Electronic Design

FOR ENGINEERS AND ENGINEERING MANAGERS
VOL. 15 NO. 17
AUGUST 16, 1967

MIL spec performance...in half the space!

Type 990 miniature solid tantalums typify TRW's creative engineering. They're *designed* to fit in half the space. *Designed* to give better shock and vibration resistance. *Designed* to MIL specs. They're *designed* to be the best hermetically sealed tantalums you can buy. Values from 8.2 to 330 mfd, 6 to 35 V.

Get the TRW tantalum story on space-savers like the 990, on standard MIL types and tantalum hi rel capability. Contact TRW Capacitor Division, TRW INC., Box 1000, Ogallala, Nebraska. Phone (308) 284-3611. TWX: 910-620-0321.

TRW®

ON READER-SERVICE CARD CIRCLE 242

The only expense HP spared in making these versatile counters...

... is yours.

Only Hewlett-Packard offers the versatility-economy combination represented by the new 5221A and 5216A Electronic Counters, using integrated circuits. Wide frequency range, high input impedance and sensitivity, long-life readout tubes with display storage, six measuring functions (in 5216A)... all this at prices as low as *one-half* that of comparable electronic counters available today.

The HP 5221A Counter has 0.1 and 1 second gate times (power line frequency time base), 1 meg/30 pF input impedance and an input signal sensitivity of 100 millivolts. It is the lowest cost frequency counter with a 10 MHz counting rate available. 4-digit readout is standard, 5 or 6 digits optional.

The HP 5216A Counter is an extremely versatile, 7-digit, 12.5 MHz counter for measuring frequency, time interval, period, multiple period average (in decade steps from 1 to 10^5), frequency ratio and totalizing. Gate times: 0.01/0.1/1.0/10 sec. Input sensitivity: 10 mV. Input impedance: 1 meg/50 pF. Time base: crystal with $< \pm 2 \times 10^{-6}$/month maximum aging rate. BCD output for operating data printers and other system elements. The price, even though the 5216A's frequency range is greater, is 30% below counters with similar functions.

Both counters feature HP's exclusive zero blanking, which makes reading easier and faster by suppressing any zeros to the left of the most significant digit. This unique benefit results from specially designed Hewlett-Packard proprietary integrated circuits used in both of the new counters.

Call your local HP field engineer for more details, or write Hewlett-Packard, Palo Alto, California 94304; Europe: 54 Route des Acacias, Geneva.

Visit Hewlett-Packard at WESCON '67
San Francisco Cow Palace, August 22-25

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02705

ON READER-SERVICE CARD CIRCLE 2

Unit Citation

We're honored! Not that we've won our crusade yet...just another battle ribbon. A while back we scored a military victory with our Model 880, the *first* solid state Mil Spec counter. This time it's a fully-militarized 5MHz all-silicon solid state universal counter-timer. Call it AN/USM-245, sir.

There's a good reason you should be interested. You see, the military model had its basic reliability well proved by our original commercial version, Model 607A. Now *there's* the one for *you!* It offers more features and capabilities than even the Admirals asked for. And it's available on-the-double.

Now hear this: Our lowest-bidder-type price is only $1,575. (Check *that* saving against our competitor!) Then check these features: Model 607A is ideal for wide-range frequency measurements, frequency ratio determination, period and multiple period or time interval measurements, and pulse count totalizing. Time base is a 1 MHz crystal oscillator (for 1 microsec resolution). Display is six decade inline with display storage. BCD output transfers directly to CMC Model 410 tape printer, computer systems, etc. Automatically positioned illuminated decimal. Either ac or dc coupling of input signal. Front and rear A and B channel inputs. Rugged, compact (approx. 3½" high). Available for bench or rack.

THANKS

With all our pride and excitement over our AN/USM-245 award, and other new products, we haven't forgotten our fellow Crusaders who've made this success possible...YOU. A FREE Crusading Engineers medal is our fun-loving way of saying thanks. Get yours by writing for data so you can "Check the Specs" of our 607A. Your "chief" will be so proud of you at mail call!

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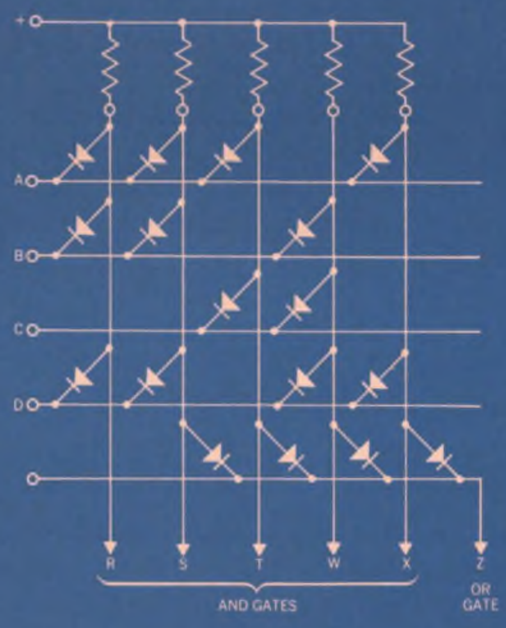
CMC

Computer Measurements Company is a Leading Designer and Manufacturer of Electronic Instrumentation to Count, Measure, and Control.

ON READER-SERVICE CARD CIRCLE 3

State of the monolithic art



Electronic Design VOL. 15 NO. 17
FOR ENGINEERS AND ENGINEERING MANAGERS AUG. 16, 1967

NEWS

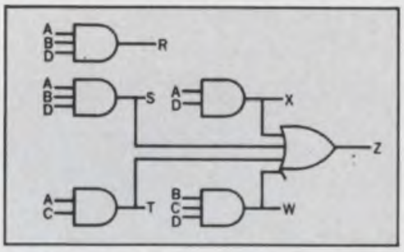
TECHNOLOGY

PRODUCTS

Departments

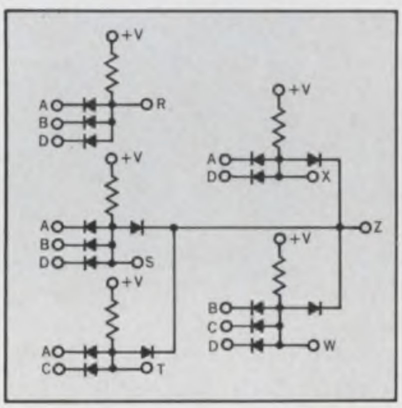
ELECTRONIC DESIGN is published biweekly by Hayden Publishing Company, Inc., 850 Third Avenue, New York, N. Y. 10022. James S. Mulholland, Jr., President. Printed at Poole Bros., Inc., Chicago, Ill., Controlled-circulation postage paid at Chicago, Ill., and New York, N. Y. Application to mail at controlled rates pending in St. Louis, Mo. 62,601 copies this issue.

Logic function generator is simplified with Radiation's 5 x 5 Monolithic Diode Matrix



Radiation's RM-77 Monolithic Diode Matrix allows design engineers to: Generate logic functions for data transfer and operational control—Eliminate unnecessary logic gates—Reduce delay time—Save space by reducing package count—Increase speed of performance—Boost fan-out capability through duplicate function generation—Combine matrices to produce many AND/OR logic functions.

Radiation's 5 x 5 Matrix, at left, forms a two-level AND/OR logic array. The logic diagram above and circuit below clarify the functions generated. The logic equations are listed below. This is only one of many applications in which Radiation's Diode Matrices offer the most reliable and the most economical approach to diode logic.

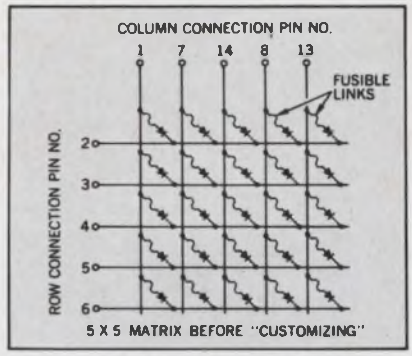


R = A·B·D S = A·B·D
T = A·C W = B·C·D
X = A·D Z = X + S + T + W

Radiation's popular dielectrically isolated matrices provide an unusual degree of flexibility. (1) RM-77 Matrices contain 25 active devices per chip. (2) A fusible link in series with each diode permits unlimited matrix patterns to be formed. And (3), circuits can be combined to produce an almost infinite variety of configurations.

In addition to flexibility, Radiation 5 x 5 Matrices offer the increased reliability of monolithic construction. Size and weight requirements are slashed through reduced package count. Further, cost of matching, testing and assembly of discrete diodes is eliminated.

Production has been expanded to guarantee fast shipment of matrices "customized" to your exact requirements. In fact, most orders are shipped on a 24-hour basis.



A new low-cost RM-177 design in ceramic dual in-line package is available in volume at a unit price of $2.50—and can be supplied to any code configuration requested.

Write or phone for data sheets on the entire line of Radiation Monolithic Diode Matrices. *Worst-case limits* are included, as well as all information required by design engineers. We'll also be glad to supply our new manual, Monolithic Diode Matrix Technical Information and Applications. For your copy, write on your company letterhead to our Melbourne, Florida office.

Radiation 5 x 5 Monolithic Diode Matrices* (typical limits)

Characteristic	Symbol	RM-74	RM-75	RM-77 RM-177†	Unit	Test Conditions ($T_A = +25°C$)
Forward drop	V_F	1.0 0.7	1.3 0.75	1.0 0.7	V	$I_F = 20$ mA $I_F = 1$ mA
Reverse breakdown	BV_R	60	60	50	V	$I_R = 100\ \mu A$
Reverse current	I_R	7	25	70	nA	$V_R = 25$ V
Reverse recovery	t_{rr}	7	11	30	ns	$I_F = 10$ mA to $I_R = 10$ mA
Crosspoint capacitance	C_{cp}	1.9	1.9	2.0	pF	$V_R = 5$ V; f = 1 MHz
Coupling coefficient	I_{CL}	20	20	20	μA	See data sheet

*Supplied in TO-84 packages. †Supplied in ceramic dual in-line package.

All Radiation integrated circuits are dielectrically isolated.

VISIT US AT WESCON BOOTH 5130-5131.

RADIATION INCORPORATED
MICROELECTRONICS DIVISION

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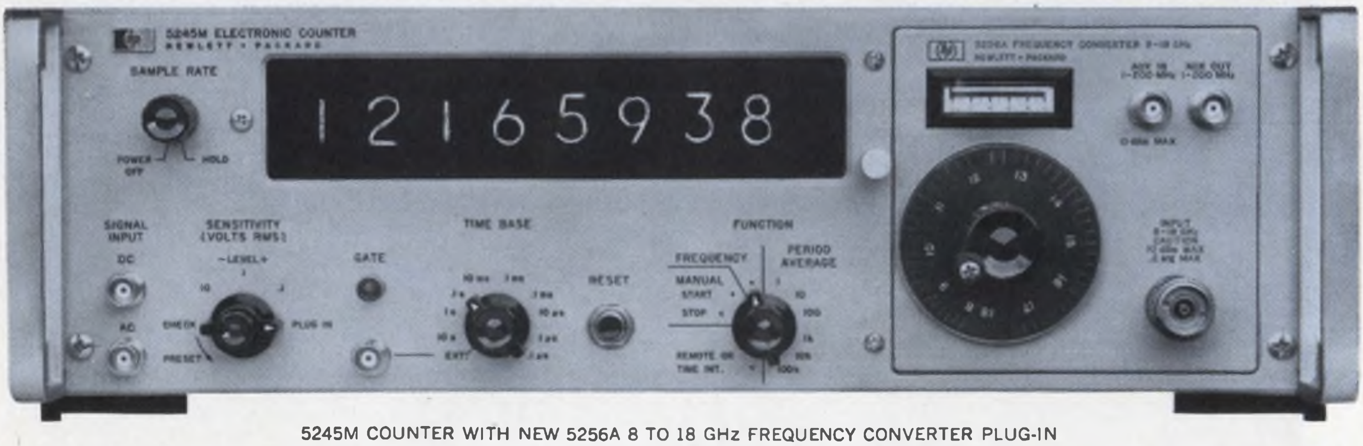
ON READER-SERVICE CARD CIRCLE 4

5×10^{-10}/day stability *

and rapid warm-up, too



5245M COUNTER WITH NEW 5256A 8 TO 18 GHz FREQUENCY CONVERTER PLUG-IN

* $<5\times10^{-10}$/day aging rate (long-term stability)
45-minute warm-up
5×10^{-11}/sec short-term stability (rms)
$<\pm5\times10^{-11}/°C$ change with temperature
$<\pm5\times10^{-11}$ change with ±10% line voltage change
$<2\times10^{-11}$ change for load changes on 5 MHz output
Time base output so stable and spectrally pure you can use it as a standard.

