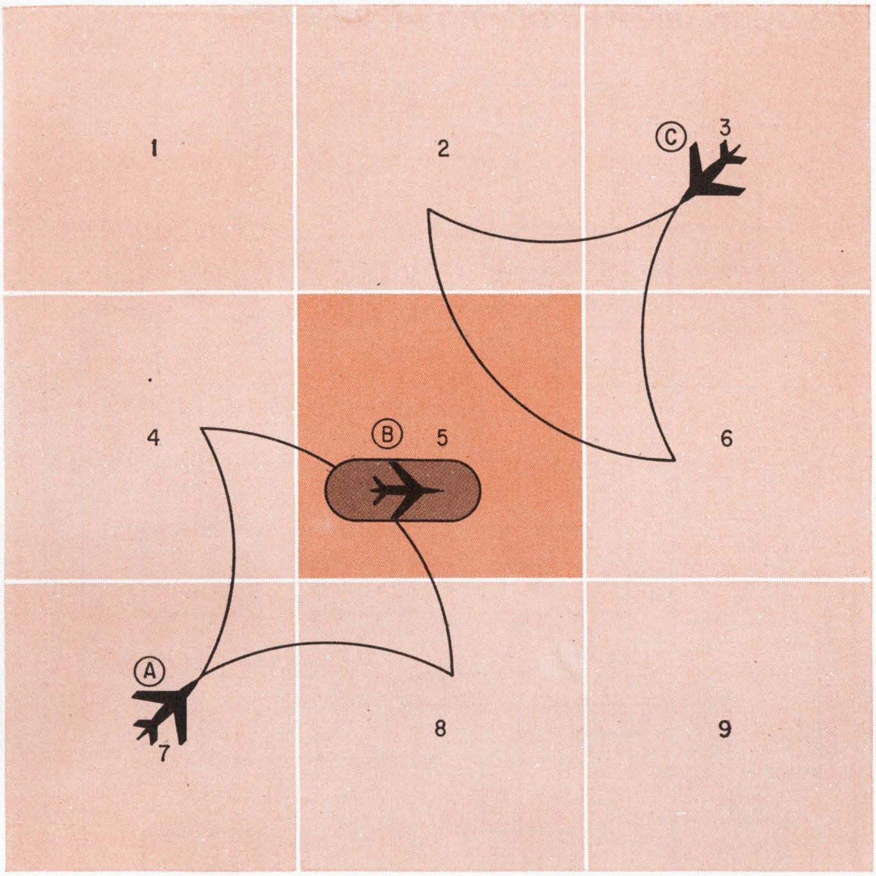
By attaching data recorders to IPC computers, says Willis, flight patterns and computer commands could be stored for the record and used to determine responsibility for near-misses or midair collisions. With such a record, pilots refusing to follow computer commands could be "ticketed" for air-traffic violations, he suggests.

Though the IPC and the cockpit collision-avoidance systems are similar in that equipped aircraft do not have to be under positive air traffic control to avoid collisions, IPC would not operate on transoceanic flights or over countries where the ground-based system was not installed. The Air Transport Association's airborne package, however, would operate anywhere in the world where similarly equipped aircraft would be flying.

Lambda calculates that IPC could function effectively even in "worst case" projections and include aircraft flying random patterns with no procedural separation and without benefit of see-and-be-seen evasive maneuvers.

Long way off. Nevertheless, Willis emphasizes only initial design work has been completed on the computer algorithm and that considerable effort remains to develop an efficient thoroughly debugged software package. Lambda believes IPC could be implemented by 1975 if appropriate data links and displays are also operable.

Willis says IPC could be used to warn general-aviation aircraft to keep clear of terminal control areas.



WORD	CONTENT
1	O
2	C
3	C
4	A
5	A+B+C
6	C
7	A
8	A
9	O

Collision avoidance. In Lambda's plan, airspace is divided into cells; one word for each cell is stored in a ground-based computer. When two or more aircraft are loaded into one word, as in word 5 at left, the computer flashes a warning to the pilots. Cones in front of aircraft A and C, both flying under visual-flight clearance, indicate where the aircraft could be in the next 40 seconds. Aircraft B is flying under instrument-flight clearance. Each cell represents distance covered in 40 seconds by aircraft travelling at 300-knots.

(continued from p. 127)

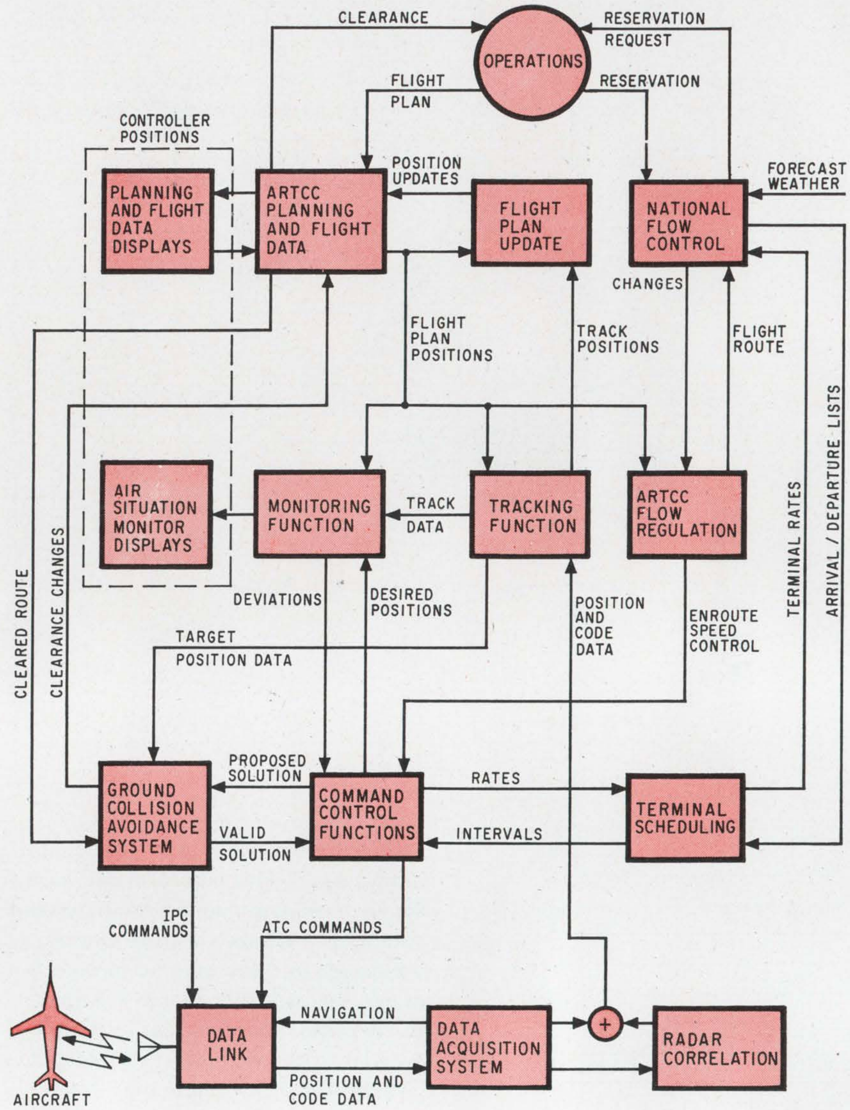
must be immune from catastrophic failure "due to hostile human acts."

The recommendation to DOT secretary John Volpe: a research program to run parallel with the NAS upgrading to clarify issues in designing and scheduling an ATC system for the year 2000.

The most significant unresolved question is whether or not the Nixon Administration is willing to initiate a spending program estimated to run upwards of $4 billion to $5 billion to achieve all the NAS upgrading, including some $250 million in R&D—a figure far greater than FAA has ever been able to get from Congress in the past. Other political considerations that could slow down implementation of the report's technology are the continuing in-house dispute between DOT and its subsidiary, FAA, over program responsibility. A number of sources point out that the Advisory Committee report was authorized by DOT—not FAA. Further, there is the distinct possibility that some segments of the aviation community—general aviation as well as air carrier interests—will feel some of the recommendations run counter to their own interests—for example, the recommended ground-based collision avoidance system that seems to conflict with the Air Transport Association's cockpit system now in test (see panel).

In apparent FAA criticism, the report says current ATC problems are "exacerbated by impatience

How upgraded ATC system would work



with the slow pace with which modern technology is being applied to air traffic control."

Nevertheless, the committee decision to upgrade the National Airspace System was based on the less expensive economics of evolution using "well-established technology" and "thoroughly tested operational concepts" to minimize the risk of failure. This approach was chosen over "revolutionary" systems—"'revolutionary' in that they advocate changing the system fundamentally and completely," explains the chairman. He advocates "giving control back to the flight deck" so that aircraft could carry most ATC hardware on board, or implementing integrated navigation, communication and data acquisition functions through such techniques.

In directing its first requirements for upgrading the NAS to a 1980's system, the committee relies heavily on automation. Using a projected Los Angeles basin traffic pattern 10 times that of 1969, and determining major system functions—flow regulation, flight data processing and updating, flight progress monitoring, terminal sequencing and spacing, separation assurance and data acquisition system processing—the study projects an EDP system capable of handling up to 42,660,000 instructions-per-second in an en-route system. Memory capacity requirements run to a comparably staggering scale, calling for as much as 1,486,400 words of fast storage in an en-route, system backed up by another 1,332,000 words of memory.

Though the third-generation ATC system computers also must provide for automatic recovery from a variety of system failures—and do it as an integral part of the computer operational program—government and EDP industry officials agree that the state of computer art will be able to meet these requirements.

What will be the state of the 1975 computer art for use in a 1980 system? The study shows 10 technology requirements, including a reliability factor for basic electronic components that is one order of magnitude greater than that experienced now. The speed of these components will have to be near 2 nanoseconds to obtain add times of 50 nanoseconds—a figure that equates to a maximum through-put of 20 million instructions per second.

In the technology cost race, substantial reductions are contemplated. Loaded logic, for example, is forecast at 60 cents to a dollar per logic node—including packaging, cooling, power, wiring and cabinetry. Main memory with a 150-to-500 nanosecond cycle time is projected to cost about 5 cents a bit regardless of whether film, wire or logic technology is used.

Second-level random access backing memory of film, wire or MOS logic would have a cycle time in the 2-to-5-microsecond range and cost a 1/10th-of-a-cent a bit. Designers forecast data banks of 10^7 to 10^8 using this approach, while ultrathin film memory for non-destructive readout is seen most cost-effective in 10^8 to 10^{10} bit packages.

Beacon. The ATC radar beacon system—primary source of position, identity and altitude in the National Airspace System—"already is approaching overload" in some of the busiest terminals, according to Mitre Corp.'s Robert C. Renick, who worked for the committee with his boss, Mitre president Robert Everett.

To produce a next-generation beacon replacement, the committee chose an evolutionary Rho-Theta design concept on which present beacons are based. Rho-Theta systems measure aircraft range and angle. Of the four in-depth studies of data acquisition, this approach beat three kinds of trilateration using a constellation of satellites, one-way ranging (time-frequency), and two-way ranging, both of the latter using ground stations.

Five general principles—including one usage limitation—should be followed for advanced beacon design, according to Renick. They include the obvious requirements that all planes have automatic altitude encoders in their beacons; data acquisition, accuracy and reliability will be adequate for an automated ground system, and beacons will be used in en-route and terminal situations for primary data acquisition, while an upgraded Vortac—vhf omnirange tactical air navigation—will be the primary navigation system. Additionally, upgrading of ground interrogator hardware will have to be effected so that aircraft with contemporary beacons still will be usable. At the same time, FAA will have to implement controls to prevent unrestrained use of interrogators that might overload the system.

Two phases. Renick believes an upgraded beacon system could be gradually introduced in as little as two years in two phases. In the first, improve interrogators operating only in two standard modes—range and azimuth, and range, azimuth and altitude—would be added to, or used as replacements for, some existing units. By separating these interrogators from the radar, better coverage and reception will ensure, according to the Mitre manager. With altitude reports from all aircraft, this third-dimension data can be delivered to the central computer which, in turn, can deliver beacon overlays registered in the coordinates of any radar. Thus, system overload can be controlled by turning off unneeded separate interrogaters at each radar.

Phase II will permit discrete addressing of aircraft equipped with new transponders. New interrogators will transmit and receive data link information, interleaved in time and space with the standard modes. In the two respective modes interrogated aircraft respond with selected coded information on range and on range and altitude, respectively.

Though this new hardware will permit more accurate aircraft positioning in high-density airspace, it also suggests either larger outlays for general aviation aircraft if they expect to continue to use high-density terminals, or installation of intermittent positive control (IPC) collision avoidance receivers to prevent garbling of beacon replies in high-traffic areas.

The hangup. Implementing the advanced beacon system, however, will require "prior agreement of all common system users—civil and military," concedes the Mitre official. "This agreement may, in practice, be unattainable for various political or operational reasons, and therefore a different approach may be more attractive in the end." One possible source of complaint is the general aviation community, whose beacon system costs would be higher since an entirely new system—rather than just an IPC decoder and display—would be required.

Renick suggests designing a new interrogator system around a new frequency in the 1600 Mhz band which would continue to transmit standard interrogations and receive standard replies, but would, he says, "transmit all roll-call interrogations and messages in the 1600 Mhz band." Both ATC and IPC replies could be received on a second frequency in this band, providing a garble-free channel for both. Renick also believes it's feasible to build a circular phased array interrogator operable at both 1030 and 1600 Mhz, although it's unlikely that existing rotating interrogators can be modified to transmit and receive data at 1600 Mhz. It's a disadvantage, he says, that has to be considered carefully in the early stages of system implementation.

By tightening specifications for both interrogators and transponder beacons in conjunction with adoption of a discrete address operation mode, says Renick, range and azimuth accuracies of 100 feet and 0.12° can be achieved. Current system accuracies are 370 feet and 0.25° to 0.4° with a center-marker, 4° beam. However, he says, "under the garbled situation that pertains to the terminal environment, FAA does not presently use center marking for separation service."

Microwave Scanning

A possible alternative to these tighter specifications is use of microwave scanning ILS for measuring such accuracies.

Mechanically-rotated airport surveillance radar (ASR) also represents a limitation on tracking accuracy in view of their 4-second rotation rate. Though this can be halved by back-to-back units, Renich calls 360-degree electronic scan systems a necessary goal.

Electronically-steered arrays eliminate the problem of mechanically rotating a large aperture antenna, which is required for the better angular accuracy and resolution of narrow beams—a 2° beam at 1030 megahertz requires an aperture of about 30 feet. They also can form multiple simultaneous transmit and simultaneous receive beams as well as use all interrogation levels efficiently.

Microwave ILS. For landing aids, the report draws on military microwave scanning beam technology in which the study sees features needed at high-density terminals—particularly if capacity is to be increased by use of dual-lane runways and closer spacing of aircraft. Existing ILS, says FAA's David Sheftel, is constrained by its single-course line character and overflight interference. Another problem: obstructions, such as hangars and other structures in the area. Microwave scanning ILS could overcome these handicaps, says Sheftel, but also appears applicable to short takeoff and landing airports due to its comparatively small size and ability to operate in relatively congested areas.

Such a system should be designed, he says, "for compatibility with carrier takeoff or landing facilities"—a reference to systems such as Cutler-Hammer's Airborne Instruments Laboratory AN/SPN-41, now in use by the Navy and also being sold as the tactical instrument landing system to the Royal Swedish Air Force [*Electronics*, July 21, pp. 46-47].

"Frequency spectrum considerations," says Scheftel, "dictate that this type of aid must fall within either the Ku band or C band in order to obtain sufficient bandwidth for channeling."

The FAA official cites a "growing consensus" that scanning beam technology is the primary contender" for just about all future military and civil applications. Certainly the approach receives a major boost from the ATC Advisory Committee report.

Nicholas Johnson, a man with a mission

Controversial FCC commissioner takes on all comers, particularly Ma Bell, in his zeal to put 'public good and public interest' ahead of everything else

By Roger Kenneth Field
Associate editor

Once a slumbering agency, the Federal Communications Commission has become in recent months the high court for the electronics industry. The agency has handed down several landmark decisions that are having tremendous impact on the way electronic technologies are applied, on the way communications products are sold, and on the way the telephone system is viewed.

Much of the pressure for change at the FCC has come from within the commission itself—from Nicholas Johnson, the controversial commissioner who is often described as a maverick. Johnson thinks in terms of "the public good, the public interest." Simply put, he places public interest before industry interest. The result is that he has made some powerful enemies of broadcasters and telephone-company executives. And with good reason.

Johnson's primary thrust is aimed at the broadcasting and telephone industries. Johnson authored the now-famous Carterfone decision opening up the $55 billion telephone system to "foreign attachments," although AT&T had fought just such a decision for decades. Johnson was instrumental in the decision allowing Microwave Communications Inc. to set up a microwave link from St. Louis to Chicago and lease channels to all comers—in direct competition with AT&T. And Johnson has been instrumental in effecting price reductions in off-hour long-distance calls—a course of action that could have enormous consequence for executives and designers involved with communications and computers.

"I have often found the public statements of [AT&T chairman] Romnes and other high officials of AT&T quite imaginative, public spirited and encouraging. It is the actions of the company that distress me"—Nicholas Johnson (above)

How Johnson feels about these and other issues could well give a hint of the future for those industries affected by decisions of the FCC. In the following exclusive interview, the commissioner speaks out and reveals his feelings and opinions.

Where is the telephone system falling down in its service to society and in its preparation for the future? What would you do to change this situation if you could control the telephone system completely?

JOHNSON: My principal concern with the telephone company [AT&T] is what I view to be the failure of the company to recognize its social, economic, and political role in our society. I think that it is impossible even to "profit-maximize," let alone serve the public interest, if one operates the telephone company the way some librarians used to operate their libraries. You may recall the story of two librarians meeting at a convention. One asked the other, "How are things going?" She replied, "Everything is marvelous. All the books are in but two—and they are coming in next Tuesday."

In what way is the telephone company like that librarian?

JOHNSON: Much of what the telephone company does is designed to prevent people from communicating, rather than encourage it.

Like what?

JOHNSON: The telephone company has failed to adequately anticipate and prepare for the present and future demand for communications service for computers. The telephone company has failed to anticipate and provide the services now being offered by cable-television companies. It has failed to conceptualize itself as in the "communications" rather than the "telephone" business. Look at all the terminal equipment potentially available that could be used: facsimile transmission, computer-access devices, closed-circuit tv, teaching machines, and so forth. The telephone company has failed to anticipate communications demands, generally, in ways that are now coming back to haunt it, such as the recent breakdown in Wall Street and elsewhere.

I would point out that each of these failures has produced a lower rate of return for the company, less profits, less dividends for shareholders, and has had a very retarding impact on the economic growth of our country and upon the ability of this company to serve the public in ways that are demanded of it. I am speaking of failures that have been just as costly for shareholders as subscribers—maybe more so.

But my principal interest is the public interest. The telephone is a device that could help to unite far-flung families and friends, yet our system of billing for long-distance calls tends to impede that. There is a political significance as well. It presently costs more to call Washington from Hawaii or Alaska than it costs to call Washington from London. This has a measurable impact on what we describe politically as the "United" States.

There are numerous other examples I could point to of practices of the telephone company that not only disserve the public interest, but also tend to rob the shareholders. I have twice attempted, in two different on-the-record proceedings, to get the company to address the consequences of our providing them a rate of return substantially in excess of what they're now earning—perhaps no limit on rate of return at all. Would you believe that they [telephone executives] were so enamored of the 19th Century public-utility principles they have

Tune him out, say the broadcasters

Commissioner Johnson may be a thorn in the side of telephone executives, but he is even more of a thorn to broadcasters. So much so, in fact, that a group of Southern broadcasting associations has petitioned President Nixon to oust Johnson from office now—four years before his seven-year term expires.

The rancor of broadcasters centers on a statement the commissioner made on a nationally televised panel show. Johnson, who has always favored allocation of free broadcasting time for candidates for public office said, "For the industry to hold up elected officials and make them pay to get time from public property (the airwaves) is kind of like a criminal stealing a woman's wedding ring after he's raped her."

To be sure, criticism of the broadcast industry by FCC commissioners is nothing new. FCC chairman Newton Minow is best remembered for characterizing television programing as "a vast wasteland." His predecessor, James Fly, likened radio to "a dead mackerel in the moonlight—it both shines and stinks." But Johnson goes beyond colorful quotes: he questions the automatic renewal of broadcast licenses, insisting instead on reevaluation each time a license comes up for renewal. And on this point, quite understandably, broadcasters are extremely sensitive.

Does the commissioner's position warrent Presidential removal? Here, in Johnson's own words, he describes what rights he believes broadcasters should and shouldn't have, and precisely why he feels that granting licenses "in perpetuity" would violate the original intention of those congressional acts that defined the purpose of commercial broadcasting:

"I think it's very unlikely that any local broadcaster who has been in the business a long time, doing an outstanding job of public service and of quality programing, is going to be deprived of his public trust—at least not by anyone I know of who has sat upon this commission, does so now, or is likely to in the future. But in this industry, as in any other, there is a small percentage of broadcasters more interested in ever-increasing profits than in their local responsibilities and public trust. Whether that percentage is 1/100 of 1% or 15% is a matter for some debate. But I think the leaders of any industry would recognize that some of their competitors are more responsible—better citizens in the business community—than others. Some of the grossest failings of broadcasters have involved double billing and misrepresentations to advertisers; the FCC has not been much more strict in penalizing those broadcasters than it has been with the broadcasters who are disserving the public.

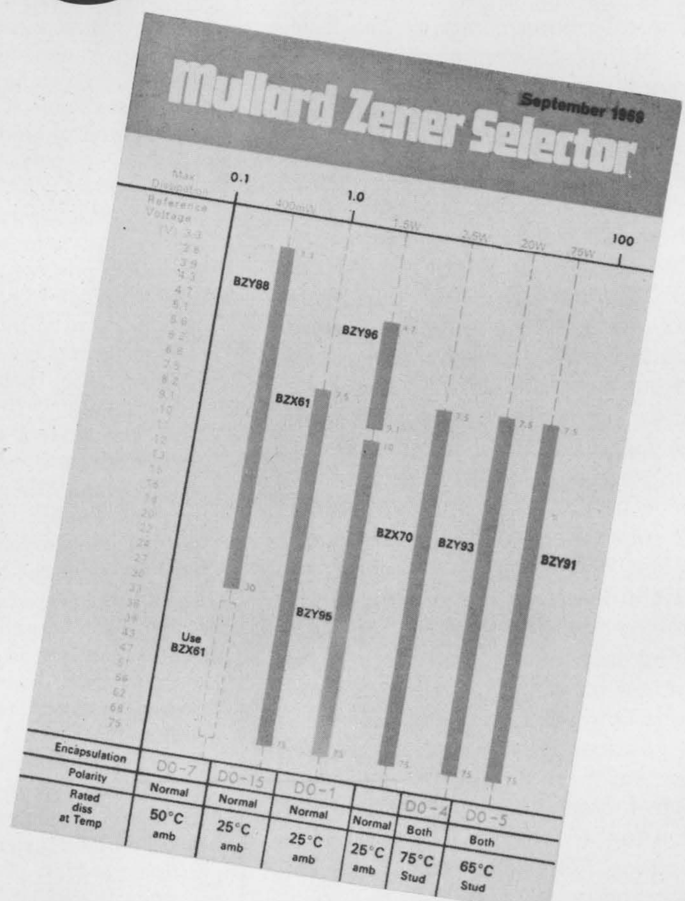
"But the important point here is that Congress in 1927 and 1934 recognized expressly the threat to democracy of the potential for control of the mass media in America. Congress anticipated stations would be owned locally, operated by people whose only business was the broadcasting business, and who recognized their responsibility to their local community.

"It expressly provided that no one could own a broadcasting license . . . in the very first section of the portion of the Communications Act that deals with commercial broadcasting. It provided that broadcasters are to be public trustees of public property, that they have no rights, save during the term of their three-year license. They have no more right to a renewal of that license than a highway contractor has to a second contract after he is finished building the first stretch of highway. They must, like an elected public official, 'run on their record.' That's a quotation from the U.S. Court of Appeals.

"One of the leading spokesmen for the Communications Act said that if ever broadcasting property should fall into the hands of a few and the mass media should be so dominated, then 'woe be to him who disagrees with them.'

"We have seen this political power come into effect today where the broadcasting industry can obtain virtually any single piece of legislation that it wants from Congress. Any elected official in this country who is running from a district that is preponderantly covered by one or a few vhf television stations simply must look to the owners of those stations as his principal constituents. I think this is dangerous. Increasingly, we are seeing stations owned not by local citizens, but by national industrial conglomerate corporations with no ties to the local community. And some of these conglomerates are running stations on a formal basis, profit-maximizing and putting out the same programing in all the communities that they cover."

20W zeners in DO-4



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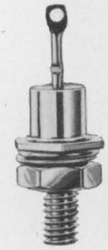

The compact DO-4 encapsulation used for the Mullard type BZY93 zener diode is the smallest available anywhere for a 20W device. It has also resulted in an extremely low cost-per-watt figure on a device with ±5% tolerance.

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grown to love that they were unwilling even to address the question? I was stunned.

The company's debt-equity ratio, which the company itself finally acknowledged had been undesirably weighted on the equity side, has held down shareholders' dividends at the same time it raised subscribers' rates. That's pretty hard to do, but Bell did it.

The company is considering trying to rectify its failure to exercise options under liberalized depreciation provisions. It has delayed introducing the new technology of electronic switching. It failed to provide a national emergency number for the people of this country—long after the "inferior" telephone companies of most of the civilized nations of the world provided the service as a matter of course. It expressed excessive reticence to develop a coin-operated telephone that would enable people to place calls to the operator without first depositing a dime. One could go on endlessly multiplying the examples of ways in which this company has failed to recognize the social, economic, and political role that it plays, to its own detriment and that of the country at large.

The Carterfone case and the MCI case seem to outline two areas that FCC has specifically opened up for competition with AT&T. One is the question of terminals, the other is the question of transmission of the information itself. Are you planning to open up competition on all fronts for AT&T—telephone communication, Picturephone, video transmission for tv networks?