The unique specifications on this new Hewlett-Packard plug-in counter belong at the top of the page. They're not mere footnotes, because they combine to offer counter time-base performance never before available.

The new HP 5245M Counter has all the features of the time-proven 50 MHz HP 5245L Plug-in Counter and, in addition, has a time-base with unprecedented accuracy and usefulness as a secondary frequency standard.

The new time-base increases measurement accuracy, particulary when making high-resolution frequency measurements with HP frequency converter plug-ins. There's less frequent need for calibration. The counter's 5 MHz output is present whenever the power cord is plugged in and serves as a secondary frequency standard with excellent stability and spectral purity. For example, spectra less than 1 Hz wide (half-power points) are obtainable when multiplied to X-Band (12.4 GHz). The fast warm-up saves time, too . . . the time-base typically comes to within 1×10^{-8} of its previous frequency within 45 minutes after a 24-hour absence of primary power under lab conditions. The long-term aging rate of 5×10^{-10}/day (max.) is achieved in a fraction of the time normally associated with such performance.

Other features include: the widest variety of high-performance front-panel plug-ins, 8-digit readout, BCD output for recorders, display storage, 1 meg/25 pf input impedance on all ranges.

The new 50 MHz counter is an all-purpose instrument. Use it for measuring frequency, period, multiple period average, ratio, multiples of ratio and for scaling by decades. And increase its versatility with the plug-ins, including the three new ones described below.

HP development of the small ultra-stable time-base for the 5245 Counter is evidence of the continuing engineering commitment that keeps the HP 5245 and 5246 Counter Series the most advanced and versatile in the industry. A steady stream of new high-performance plug-in accessories are compatible with the 5245L, 5245M and 5246L Counters.

NEW 8 TO 18 GHz FREQUENCY CONVERTER With the 5256A plugged into your HP counter you can measure from 8 to 18 GHz. Resolution is up to 1 Hz with only 4 seconds of counter operation, or 10 Hz resolution in 0.4 seconds, etc. Use is rapid and virtually fool-proof. Scheduled availability, October, 1967.

DC TO 12.4 GHz WITH ONLY TWO PLUG-INS Using only two plug-in frequency converters, the HP 5255A and 5254B, your counter measures frequencies DC to 12.4 GHz with 1 Hz resolution. The 5254B covers 200 MHz to 3 GHz, and the 5255A covers 1 to 200 MHz and 3 to 12.4 GHz—without spurious responses.

NEW PRESCALER FOR 1 mV SENSITIVITY The 5258A Prescaler gives you the most sensitive 1 to 200 MHz counting instrument available. It increases counter sensitivity to 1 mV and extends the direct readout range to 200 MHz. No tuning or arithmetic calculations. Combine it with the new 5254B Converter and your counter covers DC to 3 GHz.

For complete information on the advanced counter and plug-ins, call your local HP field engineer or write Hewlett-Packard, Palo Alto, California 94304; Europe: 54 Route des Acacias, Geneva.

5256A 8-18 GHz CONVERTER

5254B 0.2-3 GHz CONVERTER

5258A SENSITIVE PRESCALER

5245M and accessories (also compatible with HP 5245L and 5246L Counters)

HP 5245M Counter without plug-ins, $3200.
HP 5255A 3 to 12.4 GHz Converter Plug-in, $1650.
HP 5254B 0.2 to 3 GHz Converter Plug-in, $825.
HP 5253B 50 to 500 MHz Converter Plug-in, $500.
HP 5251A 20 to 100 MHz Converter Plug-in, $300.
HP 5252A DC to 350 MHz Prescaler Plug-in, $685.
HP 5258A 1 to 200 MHz Prescaler Plug-in, $825
HP 5261A Video Amplifier Plug-in, $325.
HP 5262A Time Interval Plug-in, $250.
HP 5264A Preset Unit Plug-in, $650.
HP 5265A DVM Plug-in, $575.
HP 5260A 0.3-12.4 GHz Automatic Frequency Divider, $3450.
HP 2590B 0.5-15 GHz Transfer Oscillator, $2150.

PS: There's also a new, faster digital printer, the Model 5050A (20 lines/sec up to 18 columns), $1750 + $35/column.

HEWLETT hp PACKARD

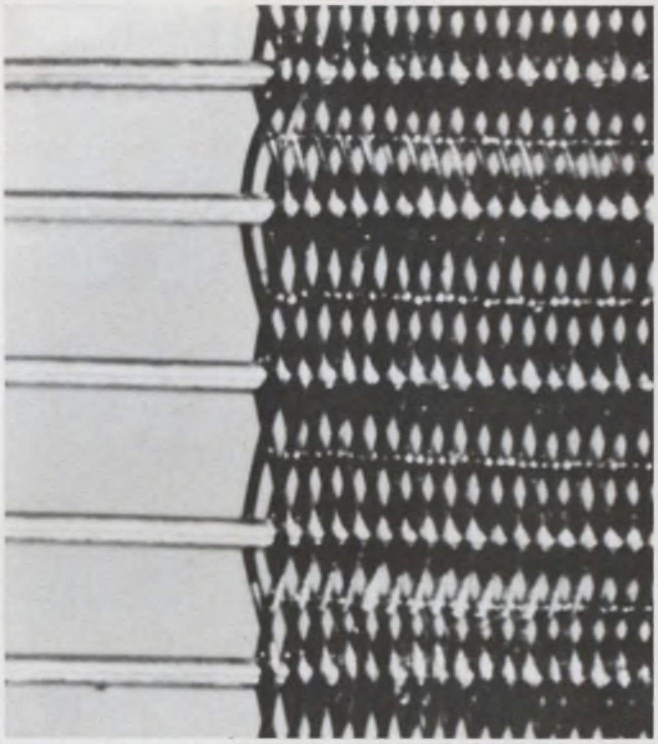
ELECTRONIC COUNTERS

2562

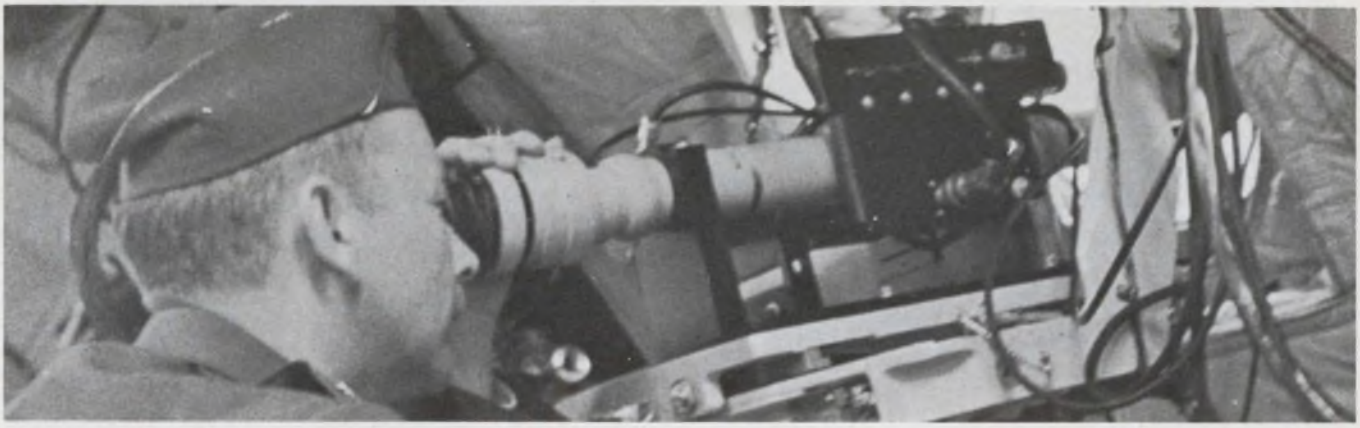
ON READER-SERVICE CARD CIRCLE 7

News

Electromagnetic interference problems need a systems approach for a solution. Page 17



Thin magnetic films on wire substrates bid to preempt certain computer memories. Page 23



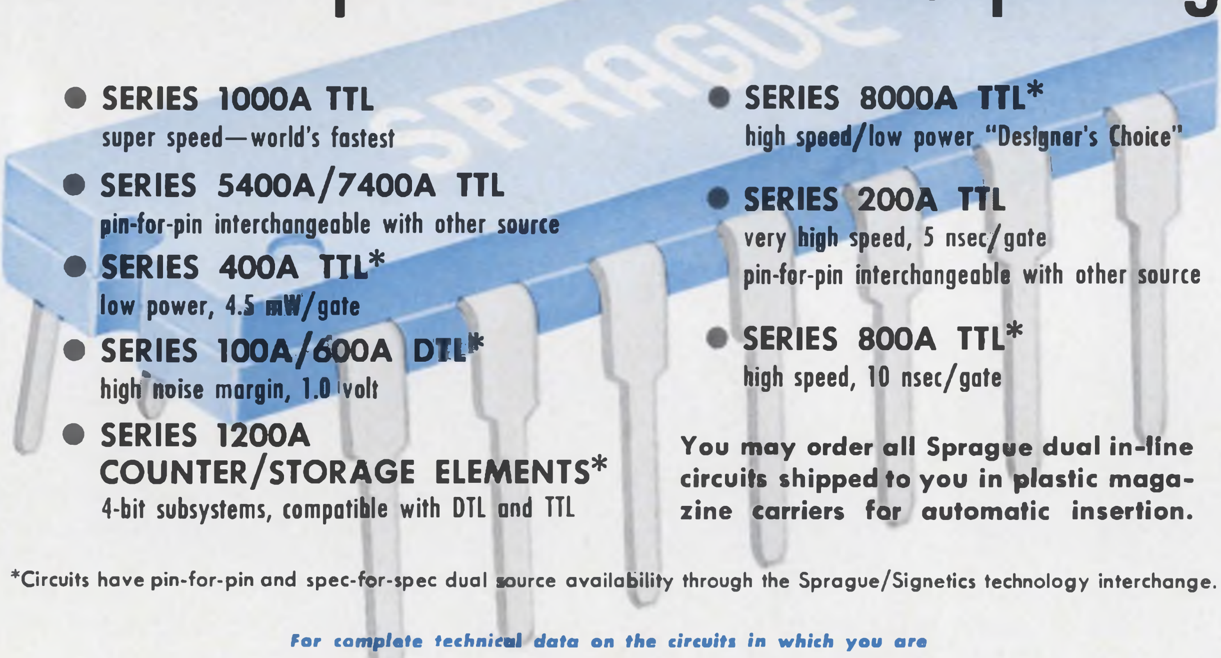
Airborne laboratory aboard a modified KC-135 is to begin worldwide flights to study the variations in visible and infrared radiation and water vapor in the atmosphere. Page 36

Also in this section:

Now from Sprague Electric!

241 LOGIC CIRCUITS IN PLASTIC DIP

Choose from 8 families of DTL and TTL in low-cost plastic dual in-line packages



- **SERIES 1000A TTL**
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  pin-for-pin interchangeable with other source
- **SERIES 400A TTL***
  low power, 4.5 mW/gate
- **SERIES 100A/600A DTL***
  high noise margin, 1.0 volt
- **SERIES 1200A COUNTER/STORAGE ELEMENTS***
  4-bit subsystems, compatible with DTL and TTL
- **SERIES 8000A TTL***
  high speed/low power "Designer's Choice"
- **SERIES 200A TTL**
  very high speed, 5 nsec/gate
  pin-for-pin interchangeable with other source
- **SERIES 800A TTL***
  high speed, 10 nsec/gate

You may order all Sprague dual in-line circuits shipped to you in plastic magazine carriers for automatic insertion.

*Circuits have pin-for-pin and spec-for-spec dual source availability through the Sprague/Signetics technology interchange.