JOHNSON: The FCC is in the business of deciding cases one at a time as they arise. And I would not want to prejudge any cases that might come along in the future. But as a general proposition, I would prefer to stand with the assumption that a fully functioning free private enterprise competitive system, with informed consumers, will best serve the public interest—and will do so better than Government regulation. It would only be in those instances in which the marketplace, for one reason or another, does not work as effectively or efficiently as it should that I would want to substitute regulation.

But certainly there is no justification in my mind for providing an essential service in our society through a Government-regulated monopoly if that service could be provided with higher quality and lower cost through a competitive system. So I think it is fair to say that—while my principal commitment is, as it must be, to serving the public interest in these matters—I will be continuing, as I have in the past, to look for areas in which the FCC can legitimately work itself out of a job and turn more of these matters over to the marketplace.

What do you think of AT&T chairman H.I. Romnes' announcement that in the future there will be a one-minute connection with a target-charge of 35 cents coast to coast? This is primarily intended for the computer people, but it is merely a token gesture in answering the data problem?

JOHNSON: I have often found the public statements of Mr. Romnes and other high officials of AT&T quite imaginative, public spirited and encouraging; it is the actions of the company that distress me. Two years ago when considering AT&T rates, I pointed out to them the gross underutilization of their $35 billion plant. The company has simply never understood—or, if it has understood, has failed to apply—the most elementary principles of peak-load pricing.

The telephone system is virtually unused from 10 p.m. until 8 a.m. I suggested that the company's shareholders would be richer and the public better served if the company would provide very significant reductions in after-midnight rates. Its response was to cut the rate from $1 to 75 cents after midnight. This was not quite the order of magnitude that I had in mind. There are very few people who would stay up until midnight in order to save a quarter.

The one-minute rate is another example of Bell's offering too little too late. In most of the civilized nations of the world, it has long been possible to call anywhere in the country on a message-unit basis—as the distance increases the time decreases. But it is possible to call the longest distance possible for some period of time for a message unit charge that may be 5 cents or

less! Compare that with our "low, low telephone rates."

Has anyone proposed that calls be priced on a continuous curve?

JOHNSON: Well, even better, some reports I have seen indicate that as much as 50% of the cost to the telephone company of a long-distance call is the cost of billing you for that call, and otherwise running a system which is dependent upon a time-distance formula and individually billed calls.

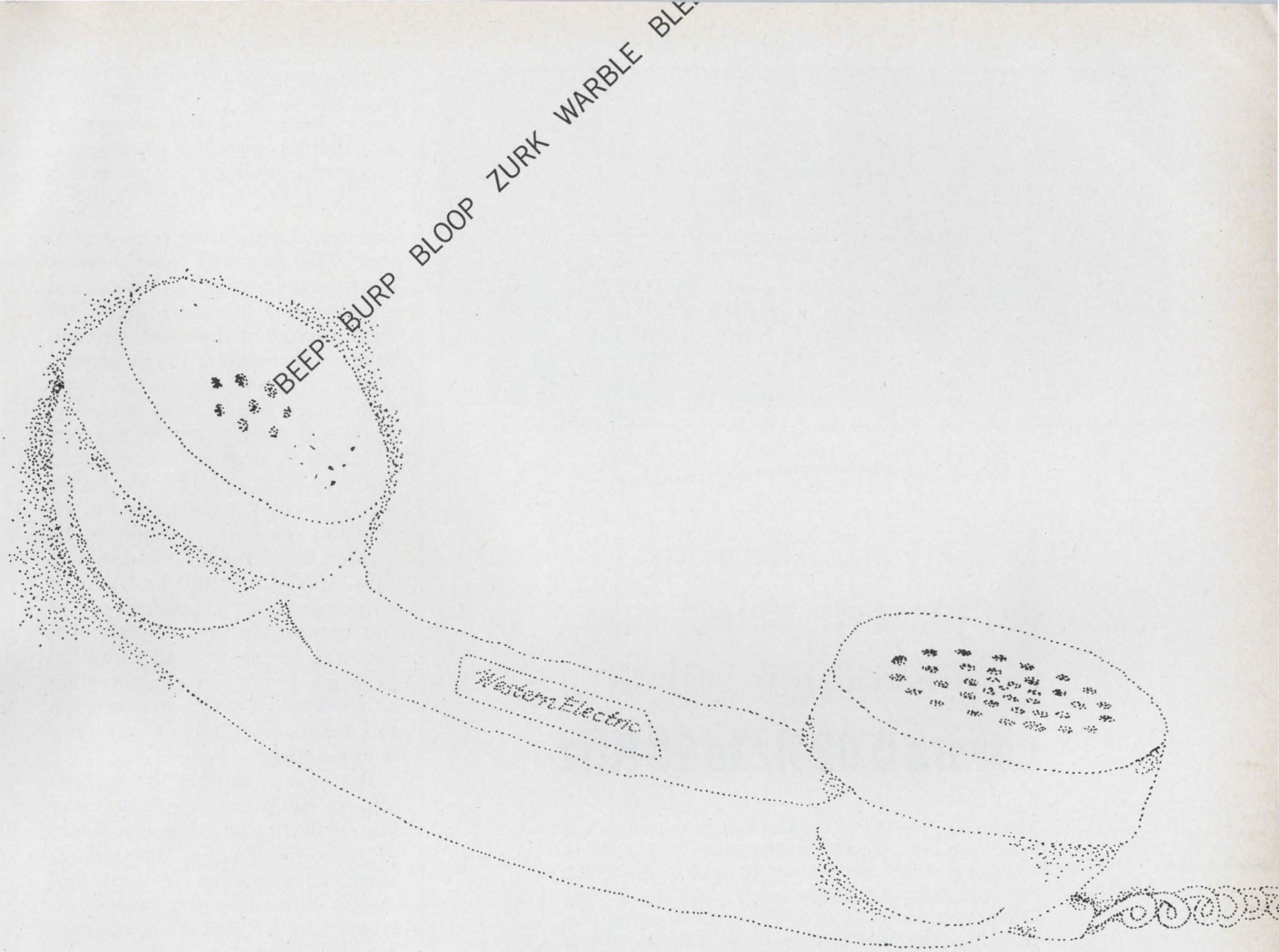
Might it be cheaper if the company simply charges you for the connection and forgets about the time? Or distance?

JOHNSON: As a general proposition, it would seem to me that the telephone company would want to offer as much service as possible on an incremental cost-free basis. That is to say, it seems to me that both the company's profits and the public interest would be served if people chose whether to use the communication system on the basis of their communications needs versus other demands upon their time, rather than in terms of cost. Note that this is what we do with most of the so-called "local" services.

When you make a local call you do not reflect upon the price that you must pay for this service. It is incremental cost-free; that is, once you pay your monthly telephone bill there is then no additional cost for your use of the telephone. You use the phone, or not, based solely upon to whom you want to talk, when, and for how long. If a system would be devised for a nationwide telephone service of this character—a system that would provide adequate revenue to the telephone company—it might be a clearly more satisfactory way of providing service.

The telephone company's principal objection to this, to the extent that I can fathom it, is that such a plan would produce an increase in the use of the telephone—an argument which the company often raises to oppose proposed improvements in service.

As you interconnect more and more phones, thoroughly, with more and more long-distance lines and more and more lines between phones, the system approaches what in



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physics is a real network. If that is the case, would it not be better to have either a blanket charge for any call independent of distance, or no charge at all, simply billing people for the use of the phone?

JOHNSON: It has often been argued that the so-called long-distance service has been grossly overpriced and used as a subsidy, in effect, for local service—a political decision to serve the needs of the state regulatory commissions, which are loathe to raise their local rates. The result may also be salutary in terms of national economic and social goals—or it may not be. Maybe we should want to encourage the installation of home telephones by soaking the rich for "long-distance" calls. Maybe it would be better to encourage greater national use of the system. My point is only that the issue has never been addressed in these terms. Your observation about the relationship between distance and cost of telephone service is interesting.

It seems to me that the irrationality of the present pricing system is best illustrated when one thinks in terms of satellite communications. If a satellite is positioned 22,000 miles from the earth's surface, then by definition all calls travel 44,000 miles—22,000 up and 22,000 back down. It makes no difference to the satellite whether the ground stations on the earth are separated by 1,000 miles or 10,000 miles. With such a system it becomes very difficult to rationalize why distance is a relevant factor in calculating price.

Is there anything manufacturers of communications equipment—the modems, terminals, receivers and transmitters—can do in the design of new equipment to cooperate with and help the FCC?

JOHNSON: There are a number of things. The answer depends upon which particular product line you are talking about. We have some difficulty with the tv receivers—X radiation and electronic radiation are now problems. We passed legislation regarding the uhf tuner: the all-channel bill. We need, from time to time, to improve mobile radio receivers and transmitters to permit them to operate on narrower bands.

MSI/LSI

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and systems designers.

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Program

1. Evolution of large scale integration (LSI)
2. MOS device structure and characterization
3. Basic MOS circuit techniques
4. Topological design and layout
5. Advanced circuit techniques
6. LSI artwork generation
7. Logic implementation with LSI
8. Design examples
9. MOS/Bipolar interface techniques
10. Low threshold technology
11. Cost consideration for LSI
12. Computer aided design
13. MOS structures and fabrication techniques
14. Process constants and minimum design rules
15. Yield factors and process control
16. Facilities and equipment requirements for LSI
17. Applications and product types most suited to LSI
18. Currently available MSI/LSI products
19. Advanced technology trends
20. Technological controversies

Purpose

The MSI/LSI seminar is designed to aquaint systems designers with the capabilities and limitations of the LSI technology. It will provide for more effective product planning through knowledgeable appraisal and proper use of LSI for specific applications. Attendees will receive instruction in MOS device models and characterization, and in MOS circuit forms and their performance comparisons. They will also learn topological rules that permit multiple sourcing of LSI arrays, procedures for the design of a standard cell library, how to make an LSI composite plan drawing, and how to determine transient response and propagation delay. LSI cost factors will be discussed, and systems designers will be instructed in the preparation of specifications for LSI.

Faculty

Presentations, discussions, and work sessions are under the direction of the staff of Integrated Systems Technology, Inc. of Santa Clara, California. Each member of the staff has wide experience in the areas of circuit design, systems application and semiconductor research and development.

Donald E. Farina—President, Integrated Systems Technology, Inc. One of the contributors to the design of the first micrologic integrated circuit families. Served as head of the R&D department in digital circuits for Fairchild Semiconductor, responsible for both digital circuit and bipolar device structure development.

For the microelectronics division of Philco-Ford Corporation Mr. Farina served as Director of R&D and was responsible for device and research devoted to MOS large scale integration. He received his BSEE at New York University in 1953.

Ronald Pasqualini—Vice President, Engineering. Widely experienced in R&D on MOS memory systems for Philco-Ford Corporation. Performed initial logic design, circuit analysis, and composite layout of a monolithic read-only memory. Was responsible for the interface between R&D processing and R&D design.

Systems design experience in integrated circuits includes shared responsibility on an Air Force large scale array navigation computer, and Ranger spacecraft. Also designed a monolithic 2-MHz binary/BCD converter employing 4-phase circuit techniques.

Mr. Pasqualini holds a BS in Aeronautics from M.I.T., 1962, and an MSEE from U.S.C., 1966.

Richard Craig—Vice President, Technologies. Mr. Craig has devoted the major portion of his career to the semiconductor. With three major semiconductor manufacturers his experience includes such early developments as planar and epitaxial processes and structures. More recent experience includes responsibility for the development of advanced MOS LSI techniques, including multilayer and minimum size structures, oxide and interface charge control, and MOS circuit innovation and evaluation.

Mr. Craig received his BA in Physics from Fresno State College in 1958.

Richard Aladine Carberry—Senior Design Engineer. Presently involved in the logic and circuit design of complex MOS devices, and the design of digital equipment utilizing bipolar and MOS IC's. As a project engineer for Philco-Ford Corporation he was involved in the design of MOS memory and arithmetic chips for a guidance computer, as well as a sequencer and other control circuitry utilizing bipolar IC's. For Lockheed Missiles and Space Company he designed analog circuits for a guidance system, switches, modulators and demodulators, active and passive filters, and various operational amplifier circuits.

Mr. Carberry holds BSEE and MSEE degrees from the University of California at Berkeley.

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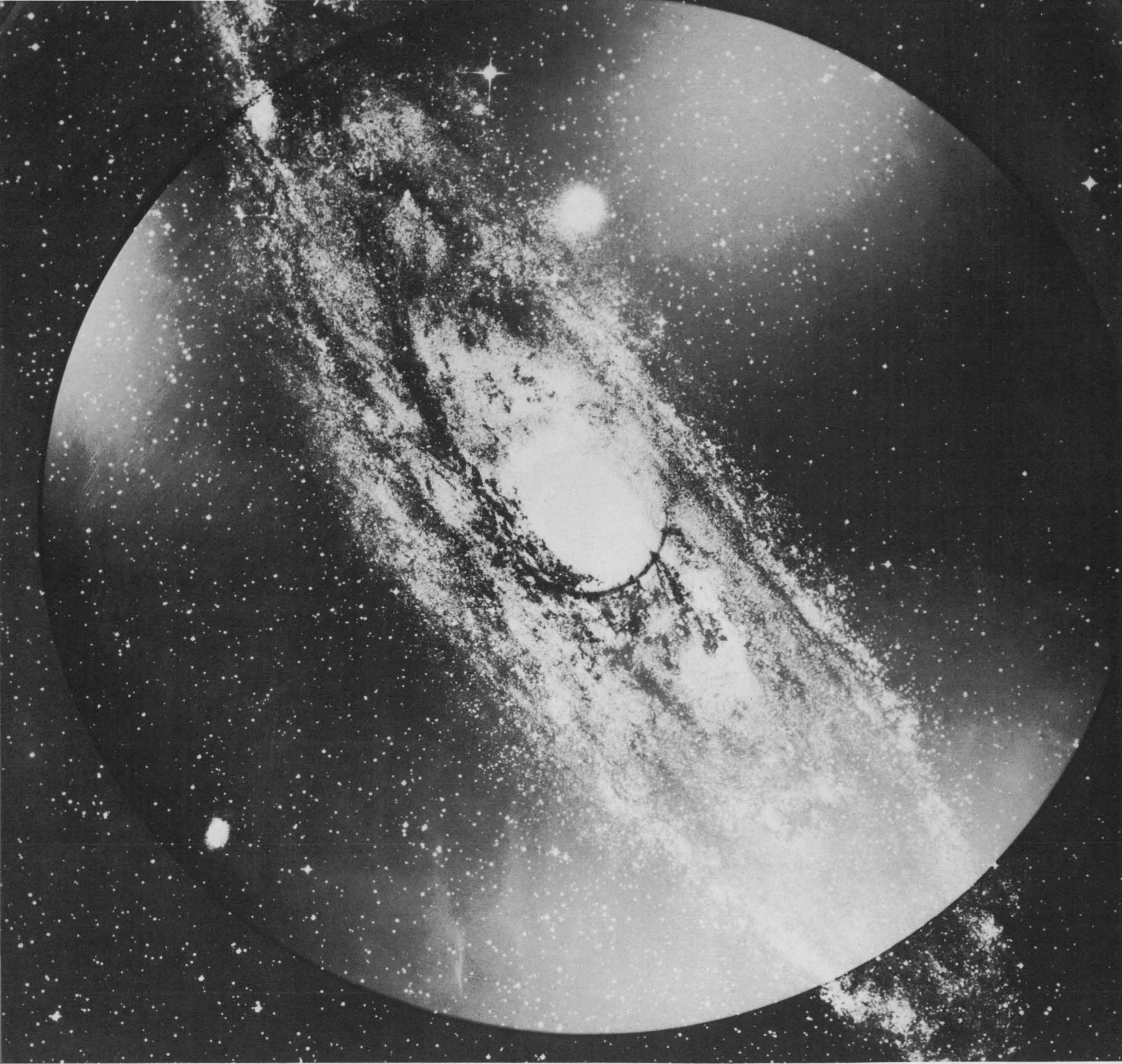


Tiny supply for IC's delivers 5 watts

1.6-cubic-inch regulated source permits half-inch spacing between p-c boards; four-stage unit can work from either a-c input or battery

Everything seems to be getting smaller in electronics—except power supplies. This results in a contrast between inch-long dual in-line IC packages and so-called miniature power supplies, which usually are bigger than a pack of king-sized cigarettes and several times as heavy.

But the newly founded Datacube Corp., has a regulated power supply that requires neither large inductors and transformers nor large filter capacitors. It has an overall efficiency of more than 60%, making for easy heat dissipation—and less heat to dissipate.

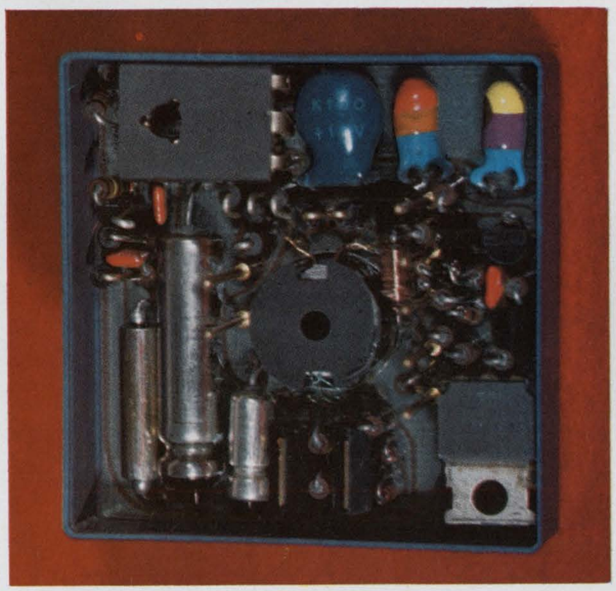
The company claims its new DUP 5-1 is the smallest power supply available in terms of watts per cubic inch. The DUP 5-1 measures 2 by 2 by 0.4 inches, making a volume of 1.6 cubic inches. Its nearest competitor (which puts out 2.5 watts to the DUP 5-1's 5 watts) measures 2.5 by 3.5 by 1.25 inches for a 10.9 cubic-inch volume.

Not only does it take less board area, but its thinness allows printed circuit boards to be packed together on standard half-inch spacings—thicker supplies may waste up to 3 p-c board sockets, even though the IC's they power are less than a half-inch high.

More blocks, less box. How did Datacube put a 5-watt power supply into such a small volume? According to Stanley M. Karandanis, vice president, the key lies in designing each of the unit's four stages to dissipate the least possible energy and to optimize them for the best combinations of voltage, current, and component size.

Stage one is a rectifier bridge. Instead of a bulky transformer reducing voltage to about the desired level at the input, Karandanis designed the DUP 5-1 to accept a-c power and rectify it directly. "We wanted a minimum of 60-hertz iron," he says. The voltage coming from the rectifier peaks at about 180 volts, and since the higher the voltage the more energy a given-sized capacitor can hold, a very small capacitor helps smooth and store the rectified energy.

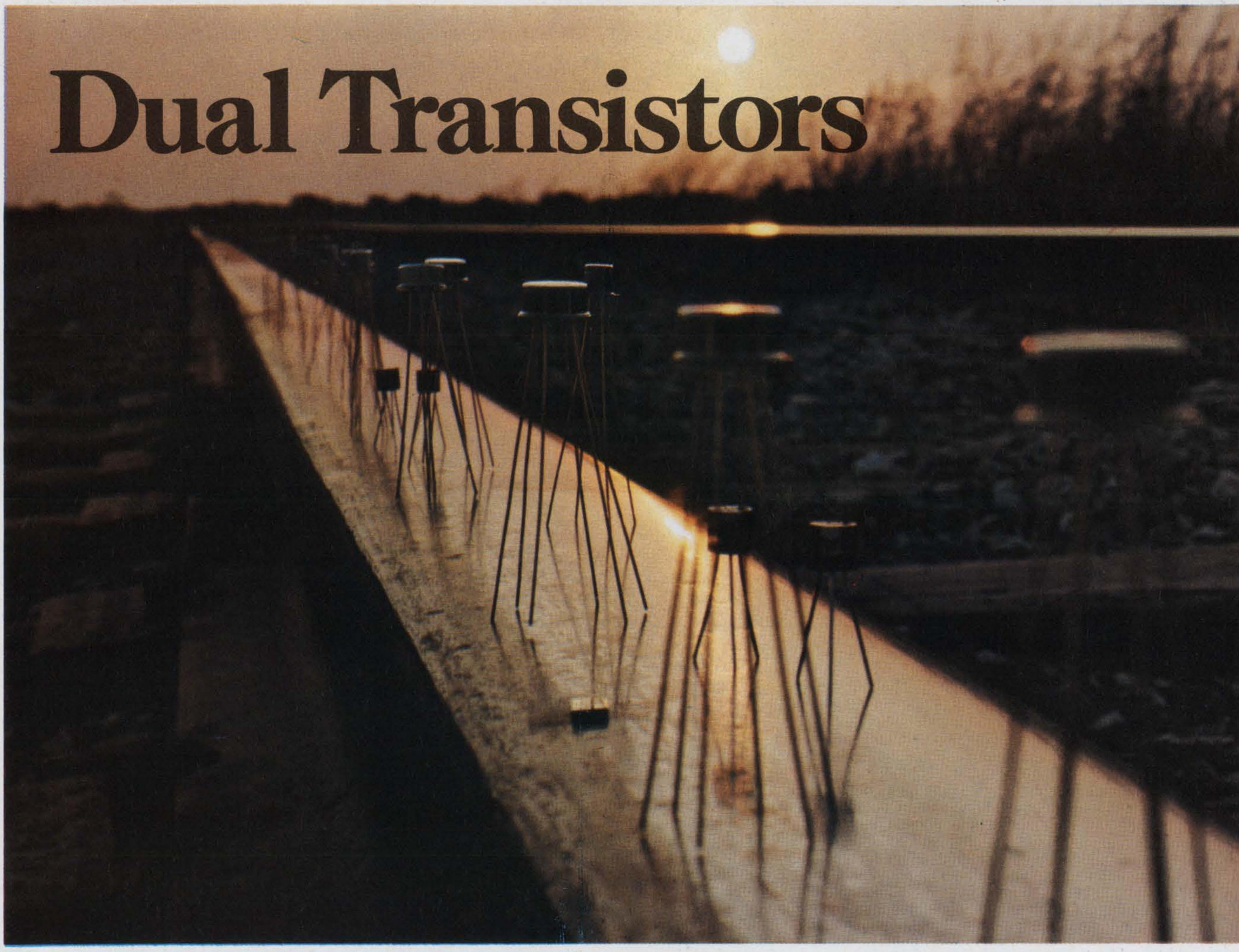
Stage two is a chopper. Fed by the rectifier, it varies the width of its output pulses to get the most energy out of the storage capacitor, and yields an output of about 45 volts intermittent d-c. A diode-choke-filter capacitor network removes a-c components from the chopper's output and feeds a d-c-



Powermite. Source for integrated circuits takes up less than 2 cubic inches. It is thin enough to permit half-inch spacing of printed-circuit boards, yet puts out 5 watts to power any of the families of digital logic.

Modular 5-volt power supplies for digital IC's

Company	Model No.	Output Power	Volume in cu. inch	Output per cu. inch	Price
Analog Devices	903	2.5 w	10.9	230 mw	$49
Arnold Magnetics	PCA-5/500	2.5 w	5.6	440 mw	$84
Computer Products	PM429	1.25 w	6	200 mw	$36
Datacube	DUP 5-1000	5 w	1.6	3 w	$49
Semicon. Circuits	P1.5.500	2.5 w	7.6	325 mw	$50



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TIS92M*	NPN	TO-18 SILECT**	2N2977	NPN	TO-71
TIS93†	PNP	TO-18 SILECT**	2N2979	NPN	TO-71
TIS93M†	PNP	TO-18 SILECT**	2N3350	PNP	TO-77
2N2060	NPN	TO-77	2N3680	NPN	TO-77
2N2223	NPN	TO-77	2N3838	NPN/PNP	FLAT PACK
2N2639	NPN	TO-77	2N4854	NPN/PNP	TO-77
2N2642	NPN	TO-77	2N5045	N-CH. FET	TO-71
2N2643	NPN	TO-77			

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to-d-c converter, stage three.

Operating at a switching frequency of about 20 kilohertz, the converter acts as a line isolator and supplies overload protection. Two transistors drive the primary of a small transformer in the converter and are very tightly specified. If, for example, the chopper were to fail, the two transistors would overload, burn out and act as a safety switch, preventing damage to any IC's powered by the supply.

Following the converter are a synchronous rectifier and a regulator. But little regulation is needed, as each stage of the DUP 5-1 has been designed to supply a tightly regulated signal to the next.

The DUP 5-1 delivers 5 volts d-c at one amp, working off input frequencies from 47 to 420 hz at 105 to 125 volts. The supply even will work from a battery. By doing away with the usual input transformer, Datacube thus has made a-c power input optional for the designer.

Accuracy of the DUP 5-1's output voltage is ±0.5 volt; with external trim it can be adjusted ±2%. Line and load regulation both are 0.05% with ripple and noise one millivolt RMS or less.

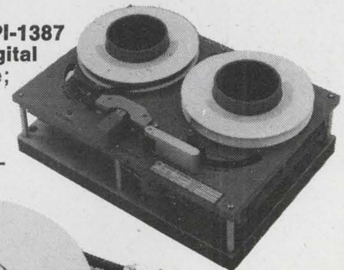
More to come. With the DUP 5-1 or other units in the line it will be possible to power any of the various logic families—diode-transistor, resistor-transistor, transistor-transistor, high-noise-immunity logic, and emitter-coupled—as well as metal oxide semiconductor and large-scale integrated circuits, and almost all analog circuits now on the market.

There also are plans for DUP-series supplies for specialized circuits like sense amplifiers which take +5 or −15 volts, as well as a combined unit offering −5 volts for TTL together with ±15 volts for analog circuits. This one is aimed especially at makers of analog-to-digital and digital-to-analog converters. There will be a supply offering +5 volts and an unregulated 180-volt output for numerical-readout tube decoder-driver applications.