For complete technical data on the circuits in which you are interested, write to Technical Literature Service, Sprague Electric Company, 347 Marshall Street, North Adams, Mass. 01247

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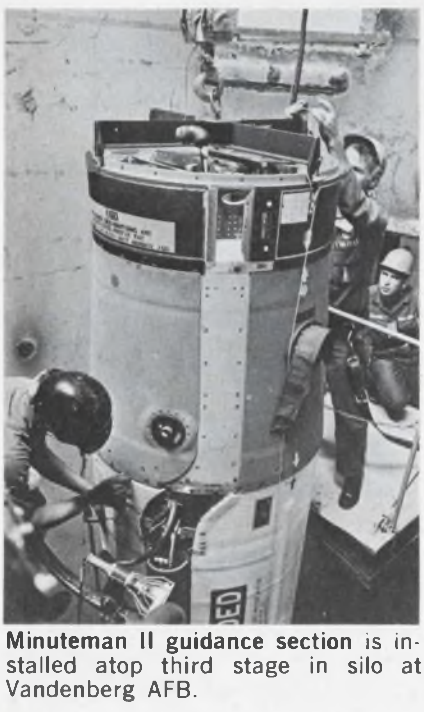
ON READER-SERVICE CARD CIRCLE 9

U. S. moves to stem missile malfunctions

Revelations by the national press and trade publications in recent weeks of excessive Minuteman II guidance and control malfunctions appear substantiated in part, despite repeated denials by the Dept. of Defense. What still is not clear is how much the U.S. strategic retaliatory force structure is weakened whenever the ICBMs are removed from alert status for subsystem replacement.

Since the July 28 statement by Air Force Secretary Dr. Harold Brown in which he praised performance of the entire Minuteman operational force, a news embargo has been in force. The guidance system associate prime contractor, Autonetics Div. of North American Aviation, Inc., reportedly has been under a tight news clamp for over a year.

Repeated queries to the Pentagon, the Air Force Systems Command,



Minuteman II guidance section is installed atop third stage in silo at Vandenberg AFB.

and Autonetics for further clarification have revealed:

- That the deficiencies have been centered in microelectronic subsystems of the guidance system and usually in the D37 digital computer.
- That some of these are microelectronic circuit-board problems, most frequently involving electrical contacts between board layers.
- That others involve unsatisfactory resistors and capacitors.
- That failures have been random.
- And that Autonetics is solving its assembly problems through a general tightening of its in- and out-of-house quality assurance requirements.

One DOD spokesman, however, said that in his opinion a recent newspaper report that "defence officials fear Minuteman malfunctions undermine readiness" may have stemmed from a military official bent on attacking Defense Secretary McNamara's policy of reliance on ICBMs as the principal defense force. Some statements in the newspaper report bear striking resemblence to an *Aviation Week* article of a year ago (Aug. 22, 1966, p. 19).

At the present time, all 800 Minuteman Is are emplaced in hardened silos. An additional 200 Minuteman IIs, providing longer range and faster response time, are on station. Minuteman III is now in development. It will provide a multiple-warhead capability and a maneuverable reentry vehicle plus advanced penetration aids. A two-year retrofit program is underway to bring the Minuteman Is up to the II version capability.

Ninety-nine per cent of all onboard electronics, excluding the reentry vehicle, are represented by the Autonetics guidance and control system. The move from Minuteman I to II required a complete redesign of this system and the broad use of integrated-circuit multilayer boards. As a result, the computer was reduced from 1.6 ft^3 and 61.5 lb to 0.43 ft^3 and 38.3 lb.

Conversely, the demands on the computer were greatly extended. The D37 memory, for example, carries a complete ground and airborne operational program, including all target data necessary for missile guidance to one of a number of targets. The particular target is selected remotely just prior to launch.

Systems checkout is performed continually in the silo, but no maintenance is attempted within the launch facility. Thus, at any given time some missiles must be down for maintenance and repair.

The Air Force states that its total number of weapons allows for a certain percentage (number classified) to be out of alert status. Dr. Brown asserts that the less mature Minuteman II guidance does have a higher than planned rate of repair but that component replacement is decreasing. Of the 39 live firings to date, he stated, 37 were successful.

He did not indicate, however, if these figures discount missiles that were shutdown prior to liftoff.

Israel invades U.S.; its goal—business

A major effort on the part of the Israeli government to break into the electronics market in the U.S. is now under way. Israel's aim is to improve its balance of payments with the U.S. Last year Israel imported $220 million dollars worth of trade goods from the U.S.; it exported only $80 million.

A joint venture between Aerodynamics Industries, Inc., Farmingdale, N. Y. and the government of Israel is designed to introduce the advanced technological, scientific and engineering skills of Israeli industries into the U.S. market. Aerodynamics Industries will market and service all Israeli equipment sold in the U.S.

There are 35 major electronics plants in Israel, manufacturing such products as transistors, meters, test equipment, communication equipment, radar, medical electronics supplies and uhf transceivers. One product to be marketed in the U.S.

News Scope CONTINUED

that demonstrates Israeli electronic capabilities is a $5000 table-top microelectronic digital computer that measures 18.8 by 17.6 by 12 in.

In 1966, some 1800 scientists graduated from Israeli universities —a very high percentage for a population of only 2.5 million. The number of professionals in the work force has been increasing by 10% a year for the last five year.

According to the Israeli Commerce Dept., Israel has the combined abilities of 15,000 engineers to field for this electronics invasion.

Navy satellites to be used by commercial shipping

Commercial ships and research vessels have been permitted to use the Navy's previously classified Navigation Satellite System.

Announcing the Government's decision, approved late last month by President Johnson, Vice President Hubert Humphrey said the Navy would shortly make available the information necessary for commercial contractors to build the receivers that would be required by nonmilitary shipping.

Humphrey said the Dept. of Transportation had been asked to draw up a plan for a more permanent navigation system for use by commercial shipping. The Navy has made no commitment to maintain the present system indefinitely for nonmilitary use.

Navy satellites to aid commercial shipping navigation.

The three Navy satellites, which have been in use since 1964, are a key to guiding the U.S. Polaris-missile submarine fleet. They enable navigators to plot ships' positions to within 200 yards anywhere on the globe; the exact degree of accuracy has not been revealed.

The all-weather system was developed by the Applied Physics Laboratory of Johns Hopkins University, Baltimore, under the direction of Dr. Richard B. Kershner, head of the laboratory's space development division.

Ships of the Lamont Geological Observatory of Columbia University, New York, and the Woods Hole Oceanographic Institution, Mass., have used the system for recent marine surveys. Offshore oil-drilling companies and other concerns that require extremely accurate navigational and positioning information have expressed interest in access to the system.

The U.N. Committee on the Peaceful Uses of Outer Space is investigating the need for a navigation satellite system. Several other nations are also considering developing their capabilities in the field.

Testing time extended for tropospheric system

Selection of a winning contractor for the Air Force's new short-range, lightweight, tropospheric-scatter communications set may be delayed.

Competitive field testing at Eglin AFB, Fla., of the two systems under consideration—the AN/TRC-104, developed by Bell Aerosystems Co. in Buffalo, N.Y., and the AN/TRC-105, built by Motorola Inc.'s Government Electronics Div. in Chicago—was due to be completed in mid-August.

However, both contractors reported to have experienced equipment malfunctions (primarily burned out transformers) and testing has been extended to about Sept. 8.

The USAF project manager, Frank Zawislan, has now requested cost proposals from both contractors for 30-, 60- and 90-day follow-on tests.

The need for an under 500-lb tactical terminal for limited-warfare use has been demonstrated by the Vietnam conflict. The R&D effort grew out of the 407L program for air-transportable, fast-reaction communications to support tactical forward aircraft controllers, according to Air Force officials. Thus the terminals must be capable of being man-packed, use a single small antenna, and require minimum setup time (under 1 hour) and maintenance. To make the design task tougher, the set must use relatively low-power but ensure reliable operation through a fading medium.

Although each contractor selected a different design approach to achieve the desired 99.8% reliability under field conditions, both exceeded all Air Force design goals. These included a 500-lb maximum terminal weight, 80-mile minimum range, 5-kilo-watt maximum dissipated power, and a minimum of four channels (voice and digital data). Both systems came in under the weight limit and each contractor claims better than 120-mile operating range, 2-kW power need, and 12 channels for communications.

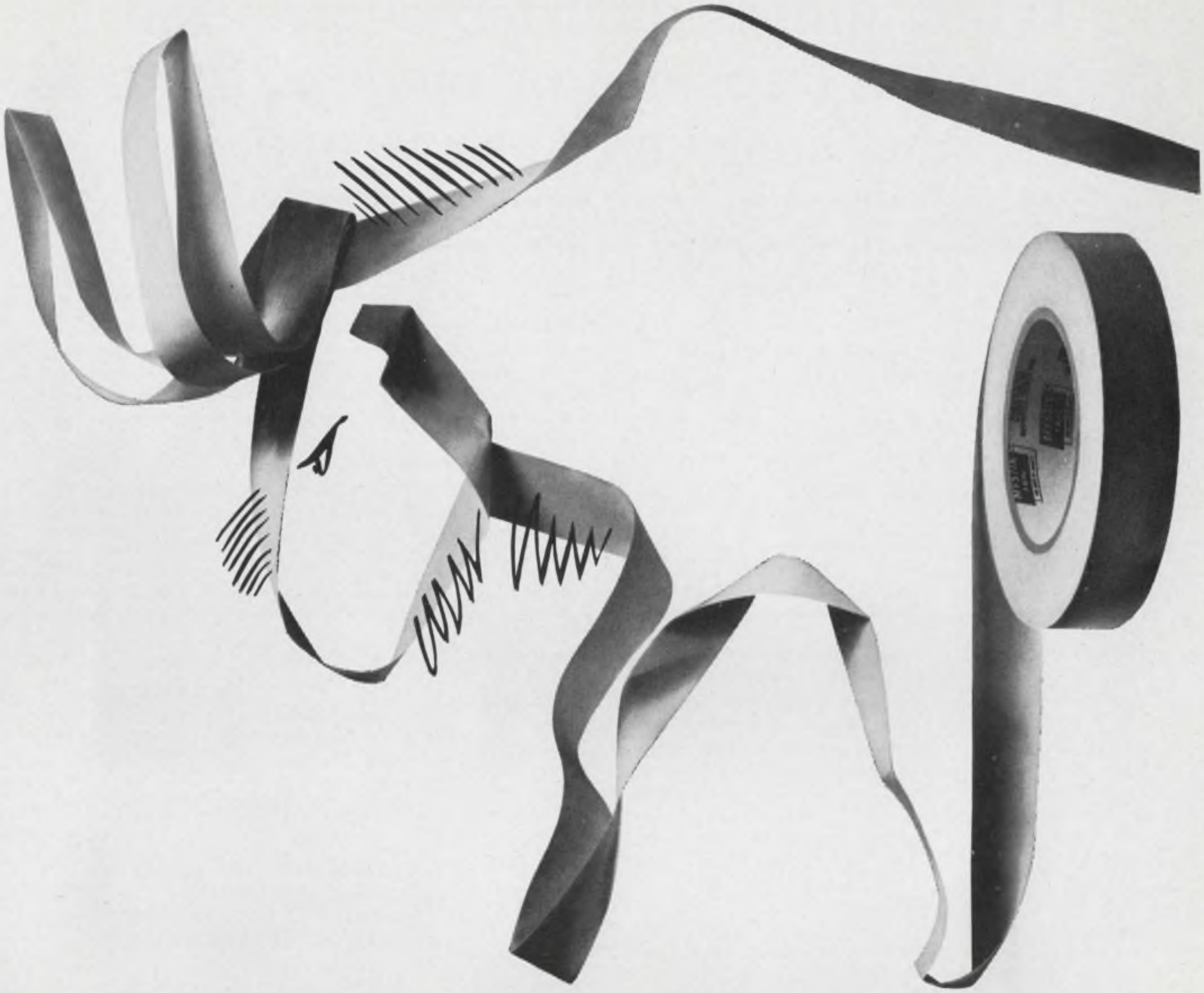
Bell employs an unusual coded-diversity transmission technique—a complex error-correction code with a multiplexed, eighth-order frequency-diversity fm signal. Motorola employs a sixteenth-order frequency-scan diversity technique. It continually checks the signal-to-noise level of all frequencies and selects the best frequency for use at any given time.

Low-cost electronic unit vies in business field

The accounting machine field, a $500 million plum for equipment manufacturers, is being invaded even at the low-price end by electronic devices.

Burroughs Corp., Detroit, recently unveiled its E3500 Electronic Processor, which dispenses with mechanical components except for input-output functions. According to a Burroughs spokesman, there is nothing else in the $12,000-to-$17,000 range that compares to the E3500.

Computation is performed in milliseconds—well within the print cycle time. The operator can manually select preprogramed subroutines.



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Mystik scores again by being the first to utilize three new materials ... Nomex, Kapton and Tedlar ... and add them to their already extensive line of pressure-sensitive tapes.

NOMEX —a highly conformable tape that offers excellent holding power and dielectric strength characteristics.

KAPTON—the featherweight of wire insulations ... excellent high temperature applications which require low weight structures.

TEDLAR—ideal for electrical applications because of high dielectric strength combined with excellent weather and hydrolytic resistance.

If you would like more information on these or any other Mystik special-purpose tapes, contact your local Mystik distributor. He is listed in the yellow pages under "Tapes—Adhesive". Or, write Mystik Tape Division, The Borden Chemical Company, 1700 Winnetka Avenue, Northfield, Illinois60093.

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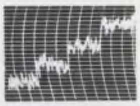
BORDEN CHEMICAL

ON READER-SERVICE CARD CIRCLE 10

When information buried in noise is periodic, transient, or random, there is a *PAR*[T.M.] instrument to recover it

PAR manufactures a complete line of signal processing equipment to measure signals of various types buried in noise. The choice of the most appropriate instrument depends upon the characteristics of the signals. The equipment falls into three general classes:

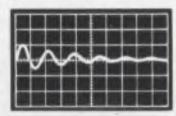


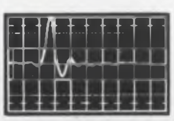
LOCK-IN AMPLIFIERS

Lock-In Amplifiers have application where the signal of interest is or can be made to appear at a single frequency and where a reference voltage related in frequency and phase to the signal can be obtained. These instruments employ phase-sensitive detection and narrow-band filtering techniques to provide a DC output signal proportional to the amplitude of the fundamental component of the signal being measured. The Lock-In Amplifier can be described as a tuned voltmeter. the response of which is "locked" to that particular frequency and phase at which the signal information has been made to appear. They operate typically in the frequency range of 1.5 Hz to 150 kHz with full scale sensitivities down to 10^{-9} volts.

Waveform Averagers are useful when, after processing, the actual waveform of the signal of interest must be maintained and the signals are repetitive waveforms or transients whose onset can be related to a trigger pulse. The application of a synchronized, repetitive waveform will result in an output that corresponds to the average value at each of the segments of the waveform being studied, whereas any non-repetitive (or un-synchronized) signals such as noise will be suppressed since their average after many occurrences will approach zero. PAR makes two instruments that perform this function: the Boxcar Integrator and the Waveform Eductor.[T.M.] The Boxcar Integrator is a single point averager in which a single slice, as narrow as 1 microsecond, of the input waveform is averaged while the position of the slice is slowly scanned through the waveform. The Waveform Eductor simultaneously averages one hundred points of the waveform which can be distributed over periods varying from 100 microseconds to 10 seconds.

WAVEFORM AVERAGERS





CORRELATION FUNCTION COMPUTERS

Correlation Function Computers are the most general form of signal processing equipment that can be constructed (Lock-In Amplifiers and Waveform Averagers are actually special cases of correlation equipment). Whereas a reference or synchronization signal is required in the other equipment discussed, autocorrelation analysis allows periodic and random signals to be defined without this restriction. An even more powerful technique is crosscorrelation which has the ability to describe the degree of conformity between two different signals as a function of their mutual delay. The PAR Signal Correlator simultaneously computes in real time 100 points of either the auto- or crosscorrelation function over total delay spans of 100 microseconds to 10 seconds.

A variety of instruments and associated peripheral equipment is available from PAR in each general class. Instrument prices range from $765 to $9500. Since PAR has wide experience in applying these systems to many situations in all fields of science and engineering (e.g.: aero- and hydrodynamics, spectroscopy, medical physics, geophysics, etc.), we welcome the opportunity to discuss your specific application. For additional information, or to arrange for a demonstration at your facility, contact Princeton Applied Research Corporation, Dept. E , P.O. Box 565, Princeton, New Jersey 08540. Telephone: (609) 924-6835.

P A R **PRINCETON APPLIED RESEARCH CORP.**

ON READER-SERVICE CARD CIRCLE 11

Systems solution to EMI problem sought

DOD seeks to beat increasing interference by having compatibility designed into equipment

Neil Sclater
East Coast Editor

The systems approach is the best way to solve increasingly complex problems of electromagnetic interference (EMI). To this end, education, measurement and conservation are areas where immediate and extensive efforts are needed.

This was the consensus of speakers at a recent symposium sponsored in Washington, D. C., by the IEEE Group on Electromagnetic Compatibility. They emphasized that electromagnetic compatibility must in future be designed into equipment and systems, because attempts at correcting problems in the field have been largely unsuccessful.

During the symposium the Dept. of Defense gave a briefing on its projected program to combat electromagnetic interference. DOD and military spokesmen illustrated their plight with numerous examples of the military's failure to organize frequency allocation and squelch interference.

It was also brought out that not only was there a lack of knowledge of the cause and effect of interference in many operational situations, but also there were numerous instances where even basic preventive specifications were not followed. Contract officers waived manufacturers' obligations to meet EMI requirements for cost or schedule reasons, only to find that solving problems in the field was much more complex and costly.

Among the bad cases cited were:

- A space capsule was lost because an explosive door bolt was fired prematurely by interfering radio signals.
- A taxi dispatcher's voice inadvertently launched a missile at a cost of millions of dollars and at serious risk to life.
- A piece of electronic equipment for checking out aircraft weapons systems passed all its factory tests but was found to be useless on an aircraft carrier. Several man-years of engineering time were required to redesign it so that it would work in its intended environment.
- An aircraft system developed with off-the-shelf electronic equipment to save time failed woefully during trials because of radio interference. A multimillion dollar contract was necessary after the aircraft was produced to overcome the difficulty.

Dept. of Defense and military spokesmen gave more specific details of equipment and frequencies involved in a separate, classified session held at the end of the conference. The news media were barred from this session because the data would "inform the enemy about weakness in our equipment."

An Army staff officer stressed the seriousness of the problem when he said that communications in Viet Nam were being carried on in a "electromagnetically dirty" environment. Maj. Gen. Dayton W. Eddy, Director J-6 (Communications-Electronics), Joint Chiefs of Staff, added that solutions to compatibility problems in Southeast Asia should also be applicable to electronic equipment operating in more sophisticated geographical locations like the continental United States or Europe.

The Pentagon's program* tackles the military's EMI problems on a systems basis. It calls for the assignment of specific electromagnet-

*See "DOD to put teeth into RFI program," ED 16, Aug. 2, 1967, p. 13.

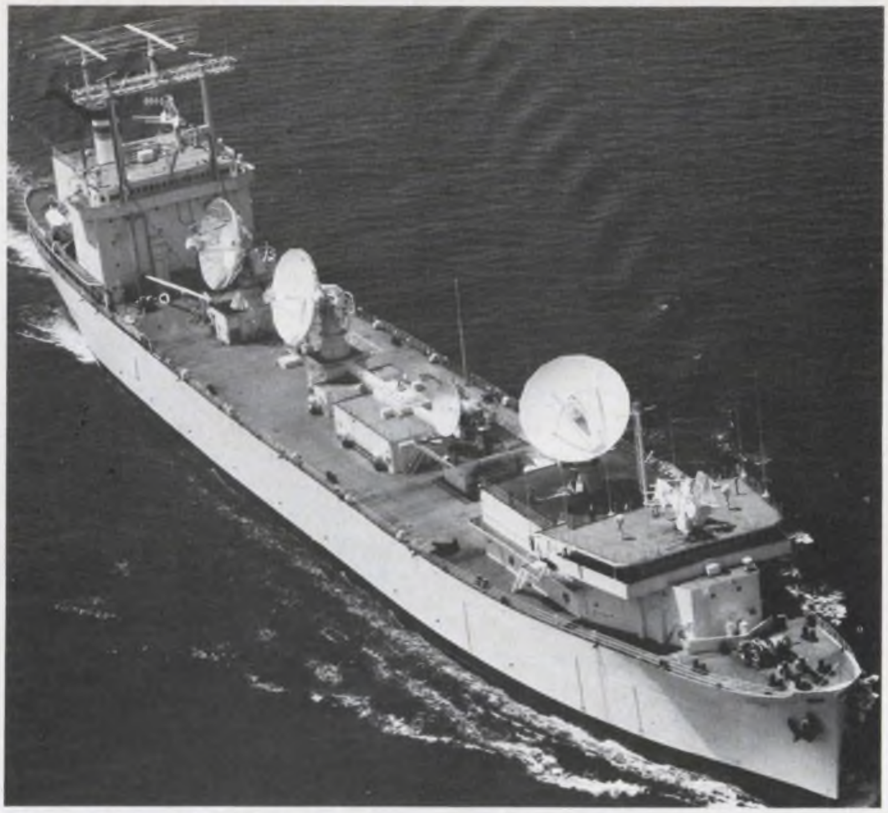
Sensitivity and dyamic range of an amplifier are being measured by Atlantic Research engineers to determine its compatibility.

Cacophony of radio frequencies is present on the deck of the aircraft carrier "USS America" as engineers measure the radio frequency "noise floor." These data are necessary as steps to eliminating unwanted rf interference.

(EMI, ***continued*****)**

ic-compatibility responsibilities to the Joint Chiefs of Staff and research elements of the Defense Dept. and the Air Force, Army and Navy.

Nearly 50 papers documented progress in interference prediction, analysis, measurement and control. All subscribed to the systems approach. Their topics included compatibility problems aboard an Apollo spacecraft-tracking ship; internal interference within integrated circuits; automated techniques for frequency control; and topographical studies for siting electronic equipment.



Forest of antennas on Apollo tracking and communications ship "Redstone" create electromagnetic "togetherness" problems. Interference can recur as ship and equipment age. Surveillance and continuous maintenance are necessary to keep all communication equipment at peak efficiency.

Communications electronics suffers from being too close to its neighbors.

Instruments for checking compatibility are lined up in Atlantic Research test van.

Apollo ship problems are typical

The electromagnetic-compatibility problems aboard an Apollo spacecraft-tracking ship were described by two engineers from General Dynamic's Convair Div., San Diego, Calif. Roger Henkel and Duane Mealey reported that many of the difficulties in operating shipboard electronics could be traced to standard deck hardware.

They said that bonding and grounding were very important in establishing shipboard electronic compatibility. But even when solved, they warned, problems can recur, especially as the ship and equipment age.

The three Apollo tracking ships are converted World War II tankers, 595 feet long with 75-foot beams. Each carries more than 455 tons of electronic equipment distributed among 11 major systems. The onboard electronics include an inertial navigator, digital computers, C- and S-band tracking, ranging and communications systems and telemetry installations. Hf, vhf, and uhf radio equipment permits ship-to-ship, ship-to-spacecraft and ship-to-shore communication.

The Convair engineers reported that serious problems occurred at the dockside when the high-frequency transmitters were fed from main-deck helical antennas. The high output power turned watertight doors into shock hazards and melted nylon rope hanging on safety cables. Once at sea, problems became even worse. When the hf transmitters were operating, shipboard receivers were inoperable.

High noise in the telemetry receivers was traced to slack safety chains, which prevent seamen from being washed overboard.

Where the chains were illuminated with rf, each link became an interference generator. Broad-band interference was detected in the 200-to-400-MHz region and harmonics as high as S band were detected. Replacing the chains with plastic line solved this problem. Correlation of variations in interference amplitudes with the ships motion and the interference origin permitted the engineers to pinpoint the chains as offenders.