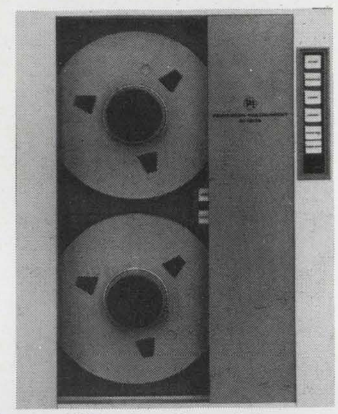
The DUP 5-1 costs $42 in lots of 50 to 99. Delivery time is four to six weeks.

The Datacube Corp., 49 Pollard St., Billerica, Mass. 01862 [338]

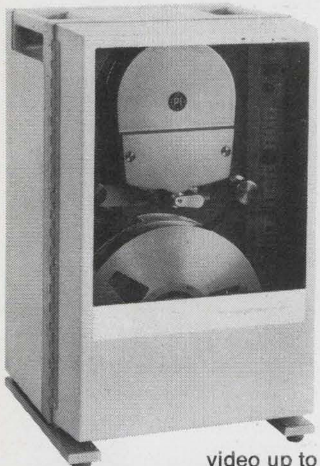
Off-the-Shelf Recorder Order Guide



PI-1387
High Environment Digital
Write only, IBM compatible; 200 BPI, 7 track formats. Inexpensive, compact, lightweight (less than 17# without tape). Operates in virtually any environment. Uses single 12 VDC power source.



PI-5100
Long Term Monitor
IRIG formats. Two models—1″ tape (weighs 60#); ½″ tape (weighs 35#). Uses 12 VDC source; low power consumption.



PI-7100
Video/Instrumentation
Captures video, radar, RF, multiplex, telemetry . . . any broadband data up to 1.5 MHz, or video up to 3.5 MHz. Operates for 90 minutes on a 10½″ reel of tape using helical scan transport. Includes VariScan™ and StopScan™ playback.

PI-1200 Digital
Read/Write, IBM compatible: 7 or 9 track formats. Three modes: high speed, slow, and incremental.

PI-6200 Portable Instrumentation
Lab quality. Pushbutton operation. Low-cost ¼″ tape. Up to 8 channels with three switchable FM or Direct record/reproduce speeds—0.375, 3.75, 37.5 ips—provide time contraction or expansion in 1:10:100 ratio. Optional loop adaptor and remote control. Operates on any power: 105 to 125 or 210 to 250 VAC; 48 to 400 Hz + and −12 VDC.

PI-2100
IRIG Portable
Records/reproduces up to 14 tracks of FM or Direct data. Snap-on reel or loop magazines, vibration isolation mounts, and many more accessories available "off-the-shelf" to increase versatility.

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Circle 148 on reader service card

Meter has 0.1% accuracy

$380 price puts 3½-digit multimeter in gap between analog and 0.01% digital instruments

Small drop. When measuring current, the 1240 has a voltage drop across it no greater than 0.2 volt. The meter's frequency range is 40 hertz to 20 kilohertz.

To hear him tell it, Tom Kelly's best customer is going to be Tom Kelly. Weston Instruments' 1240, a 3½-digit multimeter, is "just what the boys in my group have needed for a long time," he says. Kelly heads the team of Weston engineers who designed the 1240, which will make its debut at Nerem (Boston, November 5-7) along with the 1241, a digital volt-ohmmeter.

The 1240 features low price, accuracy and versatility. Selling for $380, the instrument's accuracy is ±0.1% of the reading ±0.5% of full scale when measuring d-c voltage. And in addition to five d-c voltage ranges, from 0.2 volt up to 1,000 volts, the 1240 measures a-c voltage in five ranges, from 200 millivolts to 500 volts and d-c and a-c current, each in five ranges from 200 microamps to 2 amps. It also reads resistance in six ranges, from 200 ohms to 20 megohms.

Assuming the user's viewpoint, Kelly says: "The $200 multimeters, like the Simpson 260, don't have enough accuracy for us, and we just can't afford to hand everybody in the lab a $1,000 or $2,000 instrument (whose accuracy is 0.01% or better). The 1240 fills this gap and meets the needs of most engineering laboratories." And Jack Stegenga, Weston's new product manager, predicts that the 1240 also will be popular for field testing—it accepts a special battery pack—and in production-line work—it can be panel-mounted.

When measuring d-c voltage, the 1240 has an input impedance of 100 and 1,000 megohms, respectively, for its 0.2-volt and 2-volt ranges. For the higher ranges, the impedance is 10 megohms. For a-c voltage applications, the impedance is 1 megohm and 50 picofarads. And accuracy is 0.5% reading ±1 digit for input frequencies between 40 hertz and 10 kilohertz. From 10 to 20 khz, the accuracy is

. . . dual-slope converter is the basic circuit . . .

1% ±1 digit.

Low drain. The 1240, when working as an ammeter, doesn't drain much from a circuit—the voltage drop across it is just 0.2 volt. Accuracy for d-c current readings is between 0.2% ±1 digit and 0.5% ±1 digit, depending on the range. For a-c readings, the accuracy is 1% ±1 digit or better for input frequencies between 40 hz and 10 khz.

Accuracy for all but the highest resistance range is 0.5% ±1 digit; for the 20-megohm scale it's 2%. "This means you can measure both precision resistors with 0.1-ohm resolution and those high-megohm carbon resistors," says engineer Kelly.

At 60 hz, the 1240 has a common-mode rejection ratio of 80 decibels and a normal-mode rejection ratio of 35 db. It makes five readings per second and operates on either 115 volts, 60 hz or 230 volts, 50 hz.

The 1240's basic circuit is a dual-slope converter, identical to the one used in the 1292, Weston's digital panel meter. "We have a tried and proven design," points out product manager Stegenga. Connected to the dual-slope circuit is an average-responding converter which measures a-c.

Although Weston runs against plenty of competition in the dpm market, Stegenga doesn't expect the 1240 to face many challengers. "Oh, a few companies will jump in," he says. "Anybody can build a dpm, but it takes experience to put together the circuits needed for a 26-range meter."

At Nerem, Weston also will introduce a less complex version of the 1240. Called the 1241, this meter measures only d-c voltage and resistance, and will sell for $325. While the 1240 may have a market all to itself, the 1241 is going against an entrenched foe. "Fairchild came along and made this market (for a digital volt-ohmmeter) with its 7050," says Stegenga, "and now we want a piece of it."

Delivery time of both the 1240 and 1241 will range from stock to six weeks.

Weston Instruments Division, 614 Frelinghuysen Ave., Newark, N.J. **[339]**

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Circle 151 on reader service card

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Time-sharing traffic cop

Minicomputer can do concentration, pre-processing; will handle communications for 96-terminal system

Suppose you have to process data coming into a central point from up to 96 terminals—including teletypewriter, and low- and medium-speed asynchronous modems and binary devices—and being transmitted at up to six different baud-rate combinations simultaneously. You can program a general-purpose computer to do the job, but you might be tieing up an expensive machine for this data-communications task.

To avoid the need for costly tieups of this kind, data-processing system designers are developing special machines to handle communications [*Electronics,* March 31, p. 154].

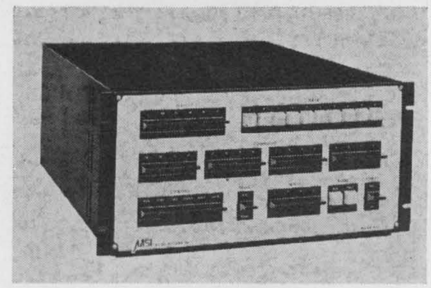
At the Fall Joint Computer Conference, Nov. 18-20 in Las Vegas, Micro Systems Inc. will introduce its entry, the Micro 812.

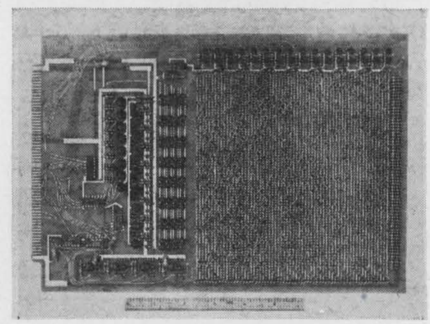
William Roberts, MSI's vice president for research and engineering, says a typical application of the microprogramed Micro 812 might be in a time-sharing system in which data from a number of lines is to be concentrated down to one phone line. "But we're not selling a concentrator," Roberts stresses. "We're selling a computer that can do concentration." MSI is aiming the machine at original equipment manufacturers for use as an interface unit to do data concentration, or as a pre-processor for larger computers "to free the larger computer from data communications worries," as Roberts puts it.

Not many machines like the Micro 812 are available, says Roberts. Interdata is the only other firm that he knows of offering a microprogramed minicomputer specifically for data communications applications, and that machine can't handle as many input devices as MSI's can.

Stored program. A microprogramed computer's control unit holds a stored program, while a fixed control machine is hard-wired. The program in the control unit can be quickly changed from one application to another, and tailors the computer for a given job without changing the hardware implementation. In the Micro 812, MSI officials say, 16 powerful microcommands are available to optimize the machine for the data-communications job, with microcommand word lengths of 16 bits. In effect, microprograming in the machine simplifies most input/output interface requirements because the data from the teletypewriters or modems is timed and buffered internally without additional hardware or software.

In the Micro 812, the microprogram is contained in a discrete diode read-only memory with a 220-nanosecond cycle time. The basic





Microprogramed. Memory card, bottom photo, carries diodes that perform microprograming in the 812. Diodes take up right half of card.

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Circle 153 on reader service card

. . . first unit handles inventory system . . .

machine, which includes a 4,096-word by 9-bit core memory for the user's program, sells for $10,000. Each group of 24 input lines dictates a need for an additional interface board in the computer. Besides handling the 96 low-speed teletypewriters (up to 360 bauds), the machine can be arranged to accommodate a maximum of 32 medium-speed input lines (less than 9,600 bauds). Each interface board will permit the computer to handle 24 additional teletypewriters or 16 additional modems.

Reserve. Roberts says a small computer without microprograming would have half its I/O capability consumed in handling 16 teletypewriters; by contrast, the Micro 812 can accommodate its maximum 96 lines and mixed baud (bits per second) rates—110 bauds, 134.5 bauds, and 150 bauds, for example—using only 70% of its I/O capability.

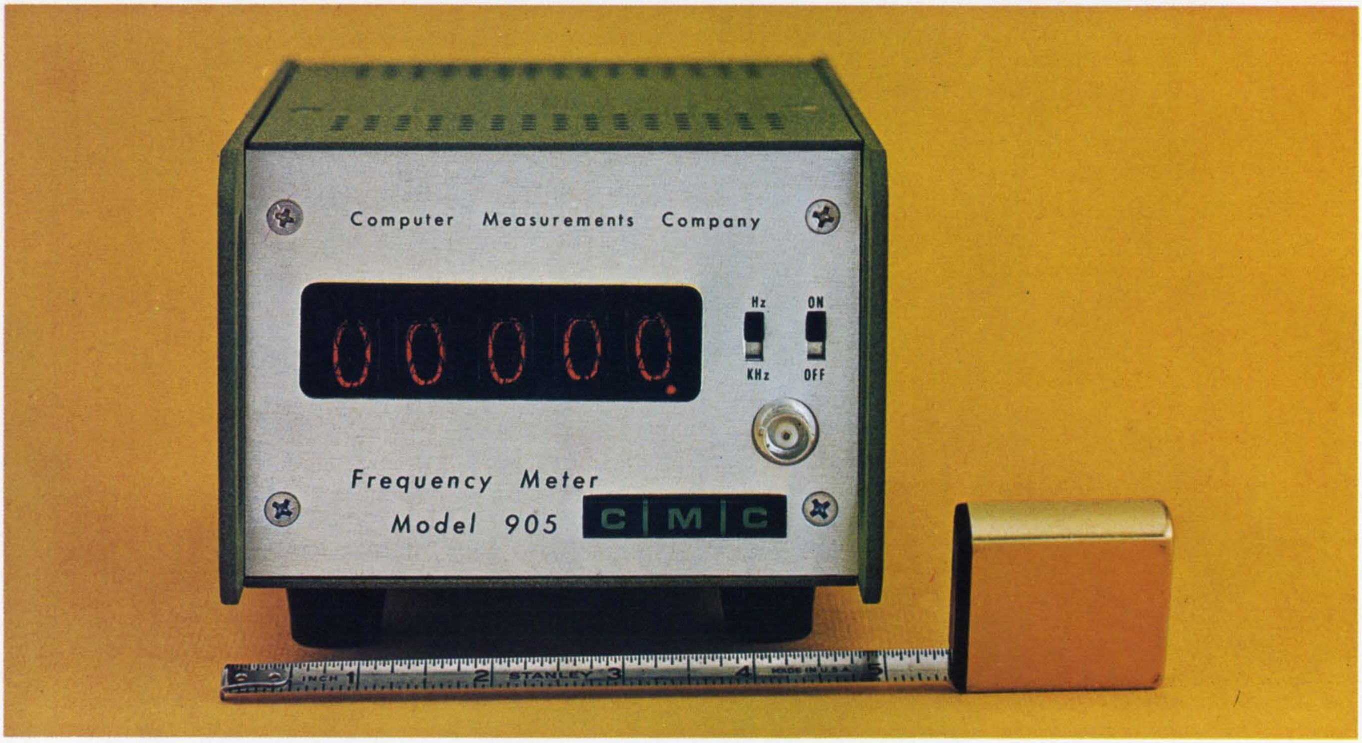
In performing the I/O function of the teletypewriters, the microprogramed read-only memory samples the inputs, reconstructs the characters it "sees" on a given input line, and, in a time-sharing system, may store a line of data—a printed line—before sending it to the central processor. Besides the microprogramed processor and core memory, the basic machine includes a systems control panel, power supply, power-fail-automatic restart, memory parity, a real-time clock, six communications rate clocks, and provisions for additional communications interface boards. The unit is 8¾ by 17⅗ by 23 inches.

The first Micro 812 machine went this month to Rydacom, a subsidiary of Ryder Systems Inc. of Miami, Fla., for use in an on-line warehouse inventory control system. MSI's Roberts expects the Micro 812 to account for some 30% of his firm's business next year; since introducing the Micro 800 and Micro 810 early this year, MSI has booked $3 million worth of business from those two machines.

Typical delivery time for the Micro 812 will be 60 days.

Micro Systems Inc., 644 East Young St., Santa Ana, Calif. 92705 **[340]**

Why pay $595 when you can have this 15-MHz counter for only $395?



WHAT!

For less than $80 per digit?

The CMC Model 905 is by far your biggest buy in a little counter. You get 15-MHz IC performance, 5-digit readout, a 1-MHz crystal oscillator, an automatic trigger level, simplified controls, and a convenient tilt-up stand—all in a tiny package only 5-inches wide and 3½-inches high.

This mighty little counter weighs only 3½ pounds, and yet it's a reliable workhorse for production line or laboratory. Its IC design results in increased reliability, improved heat dissipation, and reduced power requirements of only 8 watts typically.

Now, the low-cost high quality Model 905 brings an integrated-circuit frequency meter within the budget of every user, both large and small. If you need an instrument for making accurate frequency measurements up to 15 MHz, the Model 905 will give you maximum counter-for-your-dollar. So if it's frequency you are measuring, why pay double the 905 price for functions you don't intend to use?

CMC sales representatives in all major cities are ready now to bring a Model 905 directly to you for a personal test demonstration. Test one. (You'll be glad you did.) Buy several. (They're very small.)

For the full specs, just circle the reader service card; and for a demonstration, contact your local CMC representative.

COMPUTER MEASUREMENTS
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Hybrid power amp puts out 100 watts

First of a new line uses 'heat-spreading' technique; unit aimed at servo and aircraft intercom applications

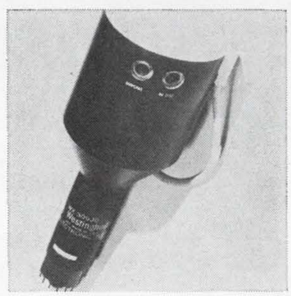
Dissipating heat from hybrid power amplifiers can be a difficult problem. And usually, the solution makes the hybrid device prohibitively expensive for all but the most demanding military and industrial applications.

But RCA's Electronic Components division believes it has an inexpensive answer to the heat problem. In fact, so convinced are division officials that they've given the go-ahead for a whole line of hybrid power amplifiers, the first of which is now ready for the marketplace.

Called the TA 7625, this first device measures 2½ by 3 by 1¾ inches and develops 100 watts output with 40 watts dissipation. According to Warren Totten, the division's marketing manager for circuit modules, it can be used in servo applications to power such things as tape drives, in intercom and entertainment systems aboard aircraft, or as a power operational amplifier. The last application is possible, says Totten, because "you can adjust the gain externally."

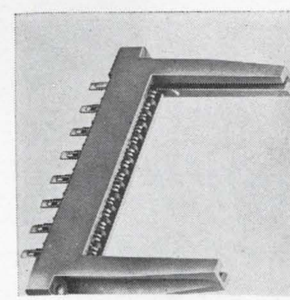
Containing two output power transistors, eight diodes, nine transistors, 23 thick-film resistors, and

Miniature multipin connectors feature a 7/16-28 threaded coupling. With 5 key mechanical polarization one shell size of ½ in. max. o-d is available in 3, 5, 7, and 9 power contacts and in combinations of coax and power types. All are rated at 1 amp. Insulating materials are fused glass or molded thermosetting compound. Ted Mfg. Corp., Shawnee Mission, Kan. [341]

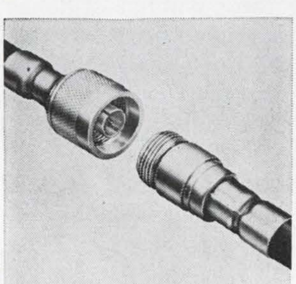


Split-screen storage tube permits stored information to be displayed on part of the screen while data is continuously read out on the remaining part. It is ideal for use where it is advantageous to visually compare known and unknown data. The tube is useful in commercial and industrial as well as medical intrumentation. Westinghouse Electric Corp., Pittsburgh, Pa. [342]

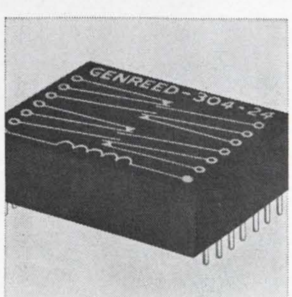
Alumina insulated bushing assembly AB1 provides electrical isolation for variable air dielectric trimmer capacitors mounted on conductive chassis or other surfaces. It has a resistance rating of 10^6 megohms, and can be used with any standard air trimmer with a 15/64 in.-64 threaded bushing. Price in lots of 100 is $2 each. Voltronics Corp., West St., Hanover, N.J. [343]



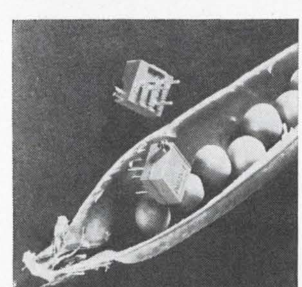
Card-edge connector 6030, available with 15 single-readout or 30 dual-readout contacts, offers a choice of terminations that includes solder (wire hole or p-c tab), taper tab, and low-cost wire wrap post. Current rating is 5 amps, with a contact resistance of 6 milliohms. Insulation resistance exceeds 25,000 megohms. Elco Corp., 155 Commerce Dr., Fort Washington, Pa. [344]



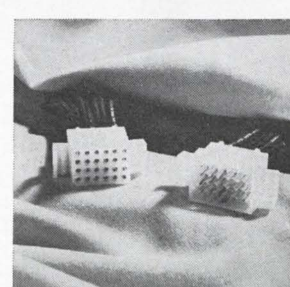
Fully crimpable N series coaxial connector is designed to exceed performance requirements of MIL-C-39012. The contact is first crimped onto the cable center conductor and then the braid is securely crimped. This 50-ohm coaxial connector performs to 11 Ghz with a typical swept frequency of 1.15 vswr. Cable retention force exceeds 125 lbs. AMP Inc., Harrisburg, Pa. [345]



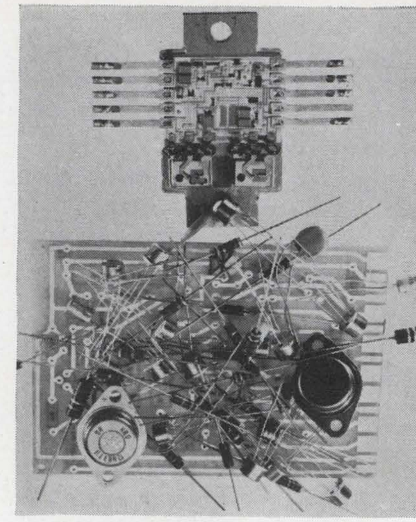
Multicircuit reed relays series 300 contain various combinations of spst and spdt miniature magnetic reed capsules in a molded housing. Electrical connections to capsules and operating coils are made by contact pins on standard 0.100-inch grid spacing for p-c boards. Standard coil operating voltages are 6, 12, and 24 v. General Reed Co., 19 Walnut Ave., Clark, N.J. 07066 [346]



Center-tap ⅜-inch trimmer potentiometer model 75SCT features resistance values from 100 ohms to 20 kilohms and standoffs for easy board washing. Its diallyl phthalate case is impervious to all normal cleaning solvents. An "O" ring seals the adjustment shaft to protect internal parts against severe environments. Techno-Components, 7803 Lemona Ave., Van Nuys, Calif. [347]



Miniature connector 1625-24 is a 24-circuit device having a nylon body with integrally molded mounting ears on both plug and receptacle. It accepts crimp-type terminals available in tin-plated brass, phosphorous bronze, and gold or silver-plated brass. The connector has applications in business machines and computers. Molex Products Co., Katrine Ave., Downers Grove, Ill. [348]



New and old. Hybrid module does job of discretes shown at bottom.

seven ceramic chip capacitors, the device's 3-decibel response is from 20 hertz to 55 kilohertz at 60 watts power level. But Dale Baugher, engineering applications leader, points out that what makes the device work is the way heat is dissipated.

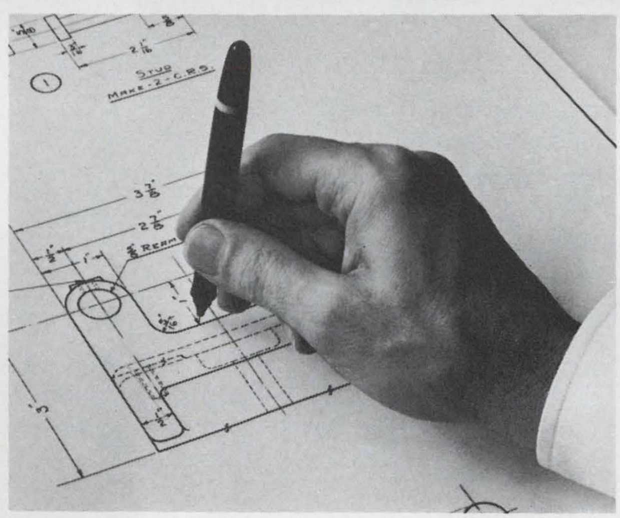
Both output transistors, which are equivalent to RCA's 2N3055 chips, are mounted on copper blocks, or heat spreaders, as Baugher calls them. Because these heat spreaders are about six times the size of transistor chips, the heat generated by the chips can spread over this larger area at about a 45° angle, thus reducing its intensity per unit area. With the heat spread out this way, it is also possible to use relatively inexpensive alumina to electrically isolate the output transistors, instead of higher-priced beryllia.

Although the customer still has to heat-sink the entire device, "we've at least made it possible for him to do this with ease because the heat is so evenly spread out," says Baugher.

Main customers. Priced at $80, the seven-amp peak linear amplifier, as Totten prefers to call the device, is still too expensive to be used in consumer electronics products. "Our primary emphasis will be for military and industrial applications. But within three years we expect to be able to get the price down to between $10 and $20, where it would be attractive for audio circuits," says Totten.

RCA Electronic Components, Somerville, N.J. 08876 **[349]**

Class Mates



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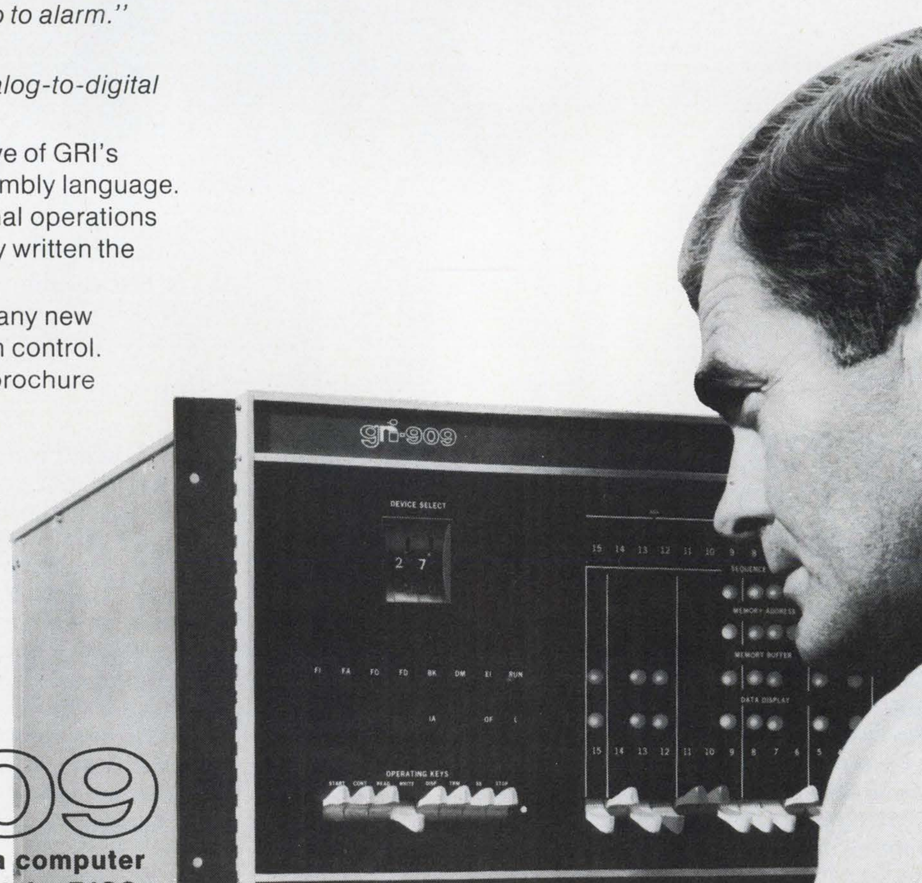


gri-909

You have never seen a computer like this before. See it at the FJCC.