Another interference source was an antenna mount gear assembly that acted as an intermittent switch as the ship rolled. Rf leakage into the i-f of a C-band tracking radar caused it to malfunction. Soot deposits from the ship's stack was the probable offender in several cases of arcing on a logarithmic periodic antenna.

Electronic data processing is being used to predict the effects of

(EMI, ***continued*****)**

topography on electronic communications equipment compatibility. John Scott of the ITT Research Institute discussed the preparation and use of topographical maps for this purpose.

Intervening topography plays a major role in signal attenuation, according to Scott. Hitherto interference prediction has usually been made with free-space calculations that treat the world as a smooth sphere. Path loss values, if used, are based on data measured over rough terrain. He said that calculation was done in this manner because there had been no economical method of introducing topography into interference prediction calculations.

In a program sponsored by the Dept. of Defense Electromagnetic Compatibility Analysis Center, Annapolis, Md., numerical mapping techniques applicable to the solution of compatibility problems are now in use. Using data processing procedures, digitized topographic maps have been produced. Scott said that data covering approximately 25 per cent of the United States are now available.

Basic data for the maps are applied to two separate computer systems. The first, called the Site Analysis Model, provides clear acetate overlays which yield line-of-sight coverage information for siting equipment when placed over scaled maps. The second, called the Power Density Model, delivers overlays that represent power density contours for selected equipment sites.

The Electromagnetic Compatibility Aanalysis Center also maintains data on the location, frequency and power of all major communications equipment in the continental United States. This information can be superimposed on regional maps to give complete information for siting new equipment or changing the output signatures of present equipment.

All information is available to civil and military personnel concerned with finding the best location for communications equipment.

EMC-Electronics living in harmony

Programs in electromagnetic compatibility (EMC) seek to eliminate interference caused by the close proximity of circuits to one another. Their aim is to have all electrical and electronic circuits live in harmony with themselves and their neighbors.

EMC seeks more than just the elimination of radio-frequency interference as a source or symptom of circuit malfunction and degradation. It seeks harmony in the total operating environment. It considers such topics as proper equipment siting, conservation of the electromagnetic spectrum and elimination of radiation hazards.

All authorities at the recent EMC symposium agreed that the total problem is becoming more difficult. Proliferation of operating systems—especially communications—and the general increase in background electromagnetic "contamination" were given as reasons.

EMC concerns everyone who uses electronic equipment, but the need to solve the problem is perhaps more critical in the military than in civil environments at present. The success of military operations, saving of lives and even national security depend on interference control.

Military ships and aircraft have dense circuitry radiating and receiving at many different frequencies. Ground-based equipment poses even more complex problems. Siting and distribution of equipment is random, depending on tactical and strategic situations. The mobility of equipment and ever changing combat conditions call for frequency management.

Military officers report that it is often necessary to shut down some system in order to make use of others.

All EMC begins at the bench, or perhaps more accurately at the drawing board. Standards, specifications and directives purport to give guidance on design, construction, operation and maintenance. Prevention is evaluated by measurement and test.

But there are several nagging questions: Are the guidelines really effective and are they being enforced? Are all participants—designers, assemblers, operators and maintenance men—educated to the problem?

There is no shortage of documents, either civil or military, giving guidance on electromagnetic interference. Numerous civil and military specifications give the limits for allowable interference, methods for its measurement, and even definitions for terms or units.

Most specifications include tests for "interference" or "susceptibility." Interference tests are concerned with electromagnetic radiation from units under test, while susceptibility tests cover the vulnerability of the units being tested to external radiation.

Tests for offending conducted interference are made with various receiving sets and analyzers. They concentrate on coupling through power lines, interconnecting leads between external housings, and antenna terminals. Instrument tests are also made for inadvertent radiation.

Susceptibility tests, on the other hand, are made with the test unit acting as its own response monitor. A degradation or malfunction shows up when the unit is exposed to a range of electromagnetic radiations. Conducted-susceptibility tests are essentially the reverse of conducted-interference tests.

So serious is the problem from the military point of view that the Dept. of Defense has split it into eight different areas of attack and charged various services and research groups with area responsibility.

The road will not be easy. Included in the tasks are such objectives as reviewing and improving specifications, guidelines, test instruments and techniques. The need for educational programs is seen and more basic information is sought on the over-all operating environment.

But even Pentagon officials realize that all this will go for naught if EMC specifications are not enforced contracturally on manufacturers. They also foresee the need for new regulations covering deployment, use and maintenance of electronics by field personnel if any headway is to be made in reducing interference.

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ON READER-SERVICE CARD CIRCLE 13

(EMI, ***continued*****)**

Considerable interest was shown in electromagnetic-interference test instrumentation. Several papers were delivered on the subject and manufacturers demonstrated their latest wares.

A general-purpose automatic spectrum surveillance system was described by David Smoller, chief engineer of Fairchild Electro-Metrics Corp., Amsterdam, N. Y. He said that until recently most RFI analysis had been "accomplished by laborious point-by-point data-taking." Measurement of RFI, he added, is complicated by the variety of transducers, nonstandard test setups and specification limits. The almost infinite variety of equipment under test also creates organization problems.

This situation, Smoler reported, has led to increasing use of automatic RFI/EMC measurement systems for testing a wide variety of equipment according to many different specifications. He said that many of the systems marketed to date have been massive and mechanically tuned, using combinations of commercial equipment designed for a narrow range of uses.

Fairchild Electro-Metrics demonstrated a spectrum surveillance system that included interference analyzers, an X-Y plotter and a spectrum display.

Smoler said that the system could survey part or all of a frequency from 20 Hz to 1 GHz, and plot spectrum profiles on the X-Y plotter. The two analyzers that cover the range are shielded superheterodyne receivers which use varactor tuning to eliminate mechanical sweeping.

Another automated data acquisition and analysis system was demonstrated by engineers from the Jansky and Bailey Depts. of Atlantic Research Corp., Alexandria, Va. They use a small computer programed to control equipment being tested. It receives the measured data, performs the required data-processing and prints out the data in final form.

The *1967 IEEE Electromagnetic Compatibility Symposium Record* is available from IEEE, Inc., 345 East 47 Street, New York, N. Y. 10017. The price is $6 for members, $12 for nonmembers. ■ ■

Plated wires cut ferrites to the core

Devices bid to preempt aerospace computer memories because of speed, ruggedness, NDRO

Richard N. Einhorn
News Editor

Plated-wire memories, mired since the early Sixties in production difficulties, are muscling their way into the main memories of third-generation commercial computers. They appear well on the way to monopolizing the aerospace computer field. The new generation of strategic missiles and counter missiles are all reportedly equipped with nondestructive readout (NDRO) memories. Many will contain plated-wire elements—including the inertial guidance computer of the Poseidon missile. And the National Aeronautics and Space Administration is reported to be considering them for the post-Apollo guidance computer memory.

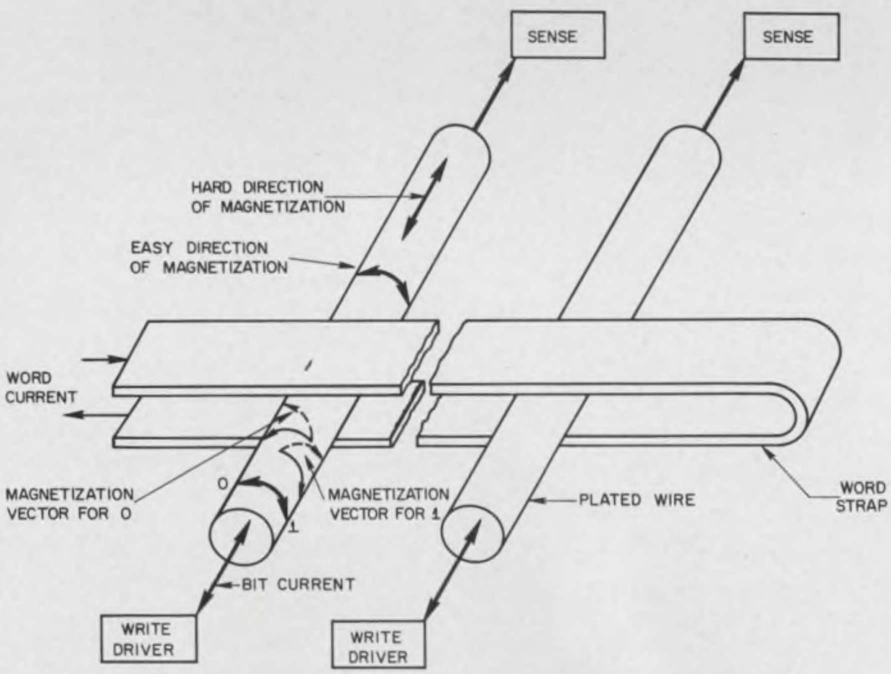
Leading contender for the Poseidon memory is said to be the Univac Div. of Sperry-Rand, which under Air Force funding has built plated-wire modules of multimegabit capacity. Univac is also equipping its 9200 and 9300 lines of commercial computers with plated-wire memories. A spokesman for Univac says that a "considerable number" of 9000-series computers has been built, although none has been turned over to customers.

Eugene C. Maupin, an engineer in the computer group of the Avionics Laboratory of Wright-Patterson Air Force Base, Ohio, says that the immediate application of his group's research is space vehicles.

"If they're suitable for space vehicles," he said, "they're also suitable for missiles and aircraft, because one of the major advantages is the very low cost. Potentially, it could be down to fractions of a cent per bit."

There are several salient reasons for employing plated-wire memories in aerospace computers:

- Little power is consumed because of high-speed switching and short driving time.
- 250-ns cycle times are feasible.
- NDRO, which is easy to attain with plated-wire memories, protects stored data, since the information never leaves the cell location. With destructive readout (DRO), the information must be fed to the electronics, where it is far more vulnerable to transients than it is in the storage elements.
- The wire memories operate over a wide temperature range—plated-wire and planar thin films have a Curie temperature (the temperature at which the material loses its magnetic properties) of approximately 500°C, which is 100 degrees higher than that of the best ferrite core.
- Wire memory elements do not themselves generate heat. Cores, on the other hand, get hot and add to system heat. In view of the heat-sink problem, spacing—and therefore density—is a limiting problem for cores but not for plated wires.
- Wire memories are mechanically rugged. On one military program an array withstood 1000 g shock and 20 g vibration—equivalent to being dropped from the roof of a ten-story building.



1. **Plated-wire memory planes** for Univac's 9000-series commercial computers are 144 bit lines by 256 word lines—36,864 bits in all. Planes are stacked for increased capacity, and multimegabit modules are feasible.

NDRO becomes attractive

Up to now, NDRO was not feasible for aerospace use, despite the inherent possibility of high speed, because the cost in size, weight and power was prohibitive. There were exceptions: the Saturn computer, with its multiaperture devices (a "big, hairy, costly, beast," in the words of one aerospace manager), and the wired-in core memories of the Apollo equipment ("inflexible, terrible," says the same critic). Rather than accept these and such other NDRO devices as transfluxers and biax, which are big, heavy, expensive and chock full of components, aerospace planners tended to say: "All right, we'll live with cores and try to protect them from transients. But at least we can fly them."

But now this is all changed. With recent improvements in the production yield of plated-wire elements, they figure heavily in the plans of

(plated wire, ***continued*****)**

NASA and the Air Force. A few years ago production yield was as low as 2 per cent. Today the yield is reported to be much better than 50 per cent—and still improving.

How do plated-wire devices differ from other magnetic memory elements, such as ferrite cores and planar thin-film arrays?

Univac uses stripline

In the technique fostered by Univac, a moderately thin film of permalloy (10,000 to 20,000 Å) is electroplated onto beryllium copper wire substrates. Parallel lengths of this wire serve as digit lines in a matrix. The word lines are formed by word straps—copper ribbons wrapped around the bit lines like sugar tongs (see Fig. 1).