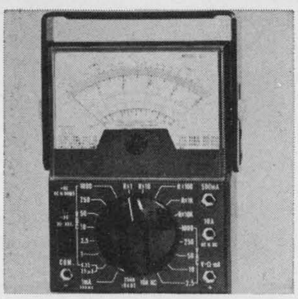
Voltmeter tells all—for $650

Instrument for testing field radars, avionics gear measures total voltage, fundamental voltage, phase

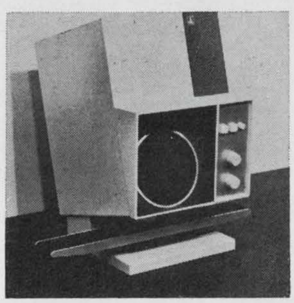
Taking measurements at a radar site on a cold, rainy day is bad enough; if you have to do some calculating while out there, your normally pleasant disposition might be totally shattered. To help make field testing and calibrating of radars, avionic equipment, and air traffic control gear a quick affair, engineers at North Atlantic Industries Inc. designed the 210 phase-angle voltmeter. Besides measuring a signal's total voltage, the 210 knocks the distortion out of a signal, and then measures the voltage of the signal's fundamental, the voltage of the fundamental's in-phase and quadrature components, and the fundamental's phase angle.

The 210 has 11 ranges, from three millivolts full scale to 300 volts. When measuring the total voltage only, the 210's frequency range is 20 hertz to 40 kilohertz. When making the phase-dependent measurements, the instrument works with signals whose frequencies are within 5% of 400 hz.

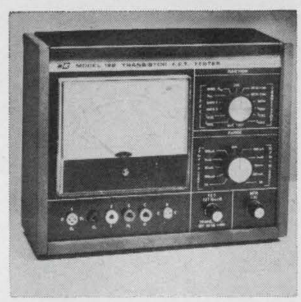
If the user wants simply to measure voltage, he connects the unknown signal to the 210, turns the function switch to TOTAL, sets the range, and reads the voltage off



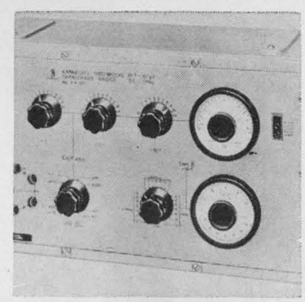
Precision multimeter model 61 features 50,000 ohms per volt sensitivity, protection of the 17μa movement against overloads of up to 100,000% in either direction, accurate response to frequencies up to 100 khz. Ranges starting at 250 mv d-c and 25 μa d-c can measure as low as 5 mv and 0.5 μa. Scientific Educational Products Corp., 30 E. 42nd St., N.Y. 10017 [361]



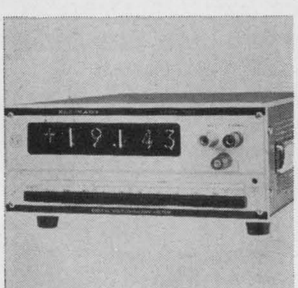
Projection surface analyzer called Surfaspec detects macroscopic imperfections and projects them for display on an eight-inch screen. It is especially suited for examination of polished and epitaxial silicon wafer surfaces. Price is in the $2,850 range, with delivery 6 to 8 weeks ARO. Applied Materials Technology Inc., 2999 San Ysidro Way, Santa Clara, Calif. 95051 [362]



In-circuit and out-of-circuit tests are possible without removing transistors or without change in basic procedure with the model 162 transistor/FET tester. Measuring 9 x 7¼ x 4 in., the d-c operated unit weighs 6 lbs. It is battery operated for complete portability. It is priced at $99.95. Dynascan Corp., B&K Division, 1801 W. Bells Plaine Ave., Chicago, 60613 [363]

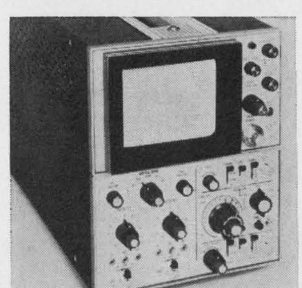


Capacitance bridge R-127 can provide immediate mutual capacitance measurements at frequencies to 1 Whz. This capability is made possible by balanced input terminals. Accuracy is ±0.1%. Primary use of the R-127 is measurement of 3-terminal networks, and small ungrounded or single ended capacitances. Siemens America Inc., 350 Fifth Ave., N.Y. [364]

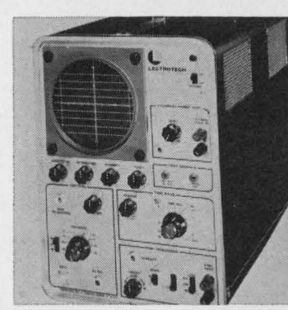


Volt/ohm/amp meter model 1820 is a 0.01% unit with 4 digits of display. It features 100% overrange, auto polarity and pushbutton operation. It provides 5 voltage and resistance ranges from 0.01 mv to 1,000 v and 0.1 ohm to 19.999 megohms, with d-c amps from 0.001 μa to 1,000 ma in 6 ranges. Eldorado Electrodata Corp., 601 Chalomar Rd., Concord, Calif. [365]

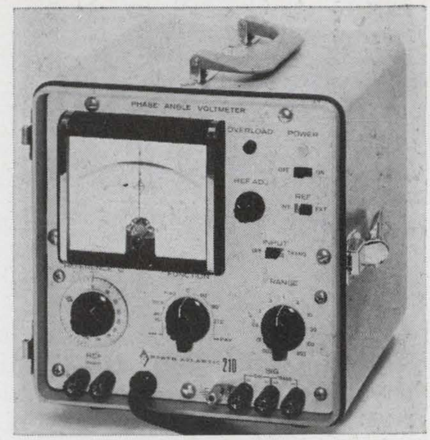
Manual balance digital indicator MDX-11 is used with bonded strain gage force and pressure transducers with 2 mv/v or 3 mv/v output signals. Full scale output is 100,000 counts with a 30% overrange capability. A course control knob of 12 add-to steps of 10,000 counts each is included. Accuracy is 0.05%. Transducers Inc., E. Rivera Rd., Santa Fe Springs, Calif. [366]



High frequency, dual channel oscilloscope 1050 offers a triggering device that eliminates trace flicker. Another advantage is maintenance of signal synchronization regardless of the vertical positioning of either trace. Unit also features sensitivity to 1 mv/cm from d-c to 25 Mhz in both channels with X10 gain. Dumont Oscilloscope Laboratories Inc., W. Caldwell, N.J. [367]



Triggered sweep, 5-in. oscilloscope/vectorscope TO-50 offers features normally found only in lab-quality test instruments at a price of $329.50. Features include 10-Mhz bandwidth; d-c amplifiers to eliminate pattern bounce, permit viewing a-c and d-c simultaneously; and calibrated vertical attenuator and horizontal time base. Lectrotech Inc., 4529 N. Kedzie Ave., Chicago [368]



Field service. Phase-angle voltmeter is designed for on-site testing.

the 210's zero-in-the-center scale. Inside the instrument is an amplifier followed by a rectifier and additional measuring circuitry.

To measure the fundamental, the user just switches to FUND; this puts in front of the amplifier a bandpass filter, centered at 400 hz. The scale shows the fundamental.

Next the user connects a 400-hz reference signal to the 210 and switches to the 0° setting. The reference turns the rectifier into a phase-sensitive demodulator which passes only that part of the input's fundamental that's in phase.

Turning the REFERENCE ϕ dial shifts the reference. The dial is scaled in degrees, and by peaking the meter with this dial, the user can determine the phase angle to within 3°.

Switching to the 90° position shifts the reference 90°, making the voltage measured by the instrument the quadrature component. The function switch has also 180° and 270° settings in case the input lags behind the reference.

The 210's accuracy for voltage measurements is 2%, and the instrument resolves 100 microvolts.

Running off a 115- or 230-volt line, the meter draws 40 watts. The power line frequency can be any value between 45 and 440 hz.

There are three models of the 210. The 210B, which routes the reference through an isolation transformer, costs $575. The 210C, which has transformers in both channels, costs $650. The 210/10, a low-accuracy model, costs $490.

North Atlantic Industries Inc., Terminal Dr., Plainview, N.Y. 11803 **[370]**

Pot promises 0.01 ppm accuracy

Unit compares two voltages by switching from one to the other; price is $6,550

When it comes to getting accuracies better than one part per million, engineers at Julie Research Laboratories Inc. suggest ordering a double—that is, a double-voltage potentiometer.

As the Julie people tell it, there are three ways to make high-accuracy comparisons. One is to use a single potentiometer. First the engineer connects one of the voltages to the potentiometer and adjusts it until he zeroes a null meter, also attached to the pot. Then he disconnects the first voltage, connects the second, and nulls again. Because the voltages aren't being measured simultaneously, drifts cause significant error.

A second approach is to use two potentiometers and two null meters. Drift problems are gone, but the cost is obviously doubled, and errors creep in because no two systems are identical.

The third and best approach, according to Julie, is to use a double-voltage potentiometer, such as the DVP-108J that the company is introducing. A single potentiometer, it can be switched from one voltage to another. This results in very-high accuracy. At worst, the accuracy is 0.1 ppm. But when the voltages being compared are close in value, the accuracy can be 0.01 ppm.

Aside from the technique itself, high stability resistors also account for the pot's accuracy. The instrument generates no more than 1 picovolt of thermal electromotive force, and the oil-immersed standard resistors in some circuits have a ratio stability of 0.2 ppm per year.

By itself, the 108 is priced at $6,550. But with Julie's ND-107 null detector/preamplifier, the instrument's price is boosted to $7,100.

Julie Research Laboratories Inc., 211 W. 61 St., New York, N.Y. 10023 [371]

Dvm nudged into market

Dana's 5½-digit unit, with multimeter plug-ins, competes with Fluke entry

The lowest-priced 5½-digit voltmeter with full multimeter capability—that's how Dana Laboratories describes its models 5230/550 (full rack width and 3½ inches high) and 5270/550 (half-rack width and 7 inches high). They sell for $1,395 as basic dvm's.

Dana says the nearest competitor is the model 8300A from the John Fluke Manufacturing Co., which sells for $1,295 without any options. But a Dana spokesman points out that its machines incorporate a millivolt-measuring capability in the basic price while the Fluke instrument offers this as an option. And a potential buyer looking for full multimeter capability finds a price tag of $2,095 for the Fluke instrument vs. $1,995 for Dana's.

Temptation. Bart Weitz, product marketing manager in the measurements division, says the instruments have been in development for some time, but their introduction wasn't hurried because no moderately priced 5½-digit machine existed to tempt possible buyers of higher-priced Dana units away from them. Then along came Fluke, so in comes Dana.

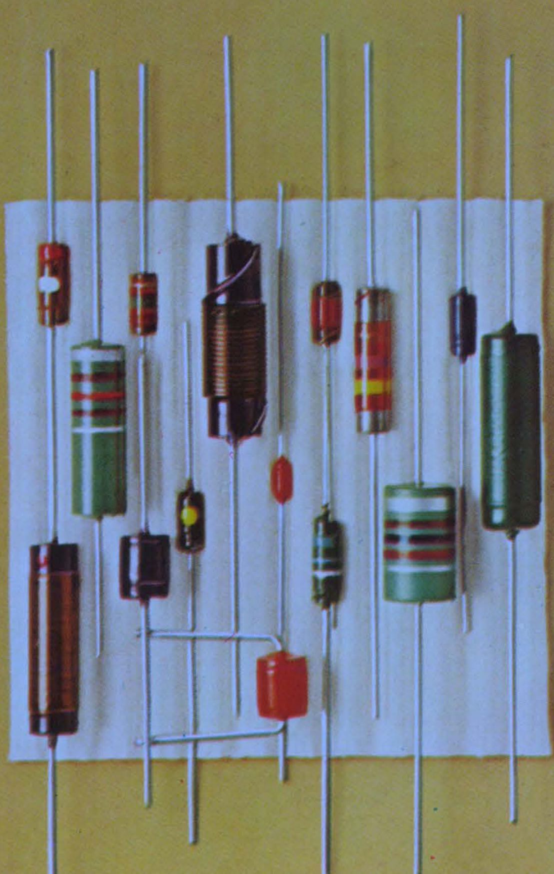
The models 5230 and 5270 offer basic autoranging d-c volts measurement from 1 volt to 1,000 volts plus 20% over-ranging

The two options that give the Dana units the full multimeter performance—a-c and ohms measurement—cost $450 and $150, respectively. The a-c option provides measurements at 1, 10, 100 and 1,000 volts rms in a range from 50 hertz to 100 kilohertz.

Additional options are an analog output to drive a strip chart recorder, $50; d-c to d-c ratio, $100; and binary coded decimal output, $250. Delivery time is 45 days.

Dana Laboratories Inc., 2401 Campus Drive, Irvine, Calif. 92664 **[372]**

Have coils gone about as far as they can go?



Chances are, you're using some pretty darned good coils right now. So you may have decided that you'll never be able to find any better ones. □ Nonsense. □ If you aren't using our brand at the moment, the solution is simple. Switch. You'll get a noticeably higher degree of reliability. (After all, we've been the leader in R. F. chokes ever since the days we helped establish the military specifications for inductors.) We also deliver a greater depth of technical assistance. And our prices? Very competitive. □ Or perhaps you're already using our coils. If so, the future is still promising. Because we'll be continuing to improve our present models and develop new ones. □ For a sample order of our pace-setting coils, write AIRCO SPEER ELECTRONIC COMPONENTS, St. Marys, Pennsylvania 15857. □ Then see where they go from here.

Ask the passive innovators at AIRCO Speer

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

Kit provides self-reversing for cassettes

Package for equipment makers uses small 2-channel record/play head to minimize hum pickup; erase heads are made of ferrite material

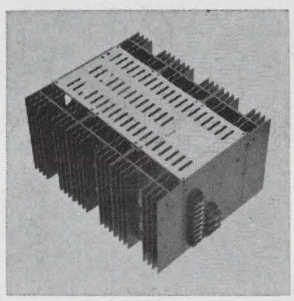
In the consumer area, sales of audio tape recorders run second only to color tv. And the rivalry between 8-track stereo and cassette systems grows sharper as equipment makers introduce such improvements as faster forward-and-rewind capabilities for 8-track tape players and automatic reversing for cassettes.

To provide self-reversing for cassettes, Michigan Magnetics has developed a two-channel record/play head that is set in the middle of two erase heads and tape guides, all mounted on a nest assembly. The company says it selected this design instead of a four-channel head because the two-channel equipment will require fewer adjustments on the part of the listener and will reduce interaction between channels.

Donald P. Humphry, the marketing manager, says "Our record/play head also is 20% to 30% smaller than any cassette head we've seen. This makes the head much less susceptible to hum pickup, a major problem with units designed for the hi-fi market."

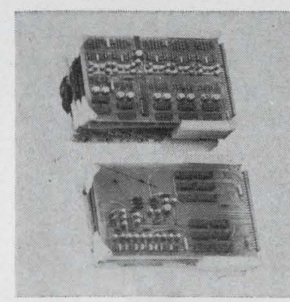
For the original equipment manufacturer, the packaged assembly offers the advantage that, since it

Line-operated, regulated, h-v power supplies series ARA-106 have an output from 4 kv to 18 kv. Ripple is less than 0.1%. They are designed for use with crt's, image pickup, display and phototubes, and as a general-purpose high voltage source. Operating temperature is —20° to 75° C. Advanced High Voltage Co., 8635 Yolanda Ave., Northridge, Calif. [381]

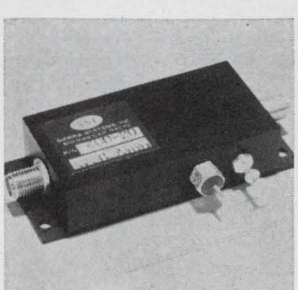


Inverter series P24 converts 22-26 v d-c to 115, 220 or 440 v a-c, 60 hz at 240 v-a. Inputs and outputs are isolated. Regulation is within ±0.2% for input variations of 22 to 26 v d-c, and is within 1% limits for load changes of ½ to full load. Output voltage is adjustable ±10% from nominal. Abbott Transistor Labs Inc., 5200 W. Jefferson Blvd., Los Angeles [382]

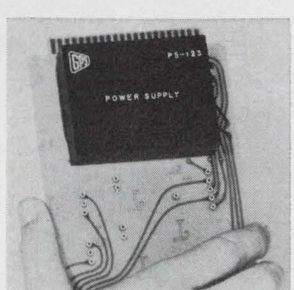
Sine wave tuning fork oscillator model 16B05's output is a short-circuit protected sine wave featuring a maximum harmonic wave form distortion of only 5%. Frequency may be specified from 360 hz to 15 khz. Input voltage is 22 to 32 v d-c with current dependent upon frequency (25 to 35 ma). Price is $148 in 100 quantity. Barden Co., 2217 Purdue Ave., Los Angeles [383]



Memory systems Alpha 10.2 and 12.2 feature modular construction. Basic modules come in sizes of 10,024 to 40,960 bits. Cycle times are 1.50 μsec for the 10.2, which has a maximum size of 1024 x 10, and 1.75 μsec for the 12.2, with module capacities to 4,096 x 10. Units occupy 65 and 130 cu in. respectively. Tetra Corp., 7273 Washington Ave., S., Minneapolis 99435 [384]

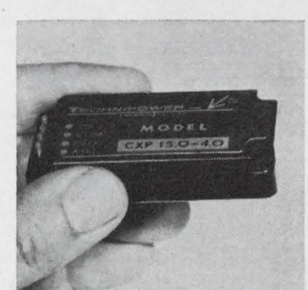


Wideband r-f amplifier model 400-20 is constructed using hybrid thick film techniques assuring high reliability and small size. It has a 1-db bandwidth from 500 khz to 400 Mhz. Gain is 20 db, ±1 db. Noise figure is a maximum of 4 db and vswr (input and output) is 2:1 max. Price is $275. Sierra Systems Inc., 2255 Old Middlefield Way, Mountain View, Calif. [385]



Encapsulated power supplies are designed to power operational amplifiers and function modules. Four units are available to supply ±15 v d-c: PS-121, 50 ma; PS-122, 75 ma; PS-123, 100 ma; PS-124, 200 ma. Single units are priced at $38, $51, $79, and $198 respectively, with quantity discounts offered. GPS Instrument Co., 14 Burr St., Framingham, Mass. [386]

H-f receiver model RA6218 features an electronic counter with a 7-digit display, locked to a built-in high stability crystal frequency source, enabling the operator to read the receiver tuned frequency to within 10 hz. Frequency range is 1 to 30 Mhz. The unit measures 5¼ x 19 x 17½ in. Racal Communications Inc., 8440 Second Ave., Silver Spring, Md. [387]



D-c/d-c positive or negative point-of-load regulators CX-95 come in 14 models with outputs from 3 to 24 d-c at 4 amps and inputs from 7 to 35 v d-c, depending on model. Input ripple reduction is better than 200:1. Built-in short-circuit protection is also featured. Price is $45 each, with quantity discounts available. Technipower Inc., Benrus Center, Ridgefield, Conn. [388]

comes prealigned in height, zenith and azimuth, it can be mounted on the cassette deck without further alignment.

A major difficulty in designing a reversible cassette system has been the need to maintain compatibility with the basic cassette design, to preserve the existing package configuration and tape format. The reversing features should not alter head dimensions or package openings, for example.

To keep the erase heads small enough to satisfy this design constraint and also protect against overheating at erase frequencies of 70 to 90 khz, the heads are made of a ferrite instead of a conventional mu-metal. The company says the ferrite can accommodate sufficient current to allow an erase level of 60 db without using a pressure pad, because of the efficiency of the magnetic circuit used in the erase heads. According to Michigan Magnetics, mu-metal heads would have to be driven so hard —to match this level of erasure— that overheating would result.

The company points to another feature of two-channel heads over four-channel types: there is no need for internal switching circuits in the tape recorder when shifting from forward to reverse drive. With four-channel heads, circuitry would be required to select the proper pair for each direction. Also, each time the tape switches direction, the user would have to readjust his amplifier to balance channels, since a new pair of tracks would be introduced.

The automatic head-reversing mechanism, in the form of assemblies called K-sets, will be sold to OEM's at \$11 to \$13 each, depending on quantity of the order.

Specifications

Record/playback head	
Impedance 1 khz	550 ohms
Record level	—12 db
Audio current	.025 ma
Bias current	.30 ma
Bias frequency	70 khz
Playback level	
at 1 khz	.20 mv
10 khz	—10db
Cross talk	35 db @ 1 khz
Tape speed	1⅞ ips
Erase head assembly	
Impedance @ 70 khz	120 ohms
Erase frequency	70 khz
Erase current	110 ma
Erasure 400 hz	60 db
Tape speed	1⅞ ips

Michigan Magnetics, Vermontville, Mich. 49096 **[389]**

CROWBAR ...?

The One Inside is FREE

Not so many years ago, the prudent transmitter engineer discharged a high voltage capacitor bank by dropping a shorting "crowbar" across its terminals. Today's "crowbar" is a protective overvoltage circuit found on DC power supplies — usually at extra cost. Now HP includes a crowbar as standard on its recently updated series of low-voltage rack supplies . . . at no change in price.

Long established as preferred system supplies for component aging, production testing, and special applications, these supplies have now been redesigned and expanded to meet the stringent demands of today's power supply user. Advantages include low ripple (peak-to-peak as well as rms), well-regulated constant voltage/constant current DC with outputs to 60 volts and 100 amps.

Where loads are critical and expensive, the extra protection — say, against inadvertent knob-twiddling — from a crowbar is invaluable. On all internal crowbars in this series, the trip voltage margin is set by screwdriver at the front-panel.

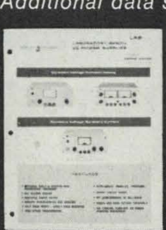
Pertinent specifications are: triggering margins are settable at 1V plus 7% of operating level; voltage ripple and noise is 200 μV rms/10mV peak-to-peak (DC to 20 MHz); current ripple is 5 mA rms or less depending on output rating; voltage regulation is 0.01%; resolution, 0.25% or better; remote programming, RFI conformance to MIL-I-6181D.

Prices start from $350. For complete specifications and prices, contact your local HP Sales Office or write: Hewlett-Packard, New Jersey Division, 100 Locust Avenue, Berkeley Heights, New Jersey 07922 or call (201) 464-1234 . . . In Europe, 1217 Meyrin, Geneva.

Additional data sheets available upon request

HEWLETT hp PACKARD

POWER SUPPLIES



LAB SERIES

smaller package, lower power, optional crowbar

331

CROWBARS

A Technical Discussion

332

1969 Power Supply Catalog

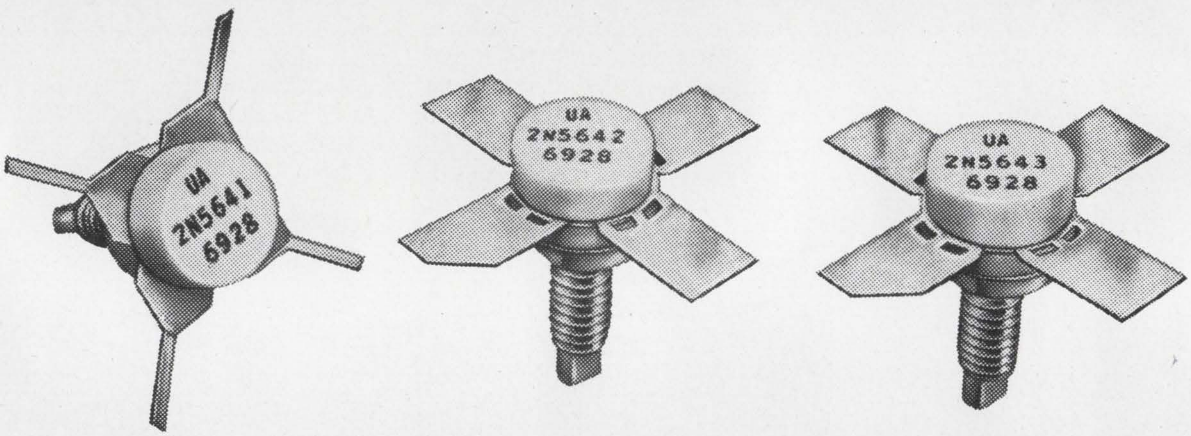
— includes total HP power supply line.

333

Circle # for details 330

21902B

3 new RF power transistors — 7w, 20w, 40w @ 175 MHz



APPLICATION	DEVICE	FREQUENCY (MHz)	Power Out (Watts)	Power Gain (Min. dB)	Efficiency Min. (%)	f_t (Typ.) (MHz)	T_j	V_{cc}	Case
Class AB, B&C VHF Amplifiers	2N5641	175	7.0	8	60	400	200	28	CT-01
			5.0 Typ.					13.6	CT-01
	2N5642	175	20.0	8	60	400	200	28	CT-02
			10.0 Typ.					13.6	CT-02
	2N5643	175	40.0	7.5	60	400	200	28	CT-02
			20.0 Typ.	7.5	60	400	200	13.6	CT-02

- **Large signal specifications**
- **Low inductance ceramic stripline packages**
- **Tantalum nitride emitter ballasting resistors**

These units are the latest members of a growing family of RF power transistors from United Aircraft. They qualify for AM-FM mobile or portable military and industrial applications. With an applied voltage of 28V, they provide output powers of 7W, 20W and 40W. At 13.6V, typical outputs are 5W, 10W and 20W.

S-Parameter data available. United Aircraft has installed a Hewlett-Packard Model 8542A Automatic Network Analyzer. It gives circuit designers valuable assistance during preliminary design. This enables ECD to recommend a semiconductor that is truly compatible with the circuit requirement.

Also available: 2N4429, 2N4430 and 2N4431 RF power transistors in stripline and hermetic packages. **Our latest RF catalog** lists data on these and other devices in our line including: 2N3553, 2N3632, 2N3866, 2N5090, 2N3375, 2N3733, 2N4440, 2N5016, 2N4428 and 2N4012.

For RF power transistors for all VHF, UHF and microwave applications, write or call:

Electronic Components DIVISION OF **United Aircraft** ®

TREVOSE, PENNSYLVANIA Tel. 215-355-5000 TWX: 510-667-1717

West Coast Office: 128 E. Katella Ave., Orange, Calif. (714) 639-4030

DESIGNERS AND PRODUCERS OF • RF AND MICROWAVE TRANSISTORS • CUSTOM HYBRID CIRCUITS • MONOLITHIC INTEGRATED CIRCUITS • SEMICONDUCTOR DICE

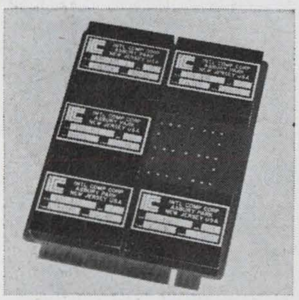
Industrial FFT computer bows

Hard-wired processor performs signal analysis on 1,000 data points in 28 milliseconds with resolution of 0.1%; interfaces with machine

When Time/Data introduced its T/D 100 about two years ago, it provided scientists with a means of using a Fourier transform algorithm to analyze signals in real time. With the introduction of the T/D 90 at the Fall Joint Computer Conference in Las Vegas, Nov. 18-20, high-speed time-series analysis will move out of the lab and go on the production line.

According to Ed Sloane, Time/Data's vice president and chief mathematician, the difference between the 100 and the 90, besides speed, is that the 100 was designed to interface with humans and the 90 will interface with machines. (The 100 can do a 1,000 point transform in 300 milliseconds and the 90 can do it in 28 msec.)

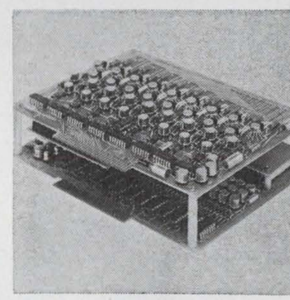
The basic 90 consists of a wired-program digital processing unit with a set of six algorithms: Rapid Fourier Transform, inverse Fourier transform, auto spectrum, spectral averaging, linear hanning and quadratic hanning (smoothing operations in power spectrum analysis). Also included in the basic unit is a system clock, strobe manual control unit, and a system junction unit. Options include the



D-c coupled f-m record/playback subsystem SDM-119 is for accurate data acquisition. Utilizing a vco with center frequencies of 13.5 and 6.75 khz that exhibits a ±0.5% stability and linearity of ±0.25%, the subsystem's playback section is accurate to ±0.5% with a ±0.25% linearity. International Components Corp., Asbury Ave. & Bowne Rd., Asbury Park, N.J. 07712 [421]

Incremental digital magnetic tape recorders are offered. Model 305 is a parallel entry recorder/reproducer system for 8-bit ASCII format sources. Model 315 is for 5-bit BCD numeric code. Model 325 is for recording scientific and research data with parallel entry in BCD format (5 digits of 4 bits each). Mobark Instruments Corp., Terra Bella Ave., Mtn. View, Calif. [422]

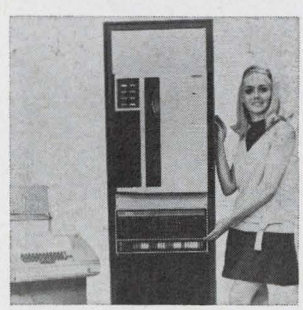
Data storage system series 1000 is for use with small to medium size computers. Two models are offered: the 1012 drive with a combination of removable and nonremovable disk, total capacity 22 million bits; and the 1011 drive with a single 11 million bit removable cartridge. System can be installed for under $15,-000. Iomec Inc., 345 Matthew St., Santa Clara, Calif. [423]



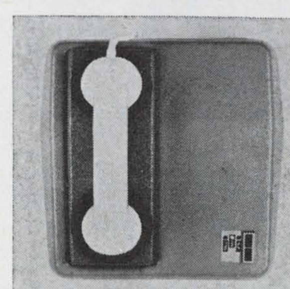
Plug-in random access core memory system FI-23 has capacities of 80 or 160 words with up to 17 bits per word. With a 2 μsec access time, this 8 μsec full cycle system incorporates the newest DTL semiconductors for logic, sense, timing and interface circuits. Power required is +5 v at 3 amps max. −5 v at 0.6 amp max. Ferroxcube Corp., Englewood, Colo. [424]

Data concentrator ADS-660 can multiplex up to 45 or more remote terminals over a single telephone line. A key feature is its ability to intermix up to 3 baud rates simultaneously. Channel capacity is determined by the baud rate speeds of the terminal devices used and the transmission line of the telephone line modems. American Data Systems, Chatsworth, Calif. [425]

Portable communications terminal Edityper is designed to operate in a conversational mode. Designed for the computer time-share market, the terminal will transmit and receive the EBCD1C, or correspondence, code. The terminal will operate with a Bell series 103A or F data set, or an equivalent acoustic coupler. Epsco Inc., Providence Highway, Westwood, Mass. 02090 [426]



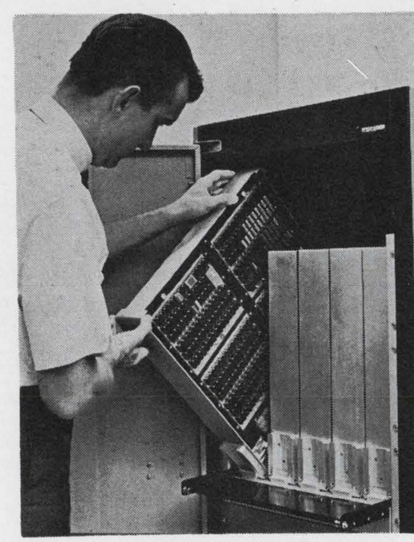
An IBM-compatible magnetic tape system with controller, interface, and software for the PDP-8 computer, is available. Computer access is by a 3-cycle data break facility with a transfer rate of 10 K, 12-bit words/sec at a tape speed of 24 ips. A single 2400-ft tape reel will store in excess of 100 million bits. Computer Equipment Corp., 3707 Rawlins, Dallas 75219 [427]



Acoustical data sets 2000 are for error-free coupling of remote terminals with computers via conventional telephone handsets. They include a linear frequency discriminator plus agc, multiple tuned receiver circuits, stable transmitters, oscillator and low second-order harmonic distortion transmitter output. DTC Corp., Leafdale Blvd., Royal Oak, Mich 48073 [428]

PC-91 digital coupler and controller which interfaces the 90 with a general-purpose digital computer; the PC-93 analog-to-digital converter; and the PC-92 display coupler which provides dual-channel linear and logarithmic d-a conversion, and controls for plotting.

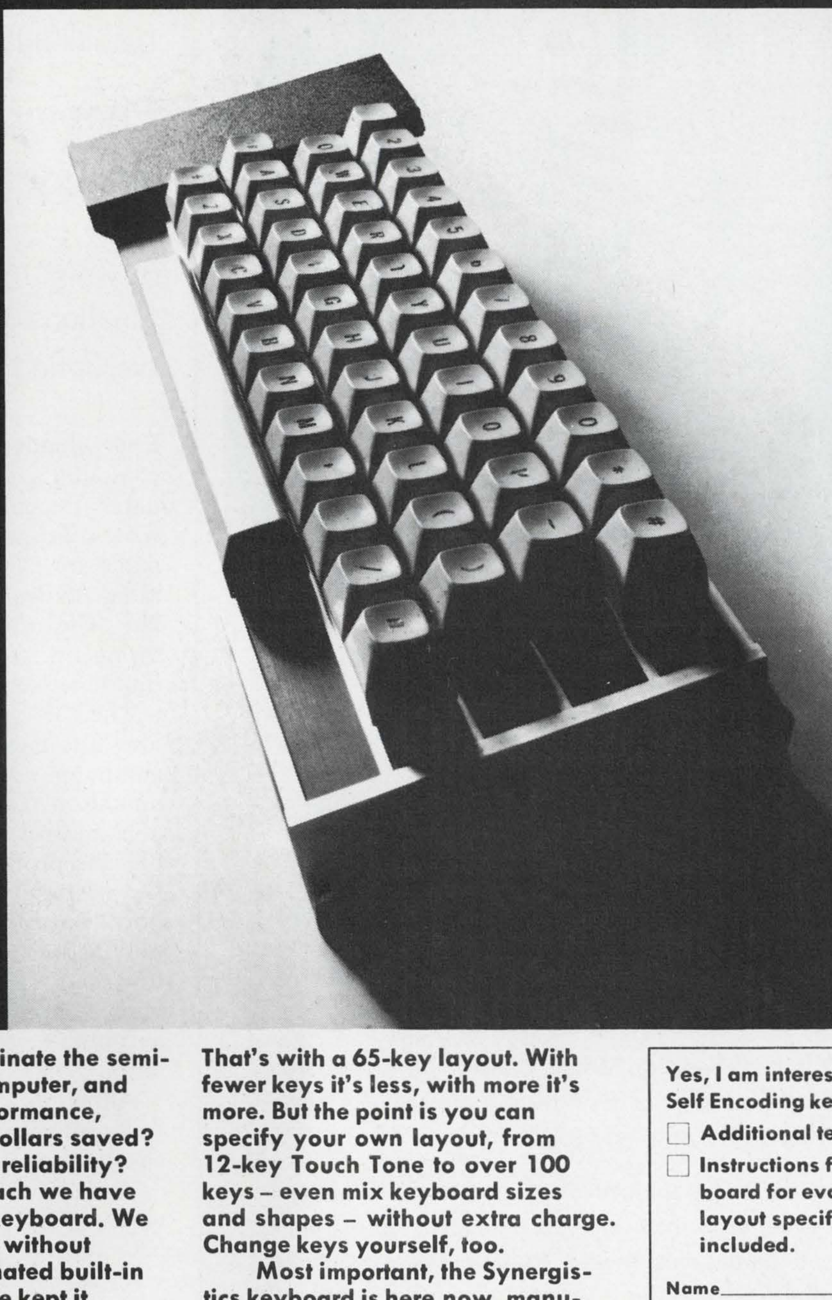
Flexible. The T/D 90 can be used as either a peripheral or a free-standing device. The system is designed for high-speed time-series analysis under computer control, and will work with almost any general-purpose digital computer. By itself, the 90 performs Fourier transforms and auto-spectral density analysis in real time. The advantage of this system, according to Sloane, is that the digital computer can be used for "bookkeeping functions" only, and the 90 will do the math. He says that mathematics can be done must faster than in a general-purpose computer.



Bookish. The T/D 90 is constructed with easy maintenance in mind; racks fold out and circuit boards open up like pages in a book.

Applications for the T/D 90 include vibration testing, speech analysis, radar signal processing, marine seismology, and analysis of medical data. Each requires a special applications console. For example, the vibration-test system would have to control the test table as well as analyze the data. And a panic button would have to be included to prevent destructive testing—in vibration testing, you cannot simply pull the plug to shut the

If you have more brains than money...



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Title__________

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Address__________

__________ Zip__________

Circle 173 on reader service card

system down, because transients are generated when power is cut off.

The T/D 90 basic processor will sell for $38,000, and delivery will begin after the first of the year.

Time/Data Corp., 490 San Antonio Rd., Palo Alto, Calif. 94306 [429]

Data handling

Peeping Tom for computers

Analyzer monitors functions without disrupting operation

Ever wonder how to monitor the computer while it's cranking out data? It could be done by a low-cost, solid state computer analyzer made by Computer and Programming Analysis, Inc. of Cherry Hill, N.J. The unit is capable of monitoring up to 18 different computer functions simultaneously.

The CPA series 7700 analyzer allows the engineer to peek into his computer without interfering with operation. The analyzer, consisting of a control module, counter module, and probes, can monitor central processing units, CPU wait time, pure wait time, overlap time, channel loading, and numerous other functions. The unit will interface with computers of all sizes and is acceptable for use with leased units.

Although not designed to "snoop" on operators, the machine can help evaluate efficiency.

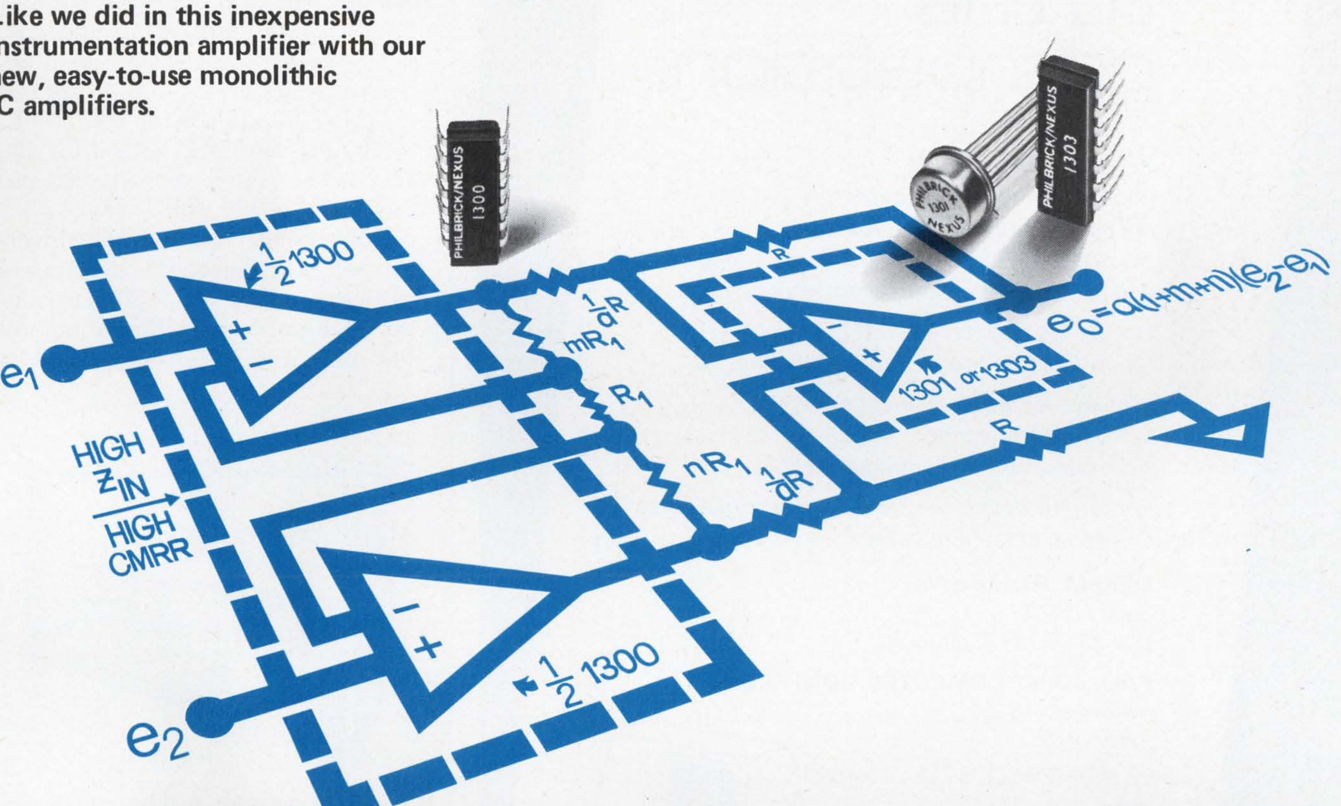
The control module is the heart of the 7700, supplying all power and master control functions as well as monitoring elapsed time. The counter module is the basic building block and contains the logic and controls to drive the readout counters.

Units can be had with up to 18 six-digit electromechanical counters or as many as three electronic counters. The probes are high-impedance differential amplifier units having a one-to-one relationship with the readouts. Normal lengths

Hung up on things analog?

Unscramble with Philbrick/Nexus amplifers.

Like we did in this inexpensive instrumentation amplifier with our new, easy-to-use monolithic IC amplifiers.



Other *new*, value-packed Op Amps from Philbrick/Nexus

Hybrid & Monolithic

1405 – This differential FET input, high speed, hybrid op amp comes in a dual-in-line size package with no external stabilization required. Salient specifications include 1 MHz full output frequency, A_o = 500K, slew rate of 50V/μsec and output current of ±20 ma.

1300 – Dual amplifier monolithic chip in a dual-in-line size package. Two general purpose amplifiers in one package for the price of one. $5.20 in hundred quantity.

1301/1303 – Single general purpose amplifiers in a dual-in-line size package (1303) and a TO-99 package (1301) compatible with μA709 size configurations. These amplifiers are *very stable*, free from latch-up, and output protected.

T82AH – Differential wideband IC amplifier in a 10-pin, TO-5 case with 70 MHz GBW, 20μV/°C max. (–55°C to +125°C), ±10 ma output current, $10.00 per hundred quantity. Has excellent performance in high speed comparator applications.

Discrete

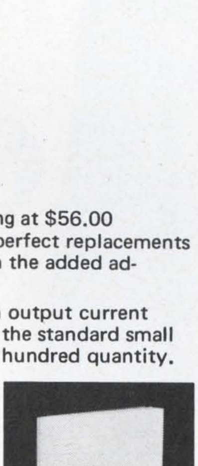
1021 – A high CMRR economy differential FET input or better known as the "100-cubed" amplifier. CMRR of 100 dB (min.), full output frequency of 100 kHz (min.) and A_o of 100 dB (min.) with a hundred quantity price of $27.00 make this a "value-cubed" amplifier! Other salient specifications are ±10V common voltage range, ± 20 ma output current and –30 pa (max.) bias current.

1022 – This differential FET input, high voltage amplifier picks up where the 20V amplifiers leave off. Specifications include power supply range of ±40V to ±150V; output voltage of ±30V to ±140V; common mode voltage of ±25V to ±135V; full output frequency of 50 kHz (min.) and output current of ±20 ma. Priced at $78.00 in hundred quantity.

1018/1020 – The lowest drift, differential, non-chopper stabilized amplifiers available! E_{os} TC (max.) of 1.5/0.5/0.25/5/1.5/0.5/0.25 μV/°C (–25°C to +85°C) and 1.5/0.5 μV/°C (+10°C to +60°C) with hundred quantity prices starting at $56.00 (101803) and $33.00 (1020). These units are perfect replacements for chopper stabilized units in many cases with the added advantage of differential inputs.

1017 – An inexpensive, general purpose, high output current (±125 ma from –25°C to +85°C) amplifier in the standard small "Q" package. More power to you at $29.50 in hundred quantity.

Write, today, for your free copy of the NEW 1969/70 Philbrick/Nexus Catalog.



For further information on any of these new Philbrick/Nexus products, contact your local Philbrick/Nexus field representative or Philbrick/Nexus Research, 22 Allied Drive at Route 128, Dedham, Massachusetts 02026. Telephone: (617) 329-1600.

No. 1 should do more . . . you expect us to.

PHILBRICK/NEXUS RESEARCH

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. . . analysis is tailored to user's system . . .

are 12 feet; longer extensions are available.

The CPA series 7700 is available in six models—models 7706, 7712, and 7718 offer a counter module with six, 12, and 18 electromechanical counters respectively, a control module, and a set of probes. Models 7706E, 7712E, and 7718E have one, two, and three electronic counters respectively. Prices run to $4,960 for the 7706, $5,420 for the 7706E, $7,690 for the 7712, $8,880 for the 7712E. The 7718E costs $10,860 and the 7718E is $12,240.

Conversion. CPA offers conversion of electromechanical counters to electronic ones at $950 per counter. Size and power limitations allow only two electronic counters per set of six counters in each counter module.

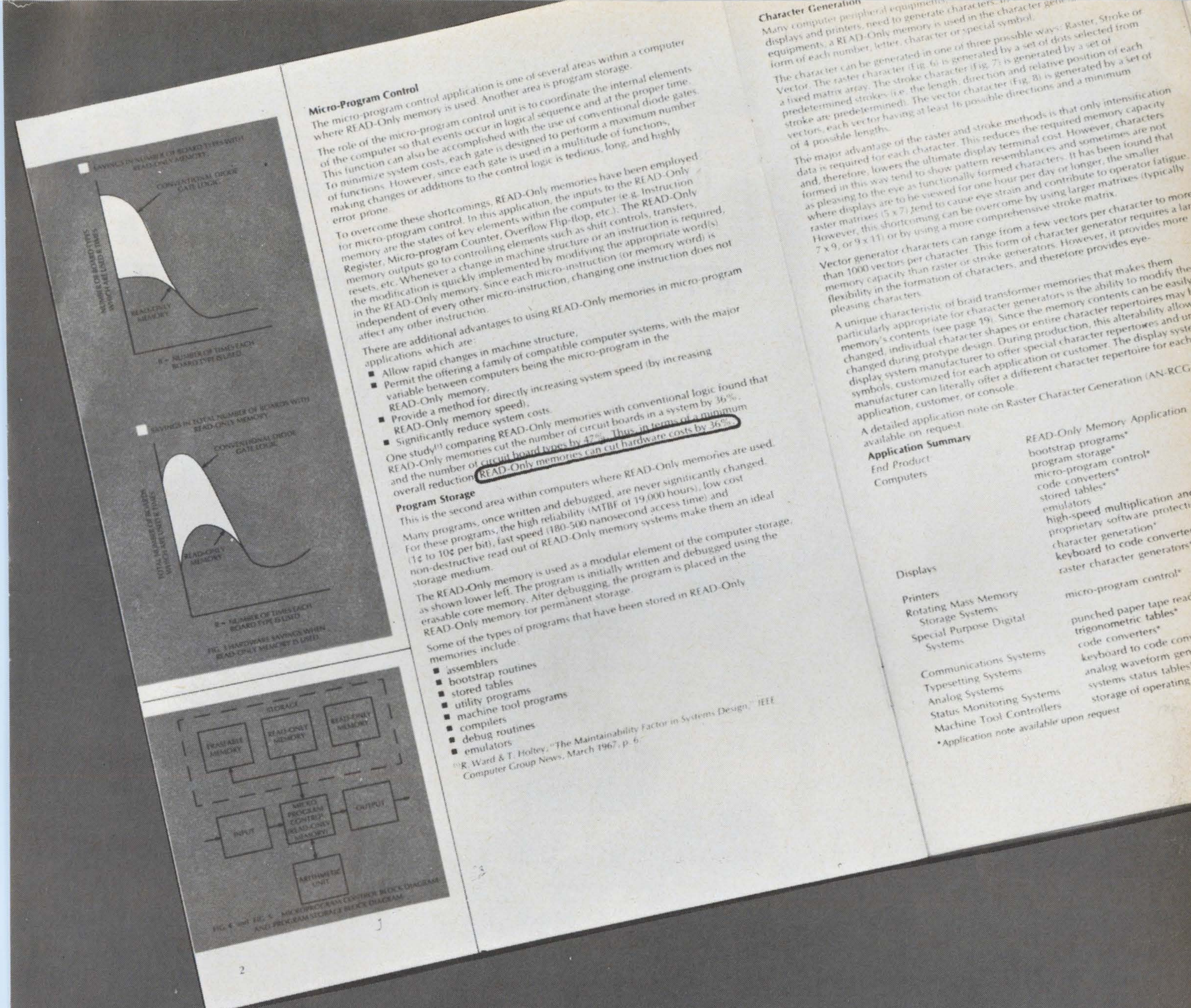
Modular. Computer analyzer can monitor up to 18 system functions.

The models 7706 and 7706E are 10 inches high, 10 inches deep, and 19 inches wide; the 7712 and 7718 series are 20 inches high and as deep and wide as the 7706 series. The first production run began this month, with a production capability of 100 units per month. Delivery time is 45 days after receipt of order.

CPA will develop an applications procedure specifically tailored for each user's requirements at no additional cost.

Technical assistance at the user's facility is available at extra cost. A six-month warranty covers materials and workmanship.

Computer and Programming Analysis Inc., 1103 Kings Highway North, Cherry Hill, N.J. 08034 [430]



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It has everything an engineer needs. From the theories behind the technology to block diagrams of specific applications like program storage, microprogram control, character generation. With lots of nice little touches in between. Sequence photos showing how you can modify the memory contents. And a huge, fold-out work sheet with all the facts you need when designing a system. Timing diagrams, interface specifications, mechanical dimensions. The works.