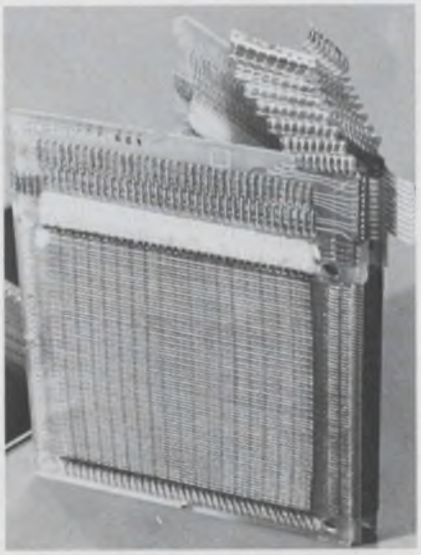
The plated-wire memory element is analogous to the planar thin film. It is anisotropic—oriented so that the easy direction (the preferred direction of the magnetic field) lies around the circumference of the film and the hard direction lies along the length of the wire. In the memory matrix the copper word strap is at right angles to the wires and encircles all of them with one turn. For Poseidon, Univac is reported to be using two turns for better coupling.

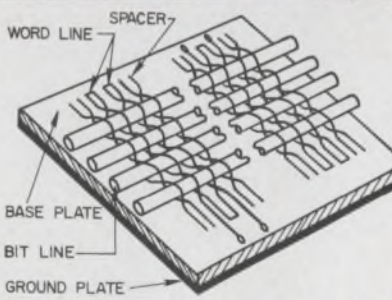
When current flows in the word strap, it produces a magnetic field that is along the axis of the wire—that is, in the hard direction. If, on the other hand, current flows along the wire, this produces a magnetic field around the circumference—the easy direction of magnetization. Application of both the word field and the bit field to a given storage location on the wire causes the bit to be stored. Writing is thus a coincident-current operation. The bit current must be large enough to partially rotate the magnetization vector, but not so large as to affect bit locations under adjacent word straps—the creep phenomenon.

Since the bit storage locations are not physically separated but are part of the same wire, there could be interference between bits. James P. McCallister, a Univac engineer, reported at the 1966 Fall Joint Computer Conference in San Francisco:

"This interference, which is reversible, occurs when information of the same polarity is repeatedly written into one bit cell. The bits under adjacent word straps may be reversed and caused the wrong information to be read out. An effective technique has been devised to prevent this interference. During a single write cycle, first the complement of the information is written and then the desired information. Thus, in every case, the magnetic history of a particular bit is balanced in ones and zeros, and no more than two write operations of the same polarity can occur consecutively at any one bit location."

In reading, the word current is turned on and the wire serves as its own sense line. The word current creates a longitudinal magnetic field that rotates the magnetization vector toward, but not up to, the axis. This displacement induces a sense voltage that is detected by a sense amplifier in the bit lines. When the word current is removed, the bit location returns to previous orientation, thereby completing the read cycle. The speed of the plated-wire memory depends on the rapid rotation and snapping back of the magnetic domain. With cores, the domain is switched completely. This takes time and power, but by the same token, cores produce a larger output.





2. **Word lines are woven** in multiple turns around plated bit lines. Librascope expects new shuttle loom to weave one 64-word-by-64-bit plane (4096 digits) every 18 minutes continuously. Eventually weaving will be programed.

Univac incorporates a switching arrangement that permits selection of one out of each group of 16 word lines. This represents a great saving, in that it eliminates 15,000 of the 16,000 diodes in a single module, thus giving a square matrix. Switching doesn't introduce significant delay, because it is set up before interrogation of the stored data.

Another configuration is the woven wire approach used by Toko Coil of Japan and its licensee in the United States, General Precision's Librascope Group in Glendale, Calif. Here, the word lines consist of insulated wire woven about the plated bit lines (see Fig. 2). A machine much like a textile loom weaves the wires back and forth into multiple turns (the figure itself is simplified). Despite this, the goal is to have no more than two solder connections for each word line, as with the Univac method.

Woven wire favored

According to Dr. Richard H. Fuller, who directs R&D at Librascope, multiturn coils have one potential technical advantage over Univac's stripline method: Because the word wires wrap approximately 180 degrees around the plated wires, instead of being tangent to them at only two points, there is a greater ability to shape the word fields more precisely; they are strong and uniform at the bit and fall off away from the bit. This is said to permit greater packaging density and to afford better coupling. This, in turn, is said to permit the use of lower word current than the Univac device.

Librascope stacks individual memory planes to form a memory module of the required capacity, as does Univac.

Yield problems facing both Univac and Librascope stem from the condition of the substrate wires and the composition of the permalloy.

(continued on p. 26)

(plated wire, *continued*)

Fuller says that scratches and die marks on the wire cause the easy direction of magnetization to follow the physical imperfections. Also, the alloy has to be carefully controlled to yield zero net magnetostriction of the film.

NDRO plated-wire memories provide the best protection for missile and space computers against radiation-induced transients, Fuller says. (Fluidic devices, which are inherently still safer, are too slow to be considered.) Semiconductor memories can be wiped out very easily. It is also easy to lose information with a core memory, because the process entails transfer to the associated electronics during readout.

The level of transient required to disturb the memory itself is several orders of magnitude higher than that required to disturb the electronics (with integrated circuits, the memory is just as vulnerable as the electronics). In a DRO memory, if the transient occurs while the data are in the electronics, information can be lost, or else it can be rewritten improperly. In a NDRO memory, loss of information in the electronics causes only temporary dislocation, since the information remains in the bit locations. Thus, when the transient dies down, the computer can resume operation, provided that the electronics haven't been permanently damaged.

Asked whether it wouldn't be possible for the transients to introduce excessive current to the word straps or wires, so that the read currents would cause spurious writing, Fuller admitted that this could happen.

He explained that writing did not normally take place unless there was coincidence of the word and digit currents. By heavy overdrive —50 to 100 per cent—it would be possible to destroy information by writing with the word current alone. Such a transient would actually pull the flux current close to the axial direction of the wire. The flux would shatter and fall back randomly, and a great deal of it would be lost. As a result, the location could not be sensed unless it was rewritten. But rewriting might be impractical.

Fuller suggested several remedies to safeguard the plated-wire memories of missile commputers. One might be the use of current-limiting devices. Depending on the energy, a fair amount could be dissipated in terminating resistors. However, if the current were high enough, it could still destroy the stored information. At sufficiently high neutron flux densities, the transient could do physical damage to the wires.

Therefore the currents would be gated and normally limited. Flow would be through saturated switches, so that excessive current would pull the switches out of saturation, and they would become highly resistant.

It might also be possible to sense the rate of rise of the transients and to turn off power to the electronics before the damaging currents were applied. This switching could be set up to operate in tens of nanoseconds. Whether this would be fast enough is not known at present.

Other companies reported to be at least minimally engaged in research are Honeywell, Fabri-Tek, Melpar, and Fairchild Semiconductor. National Cash Register uses plated rods in its 315 RMC computer and is also developing plated wires. According to recently published papers, Bell Telephone Laboratories, Murray Hill, N. J., is still active after having pioneered this technology a decade ago under U. F. Gianola, head of the magnetic device department. ■ ■

Laser deposits wiring on a microcircuit chip

An unusual technique for direct deposition of microcircuit interconnection patterns on a single semiconductor substrate is reported by Standard Telecommunications Laboratories, Ltd., Harlow, England.

In their technique, a glass plate with a thin metal film on its underside is placed in contact with the processed semiconductor slice. A beam from a helium-neon laser —used with a micropositioning table—is focused through the pattern on the plate. The beam vaporizes the film material and deposits the interconnection pattern directly onto the slice.

A minimum line-width of 25 μ has been obtained, although the company says the process is still at an early stage of development.

Local deposition is regarded as particularly important, a company spokesman noted, because "it offers an elegant solution of multilayer interconnection problems that will arise in future complex systems." ■ ■

Interconnection patterns are deposited directly onto a semiconductor substrate by means of a helium-neon laser.

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ON READER-SERVICE CARD CIRCLE 16

Bidders wanted for Navy electronics

Washington Report

S. DAVID PURSGLOVE, WASHINGTON EDITOR

Navy seeks more bidders on hardware

The Navy is having trouble finding enough bidders for much of the hardware that it buys frequently. The Navy complains that there is "limited competition" and that in the past there have generally been no more than two bids or proposals on any item. In some cases, Navy officials admit, "competition has been limited by high setup investment and the need for specialized facilities or capabilities." But, they add, "for other items there are no known major factors which should inhibit additional competition."

To encourage more companies to bid—especially smaller companies that could provide much of the needed equipment—the Navy has compiled a long list of products that small firms could supply. Over half of them are electronic.

The list includes certain signal simulators, logarithmic periodic antennas, conical monopole antennas, radio transmitters (AN/FRT-72), motor generators, certain safety and arming devices, AN/PSM-4 multimeters, AM-2123/U amplifiers, AM-368 amplifiers, AN/PDR-43 radiation detection equipment. Also needed are permanent magnets for IC/SBA-4 and LS-444/WIH loudspeakers, control radio sets (C-1138B/UR), LS-386/SIC intercom stations, certain microphone stations, waveguide horns, head sets, roll gyros, signal simulators, frequency dividers, Mark-37 time-delay relays and coaxial cable.

Companies interested in bidding when these items come up for procurement should contact the Small Business/Labor Surplus Area Specialist at the Navy organization doing the buying. That official can also provide a list of the specialists at all other facilities, along with addresses and telephone numbers.

California receives most R&D funds

California has again taken the largest slice of the Federal research-and-development-funds pie. And to nobody's surprise, New York, Maryland, Massachusetts and Texas were again the runners-up. These five states accounted for 57 per cent of the funds spent by the eight Government agencies that handle 98 per cent of Federal R&D funds. The figures are published in the National Science Foundation's survey, *Geographic Distribution of Federal Funds for Research and Development*, for fiscal year 1965, the latest annual data available. The 188-page report is available for $1.00 from the U.S. Government Printing Office, Washington, D. C. 20402.

The survey shows that 63 per cent of Federal research and development was performed by industrial firms, 21 per cent was "in house," and 8 per cent was carried out in colleges and universities. Of industry's share, 40 per cent was carried out in California, home of George P. Miller, chairman of the House Science and Astronautics Committee. The bulk of the work in California was space and military. The report shows that in New York and Texas, too, most of the work was space and military.

The Defense Department and the National Aeronautics and Space Administration together accounted for 82 per cent of the money spent on research and development. The others of the "Big Eight" agencies are the Atomic Energy Commission; Dept. of Health, Education and Welfare; Dept. of Agriculture; National Science Foundation; Dept. of the Interior; and Dept. of Commerce. The Pentagon and NASA were the major users of industrial laboratories; the Dept. of Health, Education and Welfare was the chief support of educational institutions; and the Atomic Energy Commission was the mainspring behind Federal contract research centers managed by educational institutions.

Between fiscal 1963 and 1965, the amount of money spent on Federal research and development rose by 17 per cent, the report shows, but the distribution of it among the various regions of the nation remained almost unchanged. There were more noticeable changes on a state-by-state basis. In states getting the lion's share of Federal work, the impact of changes in contracting was slight; in states receiving less, the impact on their economy was quite significant.

Tactical comsats pass major test

Communications between air, ground, sea and undersea units of the Army, Navy and Air Force have been successfully performed with a new tri-service tactical communications satellite, LES-5. This completes a development phase that is expected to lead to production and the wide use of tactical communications satellites. The satellites are being developed by the tri-service Tactical Satellite Executive Steering Group.

Development of experimental ground terminals for the test program is an Army responsibility. The program so far includes two jeep terminals, two 3/4-ton-truck terminals and a 26-foot-van terminal, all developed by the Army Satellites Communications Agency, Fort Monmouth, N. J. During the experimental phase they have been used only in the Fort Monmouth area, but they are expected soon to be moved to other areas to test the "tac-comsat" system under different conditions. A voice network has been successfully operated among three of the ground stations.

The Navy has used 60-word-per-minute teletypewriters on a ship, a submarine, an airborne P-3 Orion aircraft and at three shore stations which took part in its experiments. The Naval Electronic Systems Command's Satellite Communications Project Office monitored development of the Navy terminals. The electronics for all six terminals was basically the same, but the antennas differed from one to another.

Air Force aircraft for the experiments were drawn from Systems Command and Strategic Air Command. Ground terminals were set up at the Air Development Center, Rome, N. Y.

Lincoln Laboratory at MIT built the LES-5 (Lincoln Experimental Satellite No. 5) as part of a program to provide rapid communications for highly mobile, lower-echelon (tactical) forces. The program aims to develop equipment that is small and light in weight and offers maximum flexibility with minimum need for control.