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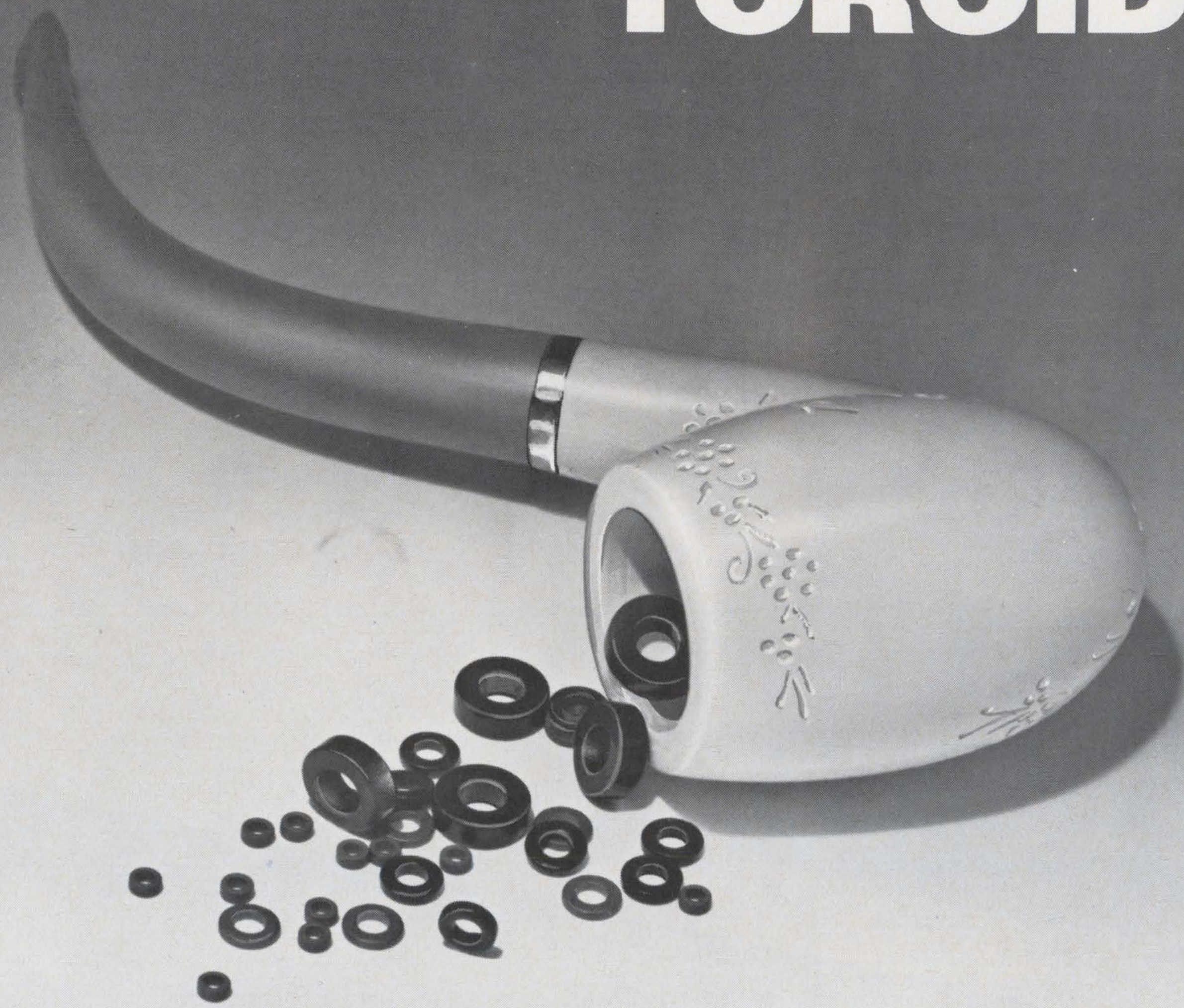
Write Paul Rosenbaum, Memory Technology Inc., 83 Boston Post Road, Sudbury, Mass. 01776, (617) 443-9911.

Memory Technology Incorporated Booth No. 4405 at FJCC

THE 5000 PERM TOROID



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ALSO A LEADER IN THE MANUFACTURE OF QUALITY FIXED COMPOSITION RESISTORS

Circle 178 on reader service card

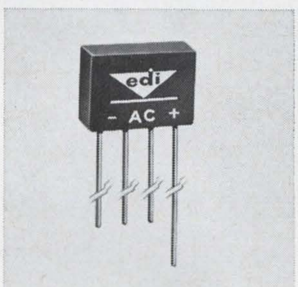
MOS IC adder handles 4 bits

Flexible unit for calculators processes binary or BCD; can be electronically stacked to provide high accuracy

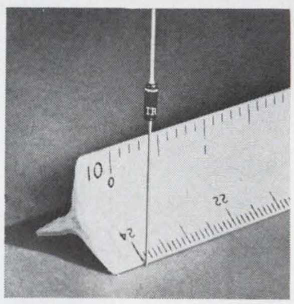
An adder that can handle four bits and either of two numerical codes is a pretty valuable integrated circuit. While most adders have a two-bit capacity and are limited to a single code, Philco-Ford's new metal oxide semiconductor IC can process four bits simultaneously and can use either the 8-4-2-1 binary code or the binary-coded-decimal code.

On top of increased capacity, the IC offers flexibility. If the designer has BCD available in his equipment, he can use it as the input to the adder; or, if 8-4-2-1 binary is more convenient, he can employ that code. Or the same IC can be used for both codes in the same equipment—by switching the control function, the MOS IC can be made to process binary in one cycle and BCD in the very next. Even for a manufacturer of two different kinds of equipment—binary-oriented or BCD-oriented—the adder offers simplified logistics, since the same unit can be used.

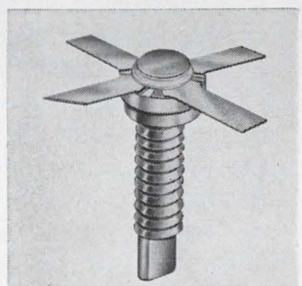
The code flexibility of the IC doesn't make it particularly complicated. "In fact," says MOS marketing manager Bob Simon, "I haven't yet figured out why other



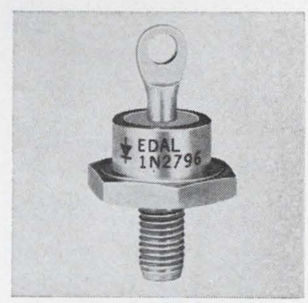
Miniature silicon rectifier bridges have piv ratings of 1,000, 1,500 and 2,000 v. Applications include voltage regulators, spark ignition systems, microwave tube and laser supplies, pocket scopes and electrostatic supplies. Dimensions are 0.625 x 0.468 x 0.25 in. A transfer molded case insures void free encapsulation. Electronic Devices Inc., 21 Gray Oaks Ave., Yonkers, N.Y. [436]



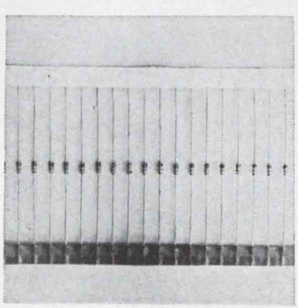
Temperature compensated zener reference units series 1N821-1N829 and 1N935-1N939 in DO-7 case provide stability and low noise. Applications include d-c voltage standards, d-c decade voltage reference sources, d-c voltmeters, X-Y strip recorders, and other applications requiring close temperature regulation. International Rectifier, 233 Kansas St., El Segundo, Calif. [437]



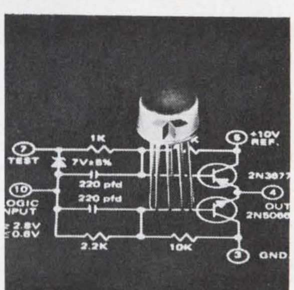
Microwave transistors operate at 2 Ghz. Source voltage is 28 v. Type 2N5766, 1 w output, can withstand infinite vswr at any phase angle. Types 2N5767 and 2N5768, 2.5 and 5 w output respectively, can withstand 3:1 vswr at any phase angle. Units are for advanced designs in radio relay, and phased array radar. TRW Semiconductors Inc., Aviation Blvd., Lawndale, Calif. [438]



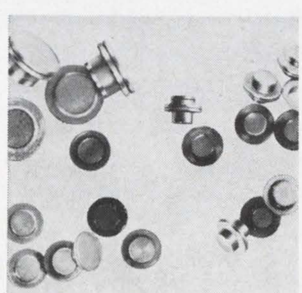
Silicon power rectifiers come in stud mounted DO-5 packages. A double diffused, passivated junction technique assures stable electrical characteristics. Both standard and bulk avalanche types in voltage ratings from 50 to 1,000 piv are available. The F3, F4 and F5 series offer max. forward current of 31, 37 and 50 amps, respectively. Edal Industries Inc., East Haven, Conn. [439]



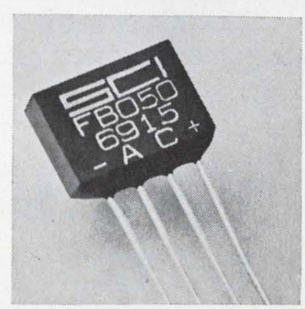
Silicon stabistors come in single (AP103), double (AP203) or triple (AP303) types. Chips are available in a 400 mw whiskerless package. Stabistors are used where controlled forward voltages are necessary such as voltage regulator circuits, sensing, and computer circuitry. Forward voltages are from 0.86 to 2.6 v at 100 ma. American Power Devices Inc., Andover, Mass. [440]



Hybrid IC ladder switches CDA4 are for direct-from-logic operation in digital-to-analog conversion. The CDA4 is meant for use with a +10-v reference. When used in conjunction with a 10K/20K ladder network, the switch provides 12-bit accuracy. Settling times under 1 μsec allow high speed operation. Price (1-99) is $38 each. Crystalonics, 147 Sherman St., Cambridge, Mass. [441]



Space-qualified microwave tunnel diodes feature a ruggedization process for extreme reliability. The amplifier tunnel diode line comes in a choice of Ge, GaAs, and GaSb and in standard models to cutoff frequencies of 50 Ghz. Extremely low 1/f noise characteristics is a feature of the detector/mixer tunnel diode line. Aertech Industries, Stewart Dr., Sunnyvale, Calif. [442]

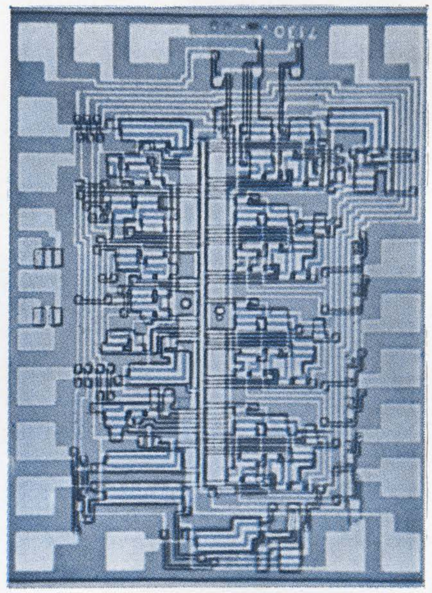


Full-wave bridge rectifiers FB are fabricated with double diffused silicon rectifier cells. Unit is encased in plastic with an in-line configuration easily adaptable to p-c board mounting. Units are rated for a maximum output current of 2 amps and peak inverses voltages of up to 1,000 v per element. Scientific Components Inc., 350 Hurst St., Linden, N.J. [443]

people haven't done it."

The IC can be stacked to provide high accuracy. For example, it may be necessary to add two 16-bit numbers. In this case, four adders can be combined, since carry input and carry output terminals—at compatible voltage and current levels —are provided on each circuit.

The IC's adding speed depends on the operation mode. With the 8-4-2-1 binary code, the add cycle time is typically 1.8 microseconds (4 μsec maximum). For the BCD code, the cycle time is somewhat



A choice. IC adder can be used, even in same equipment, for either binary or binary-coded decimal code.

longer, 2.1 μsec usually. When the IC's are stacked, the limitation on speed is the carry propagation delay, according to Simon. With the 16-bit adder, for example, the cycle time would be four times the cycle time for each IC, or 7.6 μsec.

Inputs and outputs are at typical MOS levels. At the input, a logic 0 is —3 volts and a logic 1 is —9 volts. The output levels are —2 volts for a 0 and —10 volts for a 1. Input leakage current is 100 nanoamperes at 28 volts and 25°C. Input capacitance is rather low; only 4.5 picofarads at 25°C and zero bias.

The circuit is available from distributor and manufacturer's stock. Unit price is $12.90 in quantities of 100 to 999.

Philco-Ford Corp., Microelectronics Division, Union Meeting Rd., Bluebell, Pa. [444]

New Books

Abstract magnetics

Digital Magnetic Logic
David R. Bennion, Hewitt D. Crane, and David Nitzan
McGraw-Hill Book Co., 367 pp., $15

Engineers sometimes become rather impatient with mathematicians who become so enamored of their abstract equations that their readers, if not they themselves, lose sight of whatever the abstractions are that the equations represent. The authors of this book may not have had that problem, but their readers are likely to encounter it. Indeed, the authors would have been well advised to have first described the elementary ideas with clarity, and then follow them with mathematically precise equations.

Instead, the authors plunge directly into a review of induced electromotive and magnetomotive forces, using Maxwell's equations. These equations are justly famous for their conciseness and precision. But one is jarred somewhat when the equations appear in the very first paragraph of a treatise on a subject unfamiliar to him.

In the third chapter, the authors discuss magnetic shift registers in somewhat less mathematical terms. And this discussion is immediately clearer than the one that preceded it. The following chapter describes magnetic shift registers that, unlike those in Chapter 3, don't require diodes and capacitors to isolate the stages to prevent shifting in the wrong direction.

Next comes two chapters on magnetic networks, which have loops and nodes analogous to those in electrical networks and are made of multiple aperture or multileg structures. These are reduced to generalized networks that are treated in detail. Here the authors feel obliged to throw in a few more equations, but to the reader's advantage—the equations are used as abstractions of material described in detail previously. And herein is a world of difference from the approach taken at the book's outset.

There is a chapter on formal derivation of transfer schemes, which, despite the subject matter, isn't heavily mathematical. Most of the discussion up to this point has assumed binary signals in the form of high-low or something-nothing flux or current pulses. But there is another chapter on bipolar, or positive-negative, binary signals and the designs that can be based on them—thin films, for example.

This is followed by a chapter on general logic designs, mostly combinational logic, with a short discussion of sequential or synchronous logic. This is more or less the denouement of all previous chapters—witness, in fact, the title of the book.

The book's final two chapters are more appendixes than anything else, summarizing the elementary physics of magnetism and magnetic flux-switching models. Both are chock full of equations, but these are probably less out of place here than elsewhere in the book.

Calling on computers

Computerized Approximation and Synthesis of Linear Networks

Jiri Vlach
John Wiley & Sons Inc., 477 pp., $14.95

Since most circuits contain nonlinear elements, a designer must have a technique for predicting element behavior accurately if he wants his circuit to perform as he desires. There are techniques available, and they fall into a class of mathematics called approximation theory. These techniques require a linear model that comes close to describing a nonlinear element's behavior. Then he applies known or desired inputs and determines, through analysis, what the responses will be. The designer can apply the approximation theory to any type of element, be it electrical or mechanical.

This book concentrates on two main areas—approximation theory, and synthesis. However, because network synthesis is so widely understood, it is treated here only to the extent necessary for approximation purposes and for the design of ladder networks.

Modern network design requires many tedious computations. Therefore, a computer is an almost indispensable tool. And because of this, the author not only explains the theory behind approximation techniques, but includes computer programs that can be applied. Thus the reader, for all practical purposes, has the answers to most of his problems at his fingertips. The programs are written in Fortran and described in special sections.

Knowledge of general network analysis and Laplace transform methods are assumed, as are the basic mathematics, but this information is included in the book to aid novices in the subject matter.

The first three chapters contain a review of the Laplace transform, analysis of networks, and behavior of networks with ideal characteristics. Basic are the conditions the designer must impose on different network functions to achieve desired results; any mathematical function that is the basis for subsequent network synthesis must contain all restrictive conditions imposed on it by the network to be designed. These conditions are presented in Chapter 4, laying the groundwork for the application of the approximation theory.

Different network characteristics, particularly for linear networks, are defined in Chapter 5, and programs evaluating them are also given. The following chapters introduce several transformations that make it possible to transform network characteristics into another frequency band, thus paving the way for further approximation.

Approximation of different characteristics is treated in Chapters 8 through 12; programs for solving pertinent problems are also included. The final two chapters, 13 and 14, discuss synthesis techniques and the synthesis of passive and active filters.

This book can be read in several ways. Readers interested primarily in information about the synthesis of networks should read Chapters 1 to 4, 8, and 14; those interested in approximation problems can start with Chapter 7 and return later to the preceding chapters. The book can also be used as a reference when a particular approximation problem is to be solved.

Technical Abstracts

Post-gadget era

Linear IC's in tv, and a-m and f-m receivers
Sumner B. Marshall
Sprague Electric Co.
Worcester, Mass.

Although the first integrated circuits appearing in consumer electronics were aimed primarily for advertising leverage, newer IC's have been developed that offer performance far better than their discrete counterparts. Today's IC's are found in the tv sound i-f with discriminator, amplitude modulated and frequency modulated i-f amplifier, color demodulator, and video processing circuitry.

One of the newest circuits is a sound-channel hybrid IC consisting of a 60-decibel, three-stage limiting amplifier and analog multipler used as a quadrature discriminator, and an audio preamplifier. In an a-m and f-m receiver, two of these circuits are cascaded to function as an i-f amplifier. Ceramic or hybrid lumped filters are placed between the IC's to provide an interface between the limiter and the discriminator.

The first IC, functioning as an f-m i-f amplifier, provides a gain of 60 db at 10.7 megahertz; in the a-m mode, the circuit acts as a product detector. The second IC has the same gain at the same frequency, but its multiplier functions as a quadrature f-m discriminator. The product detector, which has a higher sensitivity than a ratio detector, is available without adding to the cost. Using these IC's instead of their discrete counterparts simplifies both the alignment and fabrication of sets.

The monolithic analog multiplier, used alone, has found a natural application as a synchronous color demodulator of the National Television System Committee 3.58-Mhz chroma subcarrier. The device's accuracy and stability are greater than those of vacuum-tube demodulators.

A high-voltage monolithic circuit has been developed using a planar process with epitaxial thickness and doping level adjusted for voltage breakdowns of 150 to 200 volts. The circuit uses three transistors

Circle 185 on reader service card →

interconnected to prevent the collector-to-emitter voltage of each device from exceeding half the collector-supply voltage, thereby extending the swing capability of the amplifier to the limit of voltage breakdown. This circuit provides the direct drive of a 17-inch, black-and-white cathode-ray tube.

Presented at Wescon, San Francisco, Aug. 19-22.

Hot spot

Reflow soldering with radiant heating
David Schoenthaler
Western Electric Co.
Princeton, N.J.

The cost and quality advantages of printed circuit boards, flexible cables, and thin film circuits can be improved by reliable mass joining methods for connecting different components and devices. Reflow soldering has proven successful in such applications as it joins without forming solder bridges between adjacent connections. The technique depends on photofabrication methods to precisely deposit small amounts of solder.

Radiant heat melts the solder which flows forming a reliable connection. Some of the advantages of radiant heating are that it allows excellent control of the soldering temperature, that it permits heating of otherwise inaccessible joint areas on transparent substrates, and that it eliminates the soldering peaks left after withdrawing a soldering iron from the molten solder.

Effectiveness of radiant-heating reflow soldering depends on the spectral characteristics of the source of radiant energy, on the energy absorption characteristics of the material to be joined, and on the efficiency with which the energy is focused on the material.

Compact, high power, incandescent lamps provide the radiant energy and are small enough for their filaments to serve as a point source for the precise optical reflectors that collect and concentrate the energy.

The emissive power of the filament increases as the fourth power of temperature. Consistent with life considerations, the lamp should be run at its highest temperature. As a rule, the lamp with the lowest usable power rating will provide the most efficient filament temperature. The filament temperature determines its spectral characteristics of emission, typically from 0.76 to 4 microns.

To insure an efficient transfer of radiant heat to the material—that is energy absorption rather than reflection—the incident radiation flux should have a high percentage of short-wavelength energy. In general, it's best to heat metallic surfaces with energy less than 2 microns in wavelength. For copper and tantalum, the heat absorption increases sharply for wavelengths less than 1 micron.

When an application requires localized heating, an optical condenser system provides the higher intensity energy. The condenser gathers radiant energy over a wide area and discharges it through a small area to increase the radiant flux (watts per square centimeter).

Production soldering equipment relies on a flow of air or gas for convection cooling to protect insulation and other material from the higher soldering temperature. In fact, it's possible—in a three-second heating cycle—to make excellent solder fillets when joining Mylar-insulated wire, with minimum thermal distortion of the Mylar surface.

Presented at the International Electronic Circuit Packaging Symposium, San Francisco, Aug. 20 and 21.

Ferrites grow

Advances in planar ferrite devices

L. R. Whicker, J. E. Degenford, D.C. Buck, and F.H. Harris
Westinghouse Defense and Space Center,
Baltimore, Md.

Recent radar applications have spurred the development of low cost, reproducible microstrip devices. A wide variety of ferrite phase shifters and circulators, built by Westinghouse, promise good electrical performance for batch-processed devices.

To build these phase shifters, a ferrite film is grown by a chemical vapor disposition process. This film

—bulk ferrite, Magnesium manganese TT-390—is deposited on the surface of platinum or other noble metals, which in turn have been deposited at appropriate spots on a supporting substrate material such as forsterite. Then, ground contacts and appropriate metal paths are evaporated directly onto the metal surface.

Over a range of approximately 360° at 10 gigahertz, the film phase shifter's performance closely resembled that of the bulk TT-390. However, its insertion loss is approximately twice that of devices using bulk material.

This loss is attributed to two factors: rough ferrite surface finish and the increase of dielectric loss tangent with increasing film thickness. The former is caused by grain growth of the deposit while the latter is due to oxygen diffusing into the surface during deposition. Subsequent treatment, however, helps reduce the grain growth and thereby diminishes the loss tangent.

Puck-type circulators have been formed by placing a Mg-Mn puck or "button" in a ceramic substrate such as alumina. Typical performance data shows that over a frequency range of from 2 to 12 Ghz, these devices yield bandwidths greater than 20%, isolation greater than 20 decibels, insertion loss less than 0.5 db, and vswr of approximately 1.2—values comparable to present generation circulators.

Presented at Microelectronics Symposium, St. Louis, Sept. 10-11.

Space-age design

Integrated parametric amplifier module with self-contained solid state pump source

C.M. Allen, H.C. Okean, E.W. Sard, and H. Weingart
Airborne Instruments Laboratory,
Cutler-Hammer Inc.
Deer Park, N.Y.

Problems of size, cost, and complexity precluded the use of ultra-low-noise amplifiers in space-borne applications. However, now these barriers have been overcome with the design of a small, completely integrated, solid state S-band parametric amplifier that has its own

Technical Abstracts

pump source.

The unit, which employs thin-film microstrip technology, consists of a circulator-coupled, nondegenerate, shunt varactor diode parametric amplifier that operates at 2.25 gigahertz with a bandwidth of 100 megahertz, and a Gunn-effect oscillator pump source operating at 14 Ghz. Passband noise temperature range is 145° to 190°K.

The amplifier and pump stages are completely integrated in an aluminum housing, whose volume is less than 10 cubic inches; the unit weighs less than 0.6 pound. The only external connections are subminiature coaxial r-f input and output connectors, and a two-wire d-c bias connector requiring 8 volts at 0.5 ampere from an external supply.

The amplifier stage is fabricated on a glazed alumina substrate which has been metalized by vacuum deposition of copper-nichrome, and then photoetched, producing the required conductor pattern. The three-port circulator uses a 1-inch yig disk embedded in a hole in the substrate. A bias magnet provides a field of 600 gauss and is set in the housing base plate below the disk. Quarter-wave transformers adjust the impedance at the input and output ports of the circulator to 50 ohms; the varactor circuit is directly coupled to the third port. The circulator has a maximum insertion loss of 0.4 decibel at 2.25 Ghz and a 30-db isolation bandwidth of 120 Mhz. The idler circuit is formed by two parallel quarterwave open-circuited stubs connected directly across the varactor pill.

The waveguide pump source consists of an iris-coupled Gunn-diode oscillator cavity, a miniature waveguide isolator, and a waveguide-to-microstrip transducer. The pump source produces c-w power of 50-100 milliwatts between 13.8 and 14.2 Ghz. The isolator provides a minimum of 25 db of isolation with an insertion loss of 0.3 db and a voltage standing wave ratio of 1.25:1 over the band.

Presented at the Microelectronics Symposium, St. Louis, Sept. 10-11.

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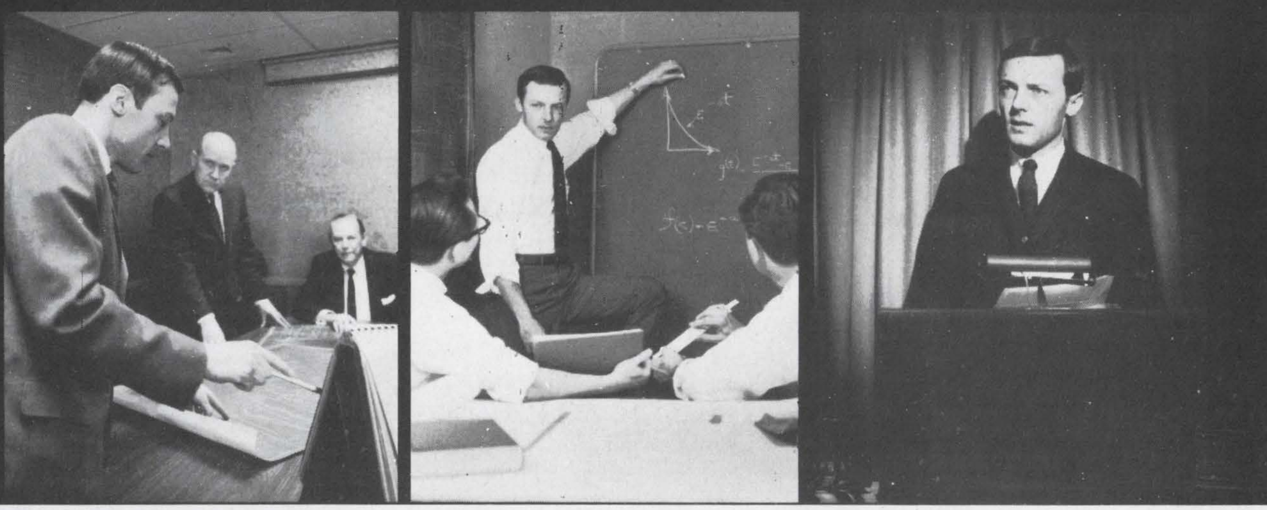

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New Literature

Semiconductor applications. Westinghouse Electric Corp., P.O. Box 868, Pittsburgh 15230. The first three booklets in a continuing series of application notes provide useful information on the application of semiconductor products to a variety of problems. Circle **446** on reader service card.

Ultrasonic cleaning system. Branson Instruments Co., 76 Progress Dr., Stamford, Conn. 06904. An ultrasonic cleaning system designed to remove organic or inorganic soils is described in four-page bulletin S-901. **[447]**

Ceramic capacitors. Union Carbide Corp., P.O. Box 5928, Greenville, S.C. 29606, has available a complete product line catalog for the Kemet line of monolithic ceramic capacitors. **[448]**

Printed circuit dies. Lenkeit Industries Inc., 258 Broadhollow Rd., Farmingdale, N.Y. 11735, has issued a brochure entitled "Printed Circuit Dies: How to Tool Them Right." **[449]**

High performance motors. IMC's Eastern Division, 570 Main St., New York 11591. An illustrated 88-page catalog describes a full line of induction, synchronous, and torque motors. **[450]**

Coaxial cable. Uniform Tubes Inc., Collegeville, Pa. 19426. An eight-page bulletin 202D describes the types of Micro-Coax miniature, solid-jacketed coaxial cable available with total shielding to eliminate radiation leakage and obtain lowest possible attenuation. **[451]**

Power servo actuators. Weston-Transicoil, Worcester, Pa. 19490, has available a folder describing a line of power servo actuators for guidance and control systems. **[452]**

Information and data processing. Beckman Instruments Inc., 2500 Harbor Blvd., Fullerton, Calif. 92634, has released a 12-page bulletin entitled "Information and Data Processing Systems." **[453]**

Cycle timers. Cramer Division, Conrac Corp., Mill Rock Rd., Old Saybrook, Conn. 06475. An eight-page catalog illustrates and describes eight series of cycle timers ranging from simple single poke units to multicircuit programers. **[454]**

Numerical control system. CTC Computer Corp., 1018 Palo Alto Office Center, Palo Alto, Calif. 94301. A pocket-sized brochure describes the consulting and programing service for the numerical control system available through the company's Software Systems division. **[455]**

Dynamic shift register. Union Carbide Corp., 8888 Balboa Ave., San Diego,

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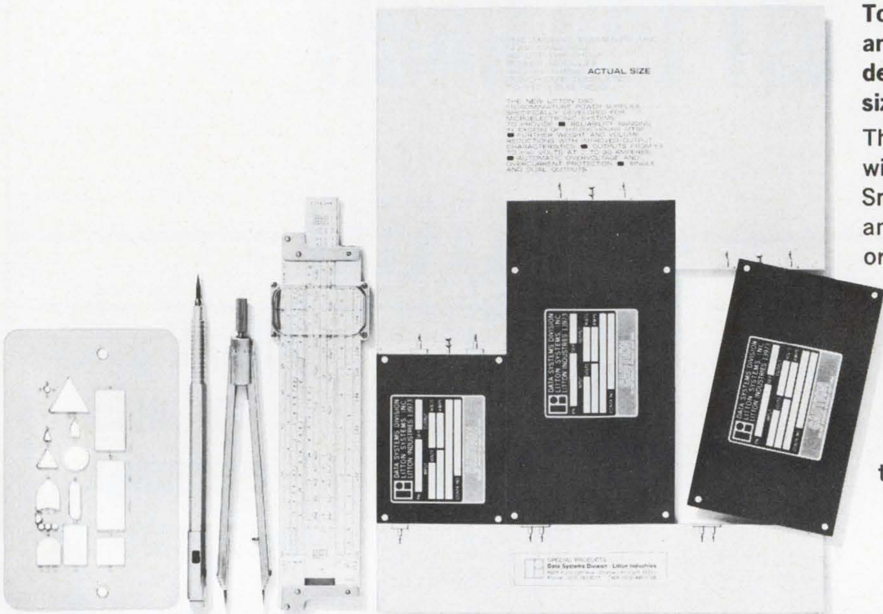

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Calif. 92123, has released a brochure on the SRD-25 MOS p-channel integrated circuit dual 25-bit shift register. **[456]**

Precision potentiometers. Bourns Inc., Trimpot Products Division, 1200 Columbia Ave., Riverside, Calif. 92507. A new Bee-Line precision potentiometer series is completely described in a six-page brochure. **[457]**

Operational amplifier. Analog Devices Inc., 221 Fifth St., Cambridge, Mass. 02142. A fold-out data sheet describes a high stability (2 μv/°C maximum drift) battery powered operational amplifier that draws only microwatts quiescent power, and runs months on a single set of batteries. **[458]**

Interactive time-sharing services. Westinghouse Electric Corp., P.O. Box 868, Pittsburgh 15230. Benefits and advantages of interactive time-sharing computer services are described in bulletin DB24-350. **[459]**

Indicator lights. Dialight Corp., 60 Stewart Ave., Brooklyn, N.Y. 11237. Catalog L-160J covers ultraminiature Datalites, a system of indication suited for computer, data processing, and automation applications. **[460]**

Multimode transceiver. RCA Defense Communications Systems Division, Camden, N.J. Bulletin AN/ARC-142 contains a description and features of a small, lightweight, solid state h-f multimode transceiver. **[461]**

Microwave reference guide. Philco-Ford Corp., Union Meeting Rd., Blue Bell, Pa. 19422, has published a product reference guide containing information on microwave solid state devices and components. **[462]**

Multichannel FSK modem. Tele-Dynamics, division of AMBAC Industries Inc., 5000 Parkside Ave., Philadelphia 19131. A versatile digital/frequency shift keyer modem that operates in three modes is described in bulletin 7260. **[463]**

Time delay module. Product Designs Inc., 111 Cardenas, N.E., Albuquerque, N.M. 87108, offers a release describing its linear adjustment precision time delay module. **[464]**

Resistor array. Beckman Instruments Inc., 2500 Harbor Blvd., Fullerton, Calif. 92634, has released a four-page catalog sheet describing its model 813 10-bit binary resistor array, specifically designed with resistance values and terminal arrangements that make it usable with Fairchild's μA722 10-bit current source. **[465]**

Beryllia ceramics. National Beryllia Corp., Cermetrol Division, Haskell, N.J., Be prepared for

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New Literature

07420, offers a comprehensive booklet on ceramic-to-metal components and assemblies for industry. **[466]**

Extruded lug terminals. Berg Electronics Inc., New Cumberland, Pa. 17070. A catalog describes a complete product line of lug type terminals having an extruded metal column for positive fastening to circuit boards and associated high-rate staking machinery. **[467]**

Transformer shields. Tapecon Inc., 475 River St., Rochester, N.Y. 14612, has prepared a data sheet (I/IS-519) in which the subject of insulated/isolated transformer shields is thoroughly discussed. **[468]**

Computer subjects. Electronic Associates Inc., West Long Branch, N.J. A recently revised index to the Applications Reference Library covers a wide variety of analog/hybrid computer subjects. **[469]**

Video terminal. Ultronic Systems Corp., P.O. Box 315, Moorestown, N.J. 08057. A four-page brochure describes the Videomaster 7000, a general purpose alphanumeric display system that sells for less than $5,000 per terminal. **[470]**

Instrumentation amplifiers. Neff Instrument Corp., 1088 E. Hamilton Rd., Duarte, Calif. 91010, has available an illustrated eight-page brochure describing its line of instrumentation amplifiers for measurement and control. **[471]**

Microwave catalog. Addington Laboratories, 1043 DiGiulio, Santa Clara, Calif. 95050. A catalog listing the latest developments in ferrite components, covers the 3-port tee, 4-port and 5-port circulators, tee isolators and multistage isolators. **[472]**

Photomultiplier tube housings. Pacific Photometric Instruments, 3024 Ashby Ave., Berkeley, Calif. 94705. A newly revised 16-page catalog on a complete line of photomultiplier tube housings is now available. **[473]**

IC digital readouts. Farrand Controls Inc., Valhalla, N.Y. 10595, has published a brochure on a line of IC digital readouts for application to a broad variety of machine tools. **[474]**

Paper dielectric capacitors. San Fernando Electric Mfg. Co., 1501 First St., San Fernando, Calif. 91341. General characteristics and complete ordering data for the complete West-Cap line of paper dielectric tubular and rectangular capacitors are highlighted in a 44-page brochure. **[475]**

Lead straightener, carrier loader. Barnes Corp., 24 N. Lansdowne Ave., Lansdowne, Pa. 19050. Bulletin PB-1010

Circle 195 on reader service card

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(Act of October 23, 1962, Section 4369, Title 39, United States Code)

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C. Total Paid Circulation.......	77,536	79,637
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features 450-021 series lead straighteners and series 450-022 carrier loaders. **[476]**

Electronic hardware. Positronic Industries Inc., 1906 South Stewart, Springfield, Mo. 65804, has released its 30-page illustrated 1970 handbook of electronic hardware. **[477]**

D-c amplifier. Solid State Electronics Corp., 15321 Rayen St., Sepulveda, Calif. 91343, has released a data sheet on the model 3051 differential operational d-c amplifier. **[478]**

Intricate metal parts. Magnetics Inc., Butler, Pa. "Recipe for Success" is the title of a pocket-size, illustrated folder describing the company's photofabrication process for making intricate parts out of thin metals. **[479]**

Electromechanical components. Allied Devices Corp., 2365 Milburn Ave., Baldwin, N.Y. 11510. Thousands of standard electromechanical components are listed in catalog No. 7. **[480]**

Flexible glass fiber optics. Corning Glass Works, Corning, N.Y. 14830. Glass flexible fiber optics applications and product descriptions are given in eight-page illustrated bulletin No. 3. **[481]**

Solid state controllers. Barber-Colman Co., Rockford, Ill. 61101, has available catalog information on a broad line of solid state controllers. **[482]**

Communications processor. Tec Inc., 6700 S. Washington Ave., Eden Prairie, Minn. 55343. Complete information on the new multipurpose programable communications system is given in brochure 706. **[483]**

Panel meters. Modutec Inc., 18 Marshall St., Norwalk, Conn. 06854. Catalog 870 lists well over 3,000 types of panel meters manufactured by the company. **[484]**

Subminiature indicator lights. Dialight Corp., 60 Stewart Ave., Brooklyn, N.Y. 11237. Two-terminal subminiature indicator lights, designed for mounting in 15/32 in., ½ in. and 17/32 in. clearance holes, are described in 12-page catalog L-178D. **[485]**

Power inverters. Fork Standards Inc., 205 Main St., West Chicago 60185. Four-page bulletin 691 announces a comprehensive line of precise frequency power inverters. **[486]**

Semiconductor fuses. Airpax Electronics, Cambridge, Md. 21613. A twelve-page catalog introduces Cel-Gard fuses for rectifier, SCR, thyristor, and power transistor protection. **[487]**

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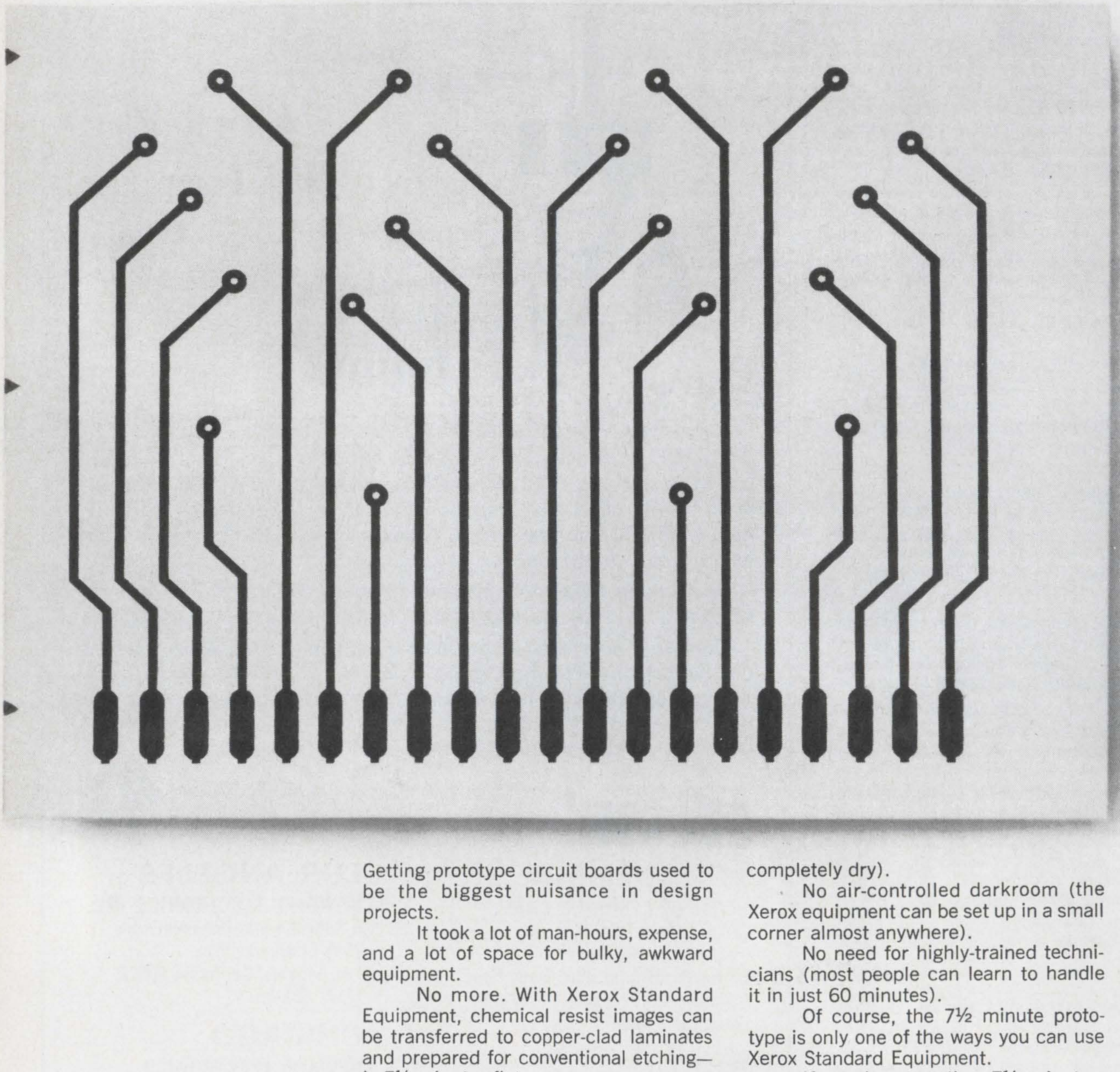

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International Newsletter

October 27, 1969

Swiss balk Siemens move

West Germany's electrical-electronics giant, Siemens AG, won't get the Swiss foothold in the European Free Trade Area it's been seeking.

The foothold would have been Secheron SA, whose forte is automatic controls for streetcars and railways. **Siemens made a bid for the company but ran into resistance from the Swiss government.** The upshot: Secheron, whose sales were $14 million for fiscal 1968, will join the fold of the ranking Swiss electrical-electronics group, Brown Boveri et Cie.

Infrared display on tv shows up backside IC mask

Belgium's leading semiconductor producer, Manufacture Belge de Lampes et de Material Electronique, expects to speed production of beam-lead integrated circuits through a new mask-aligning technique for back-etching partially processed wafers.

MBLE's method substitutes a large-screen television display for the usual through-a-microscope view of an infrared image. **The large display is obtained by mounting a Plumbicon tv pickup tube atop the wafer-mask carrier and beaming infrared light up through the assembly.** Researchers who developed the technique at MBLE's parent company, Philips' Gloeilampenfabrieken, say the speedy alignment method is accurate to a few microns.

Seawolf target: test-fire in 1970

A $12 million contract to Marconi Co. to develop the British Navy's Seawolf shipborne surface-to-air defense system should bring the system to the test-firing stage by the end of next year. Seawolf is **the expanded derivative** of the Seacat antiaircraft missile system [*Electronics*, July 21, p. 179], with antimissile capability and fully automatic operation.

Visual guidance of the missile to the target by study of the two images on a tv screen, as in Seacat, is replaced in Seawolf by automatic guidance: **the waveforms of the tv images of target and missile are used as a basis to compute trajectory correction commands,** which are radioed to the missile. Marconi will be responsible for all of the system's electronics, but will subcontract most of the data-handling development to Ferranti Ltd.

Bosch to produce semiconductors, IC's

West Germany's Robert Bosch GmbH, one of the biggest names in motor vehicle accessories, is getting ready **to produce semiconductor devices—including integrated circuits—on its own.** Pilot production will be started next spring in a new plant at Reutlingen, near Stuttgart.

The firm stresses that its new products—diodes, transistors, and integrated circuits—are for in-house use only, and that **it's not out to compete on the open market.** Industry sources feel that Bosch will not become completely independent of outside suppliers.

By producing its own components for automotive use, Bosch is stepping into one of the fastest-growing markets in Europe. Some believe that in West Germany alone **the market for active and passive devices for motor vehicle** applications will triple by next year from its 1969 value of about $10 million.

Bosch, which maintains a world-wide manufacturing and sales facility network, already has acquired considerable knowhow in automobile electronics. Several years ago, the firm, together with Volkswagenwerk

AG, pioneered an **electronically controlled fuel injection system** which is standard equipment on some Volkswagen and Mercedes cars.

Liquid crystals sandwiched as display device

Joining the race for development of solid state displays is France's Thomson-CSF. The company is working on a **liquid crystal display chip, sandwiched in glass,** that is expected to be in production in two years for voltmeters and other instruments. Thomson expects the price of the device to be lower than that of readout tubes.

In development for eight months, the device is similar to one that RCA has under development. The French firm has one patent, covering the use of several sandwiched layers of liquid crystals. **Thomson's display requires excitation voltages of from 5 to 40 volts** over a minimum timespan of 100 microseconds for each point on the chip. This relatively lengthy time lag means considerable work will have to be done before liquid crystals can be used to replace cathode-ray tubes—an entire line on a tv screen is scanned in 60 μsec.

Converter to show home movies on tv

A small British company, Vidicord Holdings Ltd., plans to market within a year a $600 converter **for running Super-8-millimeter color film through home tv sets.** The device, basically a flying spot scanner, measures 18 by 13 by 7 inches. The film cassette fits on top and a lead connects to the antenna terminals of the tv receiver. Initial models will be compatible with the European 625-line scan, but modification to a 525-line scan is possible. Under consideration is a monochrome version that would sell for about $400. In addition to home movies, **the company sees a substantial market in the educational and industrial fields**—many instruction rooms already are equipped with tv, and one converter can feed numerous receivers for simultaneous showing.

West Germans building magnet lab

Experiments in solid state physics and in semiconducting and superconducting materials are on the agenda for West Germany's first magnet laboratory, a $1.4 million installation under construction at Braunschweig's Technical University. When completed in late 1970, the facility will operate **with two or three 160-kilogauss, U.S.-supplied coil magnets** similar to those at the U.S. National Magnet Laboratory at MIT.

During the second stage of the German project—which is partly financed by the Volkswagen Foundation—the laboratory will have magnets **with field strengths above 200 kilogauss.**

Did Soviets try automatic docking?

The big questions following the Soviet Union's triple space shot: **did they or did they not try out a new, fully automatic docking system, and what happened to it?** Navigational experiments were the most important targets of the joint flight, Soviet authorities claimed in their evaluation of results —even more than the first attempts at space welding. But just what the experiments were and what equipment was used remains, as usual, ambiguous. Western space observers in Moscow believe **docking definitely was on the program,** but for some reason was not carried out. They feel that such a docking attempt might have tested a completely automatic system that would be used, for example, **on the unmanned relay rockets** bringing supplies to an orbiting space station.

Gunn diodes shoot for new jobs in high-speed digital systems

Japanese team, using planar structure for microwave oscillators, has achieved success with Gunn effect in experimental pulse generators and rectangular-pulse regenerators

Gunn diodes, already performing a number of high-frequency jobs, also may have a future in high-speed digital electronic systems, such as pulse-code modulation communications. Researchers at Japan's Nippon Electric Co. have developed experimental high-speed pulse generators and rectangular-pulse regenerators that utilize the traveling high-field domain of the Gunn effect.

Using a planar, rather than a sandwich-type, structure for fabricating microwave oscillators, the team of Kenji Sekido, Makoto Takeuchi, Yoichiro Takayama, Fumio Hasegawa, and Yoshinobu Hayakawa has produced the first reasonably successful semiconductors of this type.

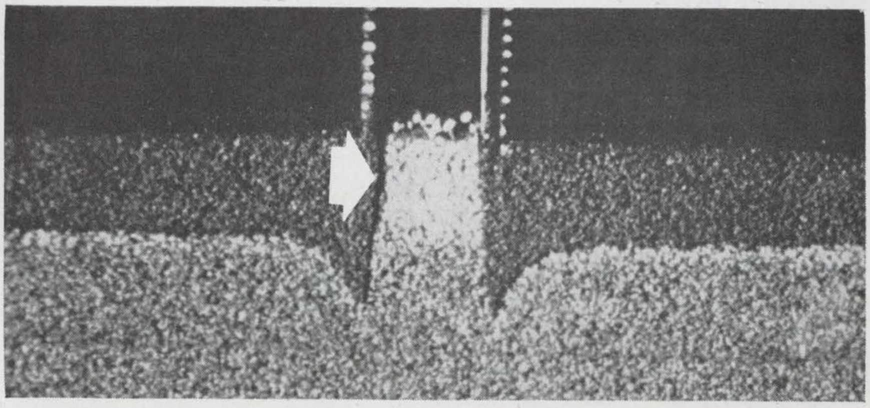
Spiked. The team's bulk-effect functional device is a two-terminal Gunn diode that exhibits spike-shaped current oscillations. With proper biasing this device can act either as a narrow-pulse generator or as a rectangular-pulse regenerator.

To obtain spike outputs that are narrow with respect to repetition rate, it is necessary that the product nL of impurity concentration and length of the device exceed a figure of about $10^{13}/cm^2$. This differs from the devices generally used as microwave oscillators, which have a comparable product on the order of $10^{12}/cm^2$.

Raising the product means that in general the device must have a longer length than standard oscillator diodes—lengths of about 100 microns are common. But the long length increases the difficulty of cooling the usual sandwich structure—essentially a very short rod of gallium arsenide with ohmic contacts at either end. The middle of the rod is far from the contacts—which can be heat-sinked—and thermal coupling to the surrounding air is poor. For this reason, planar devices perform better. The active region of the Japanese planar device is a thin epitaxial layer deposited on a semi-insulating substrate; the substrate is able to conduct away heat along the entire length of the device to a copper heat sink.

The substrate is chrome-doped gallium arsenide, which has high resistivity consistent with uniform lattice structure for growth of an epitaxial layer without imperfections. Although electrical resistivity is high, thermal resistivity of the substrate is about the same as for the gallium arsenide in the active region. Orientation is in the 1-0-0 direction. Epitaxial n-type layers with carrier densities of one to five times $10^{15}/cm^3$ are grown in either vapor or liquid phase—but liquid phase growth appears to give better results. Active layer thickness ranges from about 3 to 27 microns.

Most of the diodes fabricated have a film of 0.4-micron-thick silicon dioxide deposited on the surface. The film is selectively etched so that the remaining dioxide forms stripes whose width equals the desired electrode spacing, and whose direction is parallel to the 1-0-0 direction. Heavily doped contact layers are prepared by liquid-phase regrowth from a gallium-arsenide-saturated tin solution. Examination of wafer cross-sections shows that boundaries of active region and electrodes are along the 1-1-1 plane, which intersects the surface of the wafer at an angle of 54°. Gold-germanium ohmic contacts are ap-



Active region. Planar Gunn diode structure has an active region in the form of stripes, as shown in cross section (above). Dark layers are the electrodes—tin-doped N^{++} regions. Photolithographic techniques are used to delineate the active region, which can be from 3 to 27 microns wide.

plied to the N^{++} gallium arsenide layers.

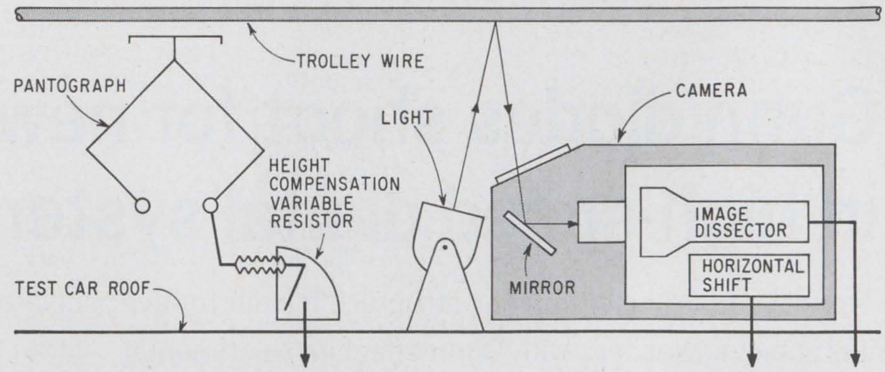
In operation. Researchers at Nippon Electric last year showed that by injecting a small sinusoidal voltage they could synchronize the frequency of the spiky Gunn oscillations in such devices and change fundamental frequency over a range of about two to one. Ability to synchronize the frequency is important when the device is used as a generator of clock pulses—an oscillator operating in stable cavity can be used to set system frequency. Oscillations are in the order of 1 gigahertz, with pulse widths of 0.2 nanoseconds.

The pulse generator is biased in the negative resistance region. Pulse repetition frequency depends on domain transit time, while pulse width depends slightly on carrier density. As the domain being transported reaches anode and is extinguished, a new domain is nucleated and the process repeats.

For operation as a pulse regenerator, the device is biased just below the threshold. When a small trigger pulse is applied, a high-field domain is nucleated and current through the device falls. Current returns to the original quiescent value after the domain transits the device and is extinguished. Pulse width in this mode is reciprocal of free-running repetition frequency, and is in the range of 0.5 to 2 nanoseconds.

Problems. There are still a number of bugs to be ironed out. For one, there is an insensitive region just above the threshold in some of the diodes in which noisy, incoherent oscillations are produced. This diode type still can be used as a pulse generator, but not for pulse regenerators, where operation extends into the noisy region.

Another problem is fabricating devices with desired impedance level. With voltage at about 30 volts, power dissipation must be kept at moderate levels—and devices have been fabricated with impedance levels of about 1,000 ohms. However, this provides power matching to the 75-ohm circuit generally used in high-speed pulse equipment such as pcm but further work is needed.



Midnight special. One night a week, test car zips down Tokaido line tracks at 125 mph while image-dissection tv camera checks overhead electrical wire wear.

Wire-sleuthing

Rejecting such modern developments as lasers in favor of a 35-year old superannuated device, Japanese National Railways has come up with a method of measuring wear in railroad overhead electric wires—at 125 miles per hour. What's more, readings are taken every 11 inches, compared with every 82 feet under an earlier method, which also required a four-man team.