New computer-library grants awarded

The U.S. Office of Education has begun to allocate $3.5 million for 38 projects in a new program of library and information sciences research. The program is designed, U.S.O.E. says, "to devise better ways of coping with the 'information explosion.'" It is heavily computer-oriented and underscores the growing importance of computers for education and library works.

One $64,408 project is being undertaken at the new Hampshire College, Amherst, Mass. The college will admit students in 1970 and is trying to use computers and dial-access communication systems to bring library services to dormitories. Under a $293,000 grant, the Smithsonian Institution in Washington hopes to develop a computerized system to make its biological and geological specimens more readily accessible for students and specialists.

PHS looks into electron beams

Industrial electron-beam devices may become subject to Federal standards. The Public Health Service is eyeing the proliferation of neutron generators and electron accelerators used by industry to cure paint, pasteurize food and sterilize consumer products. Are there hazards to workers in plants where the devices are used? The PHS Bureau of Disease Prevention and Environmental control plans to find out. The Bureau seeks a contractor to assess the hazards. Data will then provide a basis for Federal guidelines on instrument design and operating procedures. The PHS also intends to study possible hazards from isotopic X-ray and Mossbauer devices.

Navy closes a chapter in missiles

The Navy has ended a chapter in the nation's undersea ballistic missile program, with the test-firing of a Polaris A-3 by the submarine Will Rogers. The new Will Rogers, scheduled to go on patrol in September, completes a planned fleet of 41 submarines, each armed with 16 undersea missiles. Future subs will be capable of carrying more missiles. The missiles themselves, beginning with Poseidon next year, will also be larger.

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ON READER-SERVICE CARD CIRCLE 17

NEWS

In goes schematic; out comes PC art

A computer service corporation, CEIR, Inc., Washington, D.C., has adapted a program, originally designed for the Atomic Energy Commission, to produce finished artwork used in the manufacture of printed-circuit boards from an engineer's schematic. The circuit is translated onto punch cards, which are then fed into the computer. In addition to the complete printed-circuit negative, the computer also produces a verified schematic, a parts list, an assembly drawing and a hole-drilling list.

The computer's input consists of three packs of punch cards. One set defines the location of each part on the schematic, which is divided into sections by a matrix of boxes. Each box contains one component—any device of four leads or less from a piece of connecting wire to a transistor. Another set of cards defines the board's size, the location of its corners, the conductor width and its pad and hole size. A third set locates and determines the connector terminal if it has one.

With these three sets of cards the computer attempts to lay out the wiring pattern of the printed-circuit board. If it cannot do this without crossing wires on the board, it indicates this impossibility with a crisp message to the operator. If it can lay out the printed circuit's plated wiring, without shorts, it does so on a graphic console. This console is equipped with a film, which, after development, is the negative that can be used directly in the production of the PC board.

A typical 3-by-5-in. board, crammed with components, takes about 20 minutes on an IBM 7090. CEIR charges $400 to $600 for this service, including the preparation of the punch cards and the time on their computer. The firm is now working on a version that will accept multileaded integrated circuits. The program will design boards with two layers of interconnection and should be ready in six months.

The original program was called ACCEL (Automated CirCuit-board Etching Layout) and it was developed jointly by the SANDIA Corp., and the Bede Foundation. ■ ■

Balloon telescope maps far-infrared

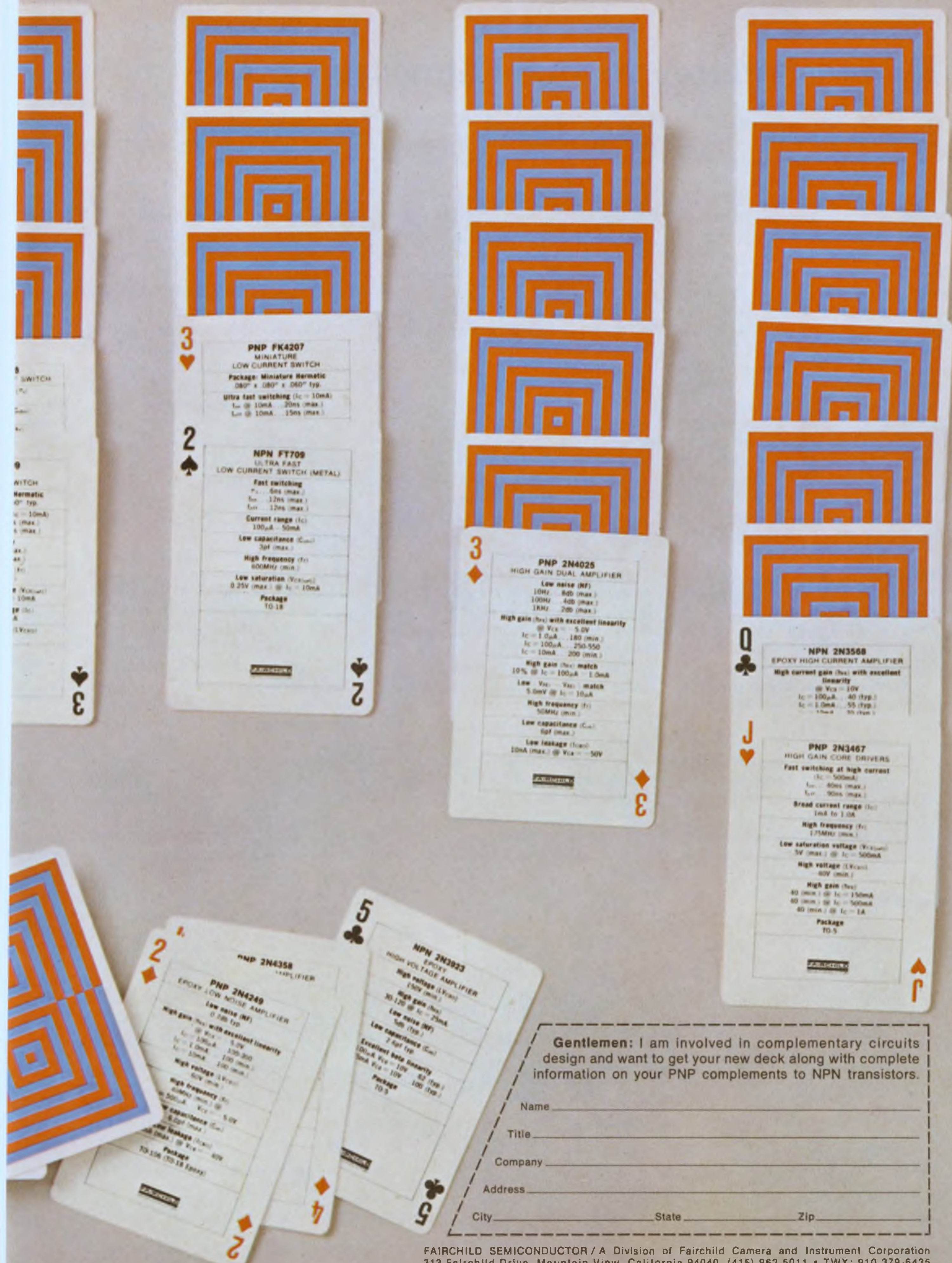
Two NASA astrophysicists who lofted an instrument-laden balloon to a height of 20 miles have conducted the first survey of the sky in the far-infrared region of the electromagnetic spectrum. In doing so, they may have discovered a way to gain valuable information on the formation of planets from the dust clouds surrounding newborn stars.

Their success was due to the balloon's ability to float over all but a few tenths of water vapor, the chief absorber of infrared energy in the atmosphere. The far-infrared, above 25 microns, is said to have been the last remaining unexplored region. Thus the gap between radio and optical astronomy has been bridged.

The astrophysicists, Drs. William F. Hoffmann and Neville J. Woolf, both of the Goddard Institute for Space Studies in New York City, placed a 1-mm chip of cryogenically cooled germanium, which served as a detector, at the focus of a 1-inch quartz lens. The balloon instrument package also included a recorder, a motor to rotate the package and and magnetometers.

The far-infrared, according to the two scientists, is normally filtered by the earth's atmosphere—along with the gamma-ray, X-ray and ultraviolet regions—and therefore is inaccessible from ground observation points. This region is said to be exceptionally difficult to detect and measure. At shorter wavelengths, such devices as photographic plates and infrared quantum detectors can be used. At longer wavelengths, radio receivers are available. But in the intermediate region, none of these methodologies can be applied successfully. The quanta of energy are too small for detection of the photoelectric effect, while the wavelength is too short for radio reception.

Hoffman and Woolf were able to take measurements that could place an upper limit on the amount of radiation from interstellar dust clouds. The composition of this dust could have important implications for theories on the origin of the solar system. Silicates would constitute an important ingredient in the formation of planets. ■ ■



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Flying laboratory to study atmospheric IR

Neil Sclater, East Coast Editor

A flying laboratory equipped as an atmospheric infrared research platform will soon begin worldwide flights to investigate variations in visible and infrared radiation.

The airborne laboratory, a modified KC-135, is attached to the U.S. Air Force Cambridge Research Laboratories, Bedford, Mass. Air Force scientists will use it to obtain a better understanding of the production and propagation of visible and infrared energy. They say that the studies are of importance to the development of Air Force surveillance and reconnaissance systems.

Experiments are planned which will take the KC-135 from the north to the south magnetic poles, according to Hervey Gauvin, director of the project. He is chief of the Radiation Effects Branch within the Optical Physics Laboratory. He said that studies will begin this month in the following areas:

- Infrared aurora and airglow and their associated chemical and luminescent reactions.
- Atmospheric water vapor as a function of latitude, season and location.
- Evaluation of schemes for detecting low-level infrared emission from targets by Air Force planes.
- Test and evaluation of Air Force IR equipment

Gauvin said that infrared aurora and airglow will be studied in normal sky backgrounds in different latitudes and seasons. The project will also obtain statistical data on atmospheric water vapor between about 5 and 8 miles above the earth at various locations. The Air Force, he says, wants to know more about how water vapor absorbs infrared radiation and affects satellite reconnaissance.

Among the Air Force equipment to be evaluated, according to Gauvin, are systems that would identify IR signatures of aircraft, missiles, and reentry vehicles.

Nine newly developed instruments have been installed on the aircraft. One is an electronic scanning spectrometer able to scan the visible infrared region of 0.6 to 1 micron at rates up to 10,000 scans per second. It uses an image dissector photo-electron multiplier tube as a detector. Digital signals from the instrument are recorded on video magnetic tape in a format directly acceptable by a computer. The complete instrument package occupies less than one cubic foot.

The special equipment on the plane also includes a servo-controlled, trainable mount which permits up to seven separate instruments to be trained on one region of the sky at the same time.

The mount with its trainable periscope, Gauvin says, permits real-time correlation of data from a variety of instruments.

The other new instruments are an infrared sky mapper, five Michelson interferometers and two infrared radiometers.

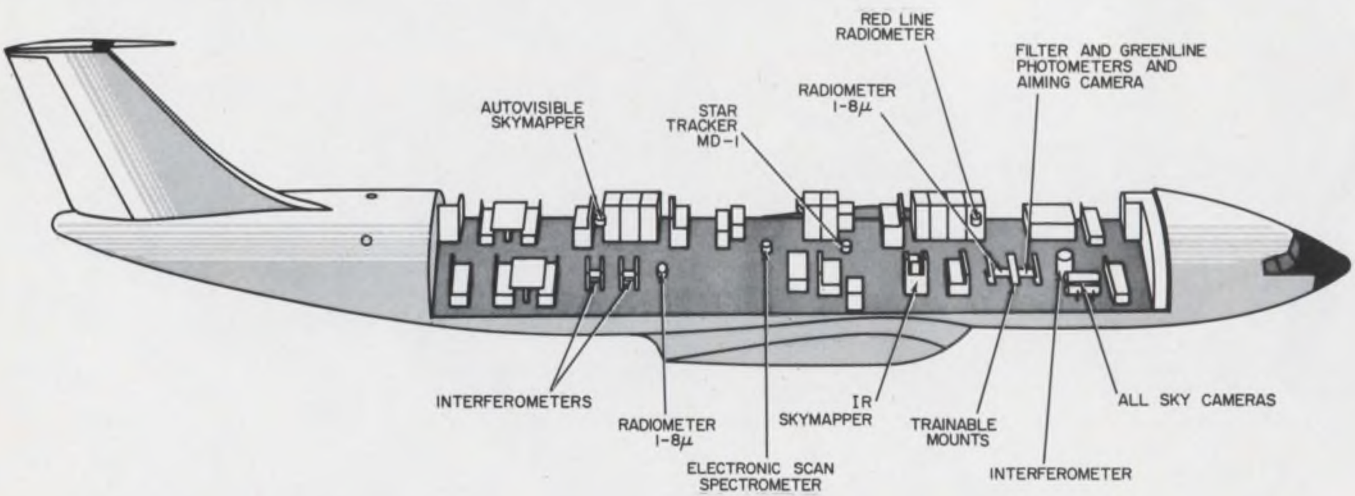
The conventional supporting instruments on the aircraft include a spectrometer and a sky mapper for visible light, a green-line photometer, and all-sky and documentary cameras.