Developed jointly with the Hamamatsu TV Co., the system uses an image-dissection television tube, invented in 1934. Even with electron multiplier assemblies, the image dissector is not used in television pickup systems because other tubes, notably the image orthicon, offer higher sensitivity. Where the latter tube scans an image on a charged plate in the tube by an electron beam, the image dissector moves the image, in the form of an electron bundle, across a pickup head.

A flat spot develops and gets progressively wider as the initially round electric wire used in feeding power to railroad trains wears away. When the wire is worn to about 70% of its original area it must be replaced because it is no longer thick enough to withstand the high pull—up to one metric ton—that dampens vibration.

Man-days. Normally, teams of four workers measure wear manually with micrometers. One man does the measuring, the second man holds the ladder, the third writes down data, and the fourth looks out for approaching trains. Measurements usually are made opposite support poles, which are 165 feet apart, and halfway between poles. This accounts for 20% of all the man-days required for maintenance of power feeding wires—including replacing wires and insulators, and periodic cleaning of insulators.

On standard train lines, with 1,500-volt d-c electrification, measurements can be made under operating conditions because a bamboo ladder provides sufficient insulation. But on the new Tokaido line, with 25,000-volt a-c electrification, power must be turned off before taking measurements; thus they have to be made during early morning hours before the start of the day's service.

The new system is designed to measure at 125 mph. One night a week a test car is driven down the tracks on the Tokaido line at this speed. Because of the new equipment in this car, wear data can be gathered with little labor, except that which is needed to analyze the records after the run has been completed.

The pantograph collector shoe keeps the flat area shiny while the remainder of the wire becomes coated with corrosion products. Since the test car is run at night, the wire can be illuminated from below with a strong return of light from the flat part and almost no reflection from the remainder of wire and surrounding space, providing there is good differentiation (high contrast) between the flat area and remainder of the wire.

Blurring. In initial experiments the image of wire was picked up by a standard industrial television camera. Good discrimination of the flat was obtained, but because of after-image on the photosensitive surface in the vidicon, the pickup became blurred at speeds above about 3 mph. However, use of an image-dissector tube with electron multiplier that was developed for space applications makes it possible to speed up the measurement, because it has virtually no after-image effect.

In actual operation, a 2,000 hertz horizontal sweep sawtooth voltage is applied to the image dissector, rather than the higher frequency used for standard tv horizontal frequency. No vertical sweep is used, because the car moves between scans. The approximately 500 microseconds of each sweep corresponds to a width scale of 500 millimeters. Thus average output pulses—corresponding to a flat with width in the order of millimeters—is in the order of microseconds. Since 125 mph is about 180 feet per second, measurements of wire widths made on individual sweeps occur at intervals of about 11 inches.

Processing of the signal from the image-dissector is fairly simple: it is first amplified and shaped, then sliced at a preset level to obtain a noise-free pulse signal. The signal goes to a computing circuit, where pulse width is corrected for variations in wire height, and then converted from width to equivalent voltage by a ramp-type converter, which drives the mirror of a photographic-type magnetic oscilloscope.

The system is designed to operate correctly for variations in wire height off the ground between 14.7 feet and 17.7 feet, and for lateral variations of up to 10 inches from the center of the track. Correction is needed for variations in height because the flat area presents a slightly different angle to the camera as wire height varies. The test car is already fitted with a variable resistor mechanically driven by the power-shoe-supporting pantograph to measure wire height—and the signal from the variable resistor is used for correction. A signal from the slicer drives a servo system that keeps the camera centered on the wire despite lateral variations in wire position; because sweep is not perfectly linear, accuracy is increased if measurement is always made on the same portion of sweep.

Other methods of testing were considered. But because the electrified wire is the source of very strong electrical noise, any measurement method sensitive to electrical noise is precluded. Illumination of trolley wire by laser on one side and measurement of height of shadow on other side was considered—and rejected because of possible damage to either trolley wire or equipment from the roll of test car and severe bouncing at railway switches.

Great Britain

Out of GaAs

In the eight years or so since researchers first realized the possibilities of gallium arsenide as a microwave semiconductor, most of them have been busy with practical development, particularly of the Gunn effect. There's been little time left over to worry whether some other material or combination of materials might offer greater potential for development of electrical effects at speeds usable in microwave systems.

However, at the Royal Radar Establishment, where much of the work that gave Britain a world lead in practical Gunn-effect devices was carried out, Cyril Hilsum and David Rees have worked steadily to develop a full theory about the properties required of an ideal microwave semiconductor —and to see what materials might provide them.

As a result, they have given in-depth theoretical study to two mixed crystal semiconductors, or crystals containing random mixtures of two different but related materials—indium arsenide-gallium arsenide, and indium arsenide-indium phosphide. Then practical work was done with the latter, because theory showed that it should be useful over a wider range of compositions.

Among other useful characteristics, indium arsenide-indium phosphide exhibits a current-controlled negative-resistance effect, and Hilsum and Rees think the effect will make possible a new type of avalanche diode with current controllable (s-type) negative resistance from d-c up to at least 10 gigahertz. They say it should also be suitable for construction of Schottky-barrier field-effect transistors, and transit-time-mode and anomalous-mode avalanche diodes operating well above the frequency limits of silicon and gallium arsenide.

Theory. Hilsum and Rees took as their starting point the basic limitation of gallium arsenide that carrier electronics will not travel faster than about $2x10^7$ centimeters per second however much the electric field strength is increased. As field strength increases above the saturation level, the electrons jump in stages to states of higher energy and greater effective mass so that they slow down, producing the depletion layer that is the basis of the Gunn effect. Hence a semiconductor material required to operate above the practical frequency limit of GaAs must allow higher maximum electron drift velocities before transfer from the initial conduction energy band to higher energy bands occurs.

Ideally the carrier electrons should be light so that they can readily achieve high speed. However, low effective electron mass is always associated with a small energy gap between the valence band and the conduction band, and materials with small energy gaps won't work at room temperatures, so that for everyday practical devices these requirements are conflicting.

However, there is another consideration. The valence band-conduction band energy gap must be smaller than the separation of the conduction bands. This is because the negative-resistance effect requires avalanching to occur readily. If the separation of the conduction energy bands is smaller than the valence band-conduction band energy gap, electrons accelerating under the effect of an increased field will transfer to higher energy, higher mass states without avalanching. But with favorable gap relationships, no more than a negligible number of electrons will transfer to the higher mass states, making high electron velocities possible.

In practice, the energy gap must be at least 0.75 electron volt for room temperature operation. Combinations of both mixed crystal systems can be found which meet this energy gap requirement, which avalanche before significant transfer from the conduction band to higher energy bands occurs, and which can reach maximum electron drift velocities of three times the maximum velocity in GaAs.

In fact, InAs-InP meets these requirements over a composition range of 30% arsenide, and 70% phosphide to 54% arsenide, and 46% phosphide, more than twice the range of the other system. The Gunn effect occurs towards the high-phosphide end of the range, when the valence band-conduction band energy gap becomes larger than the separation band gaps.

Practice. Among practical devices considered as possible negative-resistance avalanche diodes, Hilsum and Rees have considered a p^+-n junction diode. Some experimental devices fabricated from 30% indium phosphide and operating at room temperature have shown a voltage drop from 10 volts to three volts for a current increase from 10 milliamps to 40 milliamps. Maximum-to-minimum voltage ratio of about three is encouraging, says Rees, from the point of view of oscillator efficiency. When mounted in a microwave cavity these diodes have excited oscillations up to one gigahertz. Rees says that theoretical maximum operating frequency for similar devices should be at least 10 Ghz.

Closely watched buses

More and more big-city surface transit officials are realizing that to keep their buses running on time they must find some kind of electronic monitoring system using roadside markers and transceiver equipment. But such systems are costly—at the least, each roadside marker and bus must be connected both to each other and to a home base by a communications link. Hamburg, West Germany, for instance, has spent an estimated $750,000 for a system to control some 300 buses [*Electronics*, July 11, 1966. p. 177].

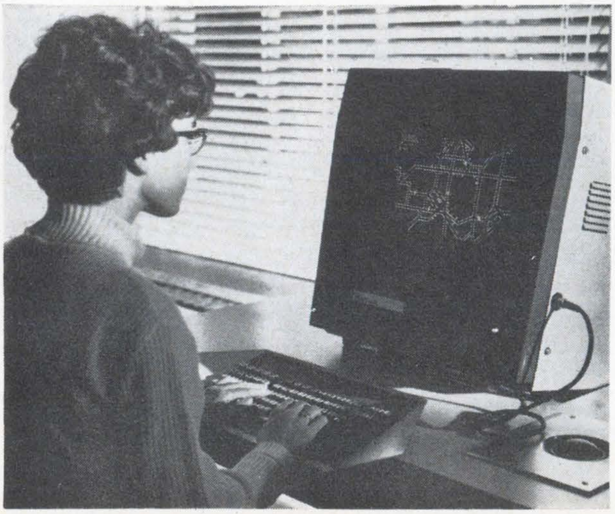
Now England's Marconi Ltd. is developing a system that may cut costs by more than half. The key: use of passive roadside markers which the buses scan optically as they pass by.

The markers in this system are merely 8-by-20-inch lamp post-mounted metal plates covered with 18 strips of polarized reflecting material of varying widths. The array of strips is unique to each location and when scanned from top to bottom by a light source on the passing bus, the reflections from the strips are transformed by photodiodes into a binary code. The code passes to a register in a telemetry system in the bus and remains there until it is finally updated by the next marker.

Call signature. The information in the register is scanned periodically by radio from a central control station, using a standard vhf/uhf mobile two-way radio. Each bus has its own two-tone call signature, and upon receiving it the radio automatically transmits the location of the last beacon passed. If the controller wants to speak to a given bus, he dials its code number and a third call tone is added which cancels the data transmission and signals to the driver to pick up his microphone. Then the mike switches the r-f link from the telemetry channel to a speech channel.

In the control room, a Marconi Myriad computer scans the buses for present position at a maximum rate of 40 per second, and presents the information on a moving-map crt display. The computer also compares actual and ideal situations, and provides a readout of all differences over a selected threshold. Marconi says maximum use of standardized equipment, plus the low cost of the markers, should bring down the price for a 400-bus system to between $200,000 and $250,000.

The system, in the experimental stage, had its first tryout earlier this month at Bristol, where city transportation officials appear very interested. In that tryout a Pye two-way radio was used and the light source was a low-power laser. But in operational systems the laser may be replaced by a quartz-iodine or neon light source. The essential characteristic is that the beam must remain adequately concentrated during transmission and reflection over a 30-foot span of road at a rate of two scans per marker at 100 miles per hour. Though this may not be necessary for bus systems in a congested city, Marconi sees applications for the system in many vehicle-control operations.



Bus watch. Crt moving-map display charts bus movements in Marconi system. Buses scan passive roadside markers for location code and transmit it to HQ over standard vhf/uhf radio link.

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As you can see, we've made it both compact and lightweight (2½ lbs.), by using a large-scale integrated circuit. So the Digitest 500 is just 2⅞" x 5" x 9", but has polarity indication, a moving decimal point, an overload indicator and built-in calibration check. Plus overrange up to 100% (on all ranges except 300VAC).

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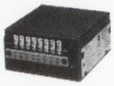

$3\frac{5}{32}'' \times 3\frac{9}{32}'' \times 1\frac{21}{32}''$

Model	ADJ. VOLT. RANGE VDC	MAX. MA. AT AMBIENT OF:[1] 40°C	50°C	60°C	71°C	Price[2]
LCS-1-01A	0-7	275	220	165	110	$70
LCS-1-02A	0-18	130	130	100	85	70
LCS-1-03A	0-32	90	90	90	50	70
LCS-1-04A	0-60	50	50	50	30	80
LCS-1-05A	0-120	18	18	18	18	85

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LUS-1-06	180 VDC	25 ma up to 71°C at nominal line voltage for use with up to 7 Nixie® tubes.	$35

LCS-2 SINGLE OUTPUT MODELS

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Model	ADJ. VOLT. RANGE VDC	MAX. MA. AT AMBIENT OF:[1] 40°C	50°C	60°C	71°C	Price[2]
LCS-2-01	0-7	550	455	350	240	$80
LCS-2-02	0-18	330	275	210	140	80
LCS-2-03	0-32	240	205	155	95	80
LCS-2-04	0-60	145	115	87	57	90
LCS-2-05	0-120	50	50	45	30	90

LCS-3 SINGLE OUTPUT MODELS

$3\frac{3}{16}'' \times 3\frac{3}{4}'' \times 5''$

Model	ADJ. VOLT. RANGE VDC	MAX. MA. AT AMBIENT OF:[1] 40°C	50°C	60°C	71°C	Price[2]
LCS-3-01	0-7	1200	1000	750	500	$90
LCS-3-02	0-18	750	620	480	320	90
LCS-3-03	0-32	400	350	265	170	90
LCS-3-04	0-60	240	190	140	85	99

(Nixie is trademark of Burroughs Corp.)

Circle 212 on reader service card

LCS-4 SINGLE OUTPUT MODELS (Fixed Voltage)

$4\frac{29}{32}'' \times 4\frac{29}{32}'' \times 5''$

Model	FIXED VOLT. RANGE VDC	MAX. AMPS. AT AMBIENT OF:[1] 40°C	50°C	60°C	71°C	Price[2]
LCS-4-3	3±5%	4.5	3.9	3.1	2.0	$130
LCS-4-3P6	3.6±5%	4.5	3.9	3.1	2.0	130
LCS-4-4	4±5%	4.5	3.9	3.1	2.0	130
LCS-4-4P5	4.5±5%	4.4	3.7	2.9	1.8	130
LCS-4-5	5±5%	4.4	3.7	2.9	1.8	130
LCS-4-6	6±5%	4.0	3.4	2.6	1.5	130
LCS-4-8	8±5%	4.0	3.4	2.6	1.5	130
LCS-4-10	10±5%	3.2	2.8	2.2	1.3	130
LCS-4-12	12±5%	3.1	2.8	2.2	1.3	130
LCS-4-15	15±5%	2.8	2.6	2.1	1.3	130
LCS-4-18	18±5%	2.6	2.4	2.0	1.2	130
LCS-4-20	20±5%	2.4	2.2	1.9	1.1	130
LCS-4-24	24±5%	2.2	1.8	1.5	0.95	130
LCS-4-28	28±5%	2.0	1.6	1.4	0.85	130
LCS-4-36	36±5%	1.8	1.5	1.3	0.85	140
LCS-4-48	48±5%	1.2	1.1	0.9	0.75	140
LCS-4-100	100±5%	0.46	0.46	0.46	0.34	140
LCS-4-120	120±5%	0.40	0.40	0.40	0.30	140
LCS-4-150	150±5%	0.32	0.32	0.32	0.25	180

LCS-4 SINGLE OUTPUT MODELS (Wide Range)

$4\frac{29}{32}'' \times 4\frac{29}{32}'' \times 5''$

Model	ADJ. VOLT. RANGE VDC	MAX. AMPS. AT AMBIENT OF:[1] 40°C	50°C	60°C	71°C	Price[2]
LCS-4-01	0-7	3.3	3.0	2.3	1.5	$130
LCS-4-02	0-18	1.8	1.6	1.2	0.8	130
LCS-4-03	0-32	1.0	0.9	0.7	0.5	130
LCS-4-04	0-60	0.55	0.5	0.43	0.3	140
LCS-4-05	0-120	0.25	0.25	0.22	0.16	140

LCD-2 DUAL OUTPUT MODELS

$3\frac{5}{32}'' \times 3\frac{9}{32}'' \times 3\frac{9}{32}''$

Model	ADJ. VOLT. RANGE VDC (EACH SIDE)	MAX. MA. AT AMBIENT OF:[1] 40°C	50°C	60°C	71°C	Price[2]
LCD-2-11	0-7 0-7	300 300	240 240	175 175	115 115	$125
LCD-2-12	0-18 0-7	160 300	130 240	100 175	65 115	125
LCD-2-13	0-32 0-7	120 300	95 240	70 175	45 115	125
LCD-2-22	0-18 0-18	160 160	130 130	100 100	65 65	125
LCD-2-23	0-32 0-18	120 160	95 130	70 100	45 65	125

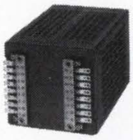
guarantee on parts and labor will.

LCD-2 DUAL OUTPUT MODELS Continued

Model	ADJ. VOLT. RANGE VDC (EACH SIDE)	MAX. MA. AT AMBIENT OF: [1] 40°C	50°C	60°C	71°C	Price [(2)]
LCD-2-33	0-32 0-32	120 120	95 95	70 70	45 45	$125
LCD-2-44	0-60 0-60	65 65	52 52	37 37	23 23	170
LCD-2-55	0-120 0-120	30 30	30 30	22 22	14 14	170

LCD-3 DUAL OUTPUT MODELS

3³⁄₁₆" x 3¾" x 5"



Model	ADJ. VOLT. RANGE VDC	MAX. MA. AT AMBIENT OF: [1] 40°C	50°C	60°C	71°C	Price [(2)]
LCD-3-11	0-7 0-7	700 700	590 590	480 480	340 340	$150
LCD-3-12	0-7 0-18	700 400	590 350	480 300	340 210	150
LCD-3-13	0-7 0-32	700 225	590 190	480 160	340 120	150
LCD-3-22	0-18 0-18	400 400	350 350	300 300	210 210	150
LCD-3-23	0-18 0-32	400 225	350 190	300 160	210 120	150
LCD-3-33	0-32 0-32	225 225	190 190	160 160	120 120	150
LCD-3-44	0-60 0-60	130 130	100 100	70 70	45 45	175

LCD-A DUAL OUTPUT MODELS

3³⁄₁₆" x 3¾" x 6½"

Model	ADJ. VOLT. RANGE VDC	MAX. AMPS. AT AMBIENT OF: [1] 40°C	50°C	60°C	71°C	Price [(2)]
LCD-A-11	0-7 0-7	1.0 1.0	0.9 0.9	0.7 0.7	0.5 0.5	$155
LCD-A-12	0-18 0-7	0.5 1.0	0.45 0.9	0.4 0.7	0.3 0.5	155
LCD-A-13	0-32 0-7	0.35 1.0	0.3 0.9	0.25 0.7	0.2 0.5	155
LCD-A-22	0-18 0-18	0.5 0.5	0.45 0.45	0.4 0.4	0.3 0.3	155
LCD-A-23	0-32 0-18	0.35 0.5	0.3 0.45	0.25 0.4	0.2 0.3	155
LCD-A-33	0-32 0-32	0.35 0.35	0.3 0.3	0.25 0.25	0.2 0.2	155
LCD-A-44	0-60 0-60	0.2 0.2	0.18 0.18	0.14 0.14	0.12 0.12	180
LCD-A-55	0-120 0-120	75 ma 75 ma	75 ma 75 ma	75ma 75ma	60 ma 60 ma	200

Write, wire or call for new 72-page catalog

LCD-4 DUAL OUTPUT MODELS

4²⁹⁄₃₂" x 4²⁹⁄₃₂" x 5"

Model	ADJ. VOLT. RANGE VDC	MAX. AMPS. AT AMBIENT OF: [1] 40°C	50°C	60°C	71°C	Price [(2)]
LCD-4-11	0-7 0-7	1.8 1.8	1.5 1.5	1.2 1.2	0.7 0.7	$190
LCD-4-12	0-18 0-7	1.0 1.8	0.8 1.5	0.65 1.2	0.4 0.7	190
LCD-4-13	0-32 0-7	0.6 1.8	0.53 1.5	0.4 1.2	0.24 0.7	190
LCD-4-22	0-18 0-18	1.0 1.0	0.8 0.8	0.65 0.65	0.4 0.4	190
LCD-4-23	0-32 0-18	0.6 1.0	0.53 0.8	0.4 0.65	0.24 0.4	190
LCD-4-33	0-32 0-32	0.6 0.6	0.53 0.53	0.4 0.4	0.24 0.24	190
LCD-4-44	0-60 0-60	0.33 0.33	0.3 0.3	0.24 0.24	0.15 0.15	240
LCD-4-55	0-120 0-120	0.12 0.12	0.12 0.12	0.12 0.12	0.075 0.075	240
LCD-4-152 Fixed	15±5% 15±5%	1.5 1.5	1.3 1.3	1.0 1.0	0.6 0.6	220

OVERVOLTAGE PROTECTION ACCESSORIES
(Separate OV required for each output)

Model	ADJ. VOLT. RANGE VDC	FOR USE WITH	Price [(2)]
LC-OV-10	3-24	LCS-1, LCS-2, LCD-2, LCS-3, LCD-3	$20
LC-OV-11	3-47		20
LC-OV-12	3-70		25
LM-OV- 1	3- 8	Fixed Voltage LCS-4, LCD-4	30
LM-OV- 2	6-20		30
LM-OV- 3	18-70		30
LH-OV- 4	3-24	LCD-A & wide range LCD-4, LCS-4	35
LH-OV- 5	3-47		35
LH-OV- 6	3-70		35

NOTES: (1) For operation at other than 57-63 Hz, consult factory for ratings and specifications.
(2) All prices FOB Melville, N. Y. All prices and specifications subject to change without notice.

One day delivery—90% of all models

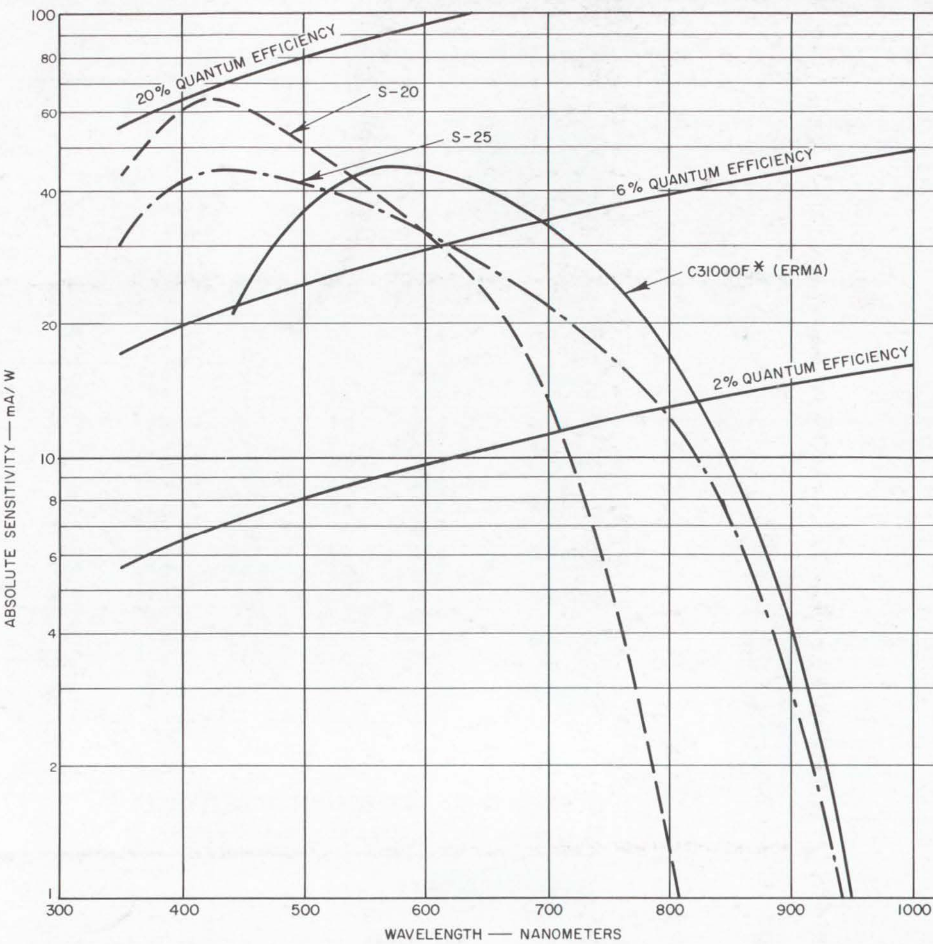
Guaranteed for five years material and labor

These are new reduced prices effective November 1, 1969.

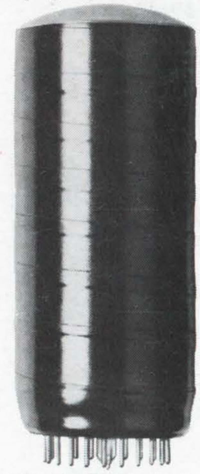
LAMBDA
ELECTRONICS CORP.
A Veeco Company

515 BROAD HOLLOW ROAD, MELVILLE, L. I., NEW YORK 11746. TELEPHONE: 516-694-4200. TWX 510-224-6484; CABLE: LAMBDATRON, MELVILLE, N. Y.

TYPICAL RESPONSE CHARACTERISTICS.



The C31000F was used as the detector in the Apollo 11 laser ranging experiment.



NEW! EXTENDED RED RESPONSE RCA-C31000F QUANTACON PHOTOMULTIPLIER

The C31000F is new! It's an Extended-Red, Multi-Alkali cathode version of the previously-announced C31000D. C31000F is recommended for applications in the red area of the spectrum, particularly laser detection and Raman spectroscopy. The latest addition to the RCA QUANTACON photomultiplier family, it is characterized by the use of Gallium Phosphide as the secondary emitting material on the first dynode.

Gallium Phosphide boosts the single electron resolution of this newest RCA QUANTACON photomultiplier as much as 10 times over that of tubes using conventional dynode materials. As a result, it is possible for this 2" dia. light detector, whose prototype is the industry-famous 8575, to discriminate between light-producing phenomena that generate one, two, three, or four photoelectrons.

Developed by RCA, the use of Gallium Phosphide places the C31000F and other RCA QUANTACON photomultipliers at the forefront of devices that can reveal nuclear, astronomical and biochemical events never seen before.

For more information on this 12-stage device, and other RCA QUANTACON photomultipliers, including the C31000D and the 5-inch C70133B, see your local RCA Representative. For technical data on specific types, write: RCA Electronic Components, Commercial Engineering, Section J19P-2/ZP1R, Harrison, N. J. 07029. In Europe, contact: RCA International Marketing S. A., 2-4 rue du Lièvre, 1227 Geneva, Switzerland.

*Typical Q.E. at 860 nm is 1.4%, corresponding to a radiant sensitivity of 10 mA/W. C31000E is the flat-faceplate version of the C31000F which has a curved faceplate.

RCA