Atmospheric research data may be recorded on any of five 14-channel magnetic-tape recorders and a video magnetic-tape recorder. The recording equipment has features that permit the data to be timed and indexed for ease of data reduction.

A liquid-nitrogen-cooled optical chopper, positioned outside a window of the aircraft, permits interferometer systems to make extremely low-level infrared measurements.

The aircraft is equipped with an MD-1 Astro Tracking System for navigating in parts of the world lacking adequate navigational aids.

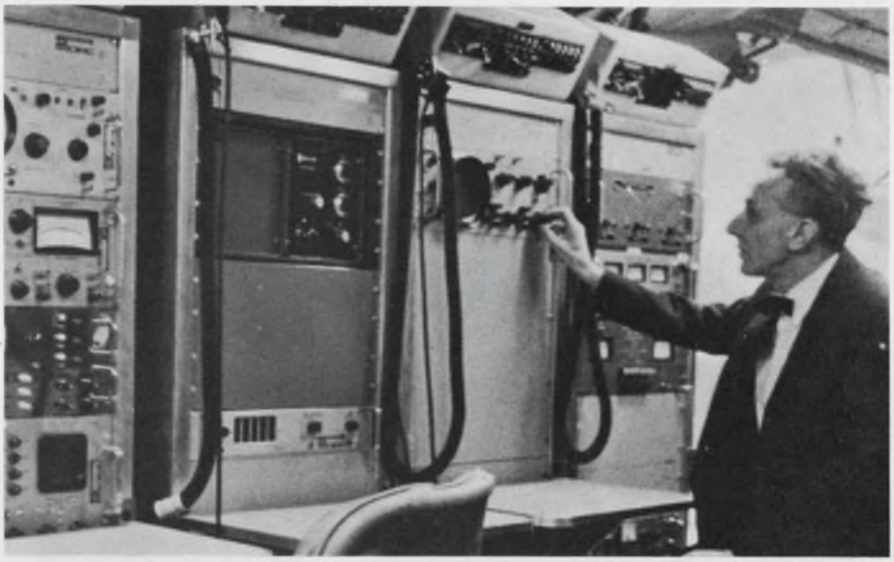
The KC-135 was extensively modified for the installation of the instruments by Hayes International Corp., Birmingham, Ala. The internal framing was rebuilt to permit the installation of the many additional viewing ports in the pressurized cabin. The plane will be able to fly at altitudes greater than 40,000 feet but for long flights will cruise at about 37,000 feet. At that height it will be above 98 per cent of the earth's atmosphere. ■ ■



Nine newly developed scientific instruments and many conventional instruments, installed aboard this flying thermal radiation laboratory, form a well equipped and versatile platform for the study of atmospheric radiation.

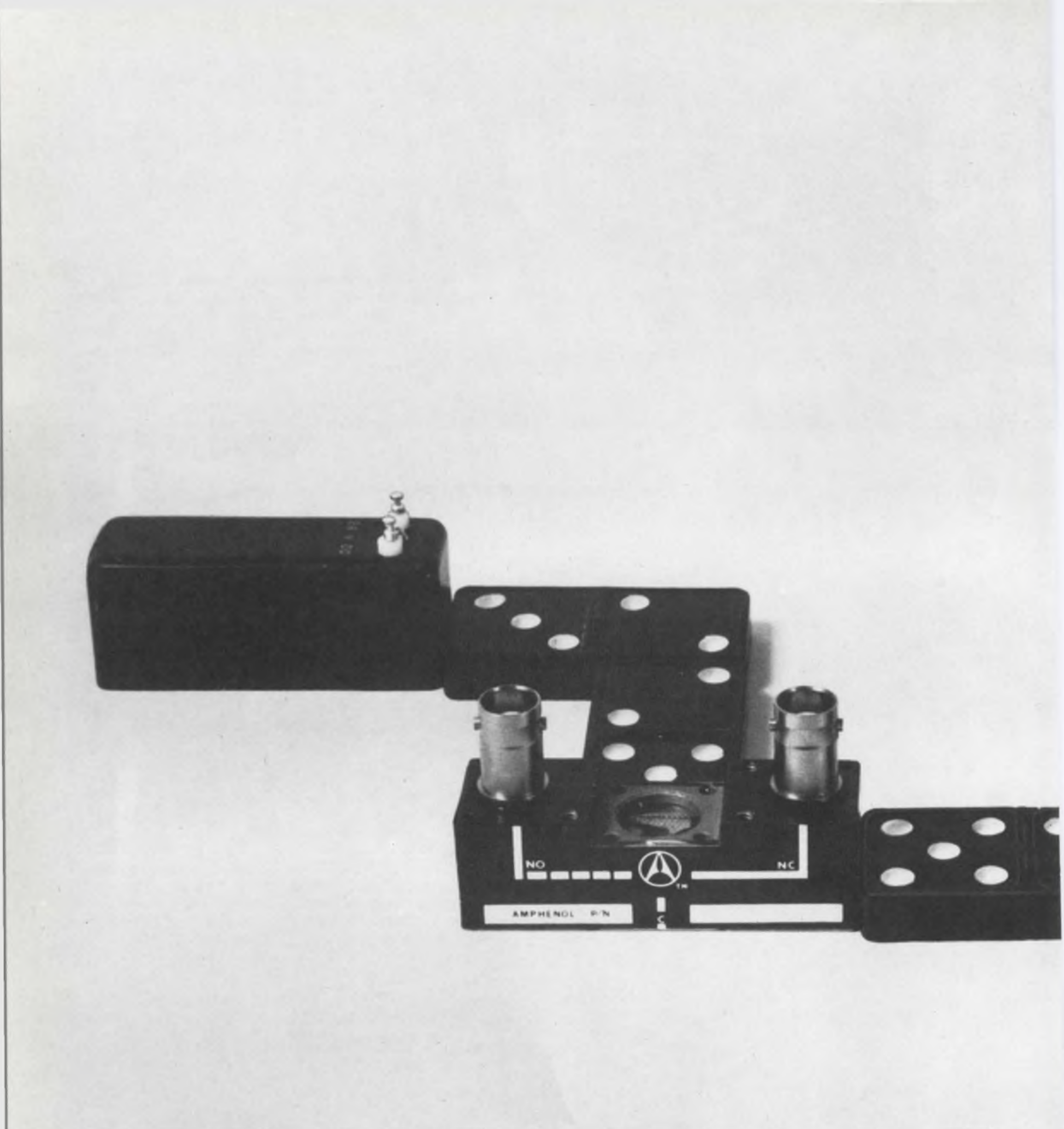
The servo-controlled master tracking station is positioned by Maj. William Grieder with a joystick control. Located on the mount is a 16-mm gun-sight camera, a narrow-band photometer and a wide-field telescope for aiming and tracking. Two other mounts are slaved to track with this station, permitting as many as seven instruments to be aimed simultaneously.

One of the two laser-referenced interferometer spectrometers is aimed by engineer Robert Pierce. Instruments are sensitive in 1- to- 8-micron band and have nitrogen-cooled detectors.



The remote-control monitor for an 8-to-14-micron-band filter radiometer is adjusted by Hervey Gauvin, the flying-laboratory project manager. The equipment racks before Gauvin also contain electronics for sweeping three 1-to-14-micron-band interferometer spectrometers and other devices that will monitor the radiometer.

The Air Force KC-135, recently modified at a cost of about $329,000, will soon begin worldwide research flights. The fuselage framing was built to permit the installation of many pressurized viewing windows.



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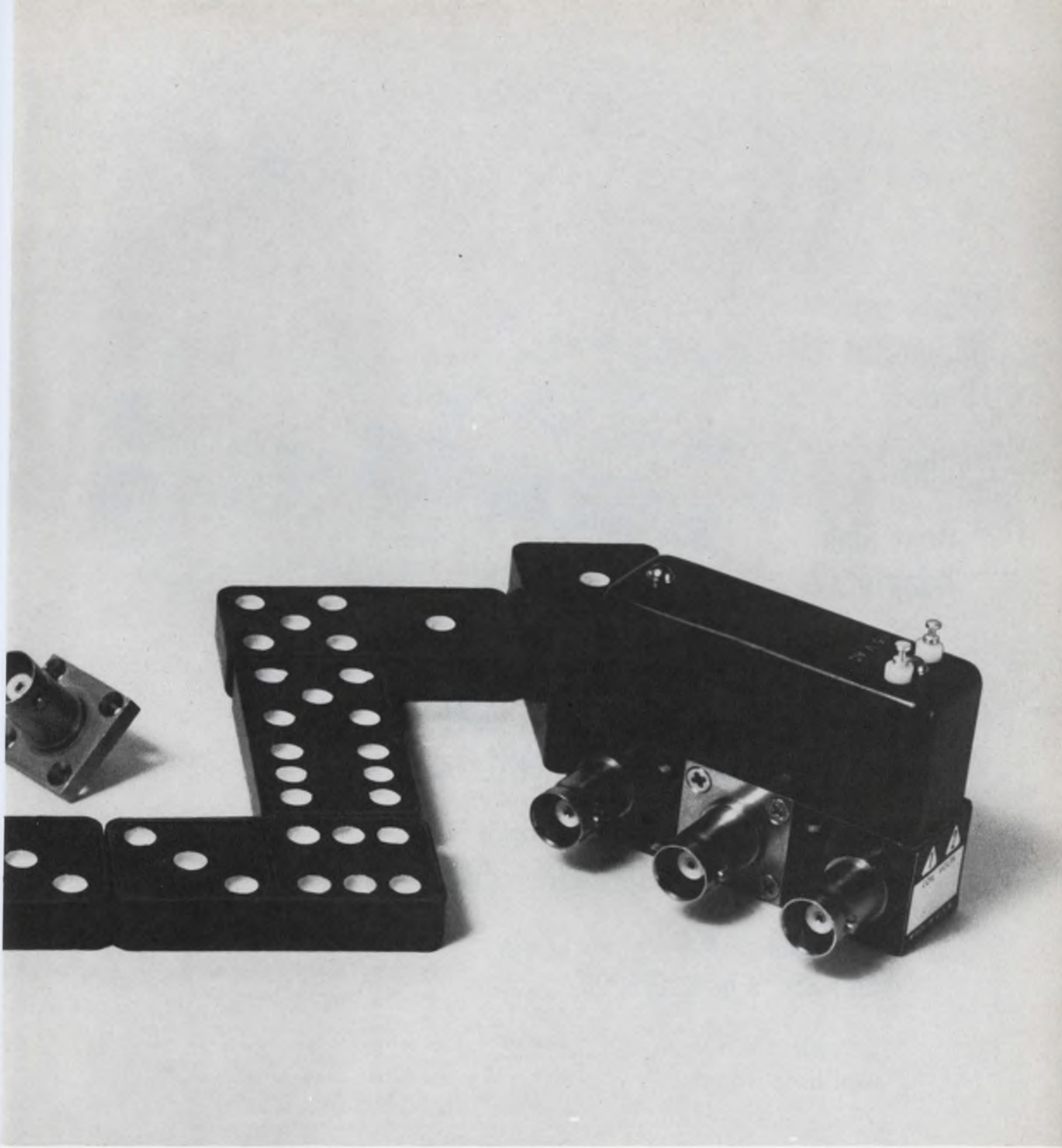

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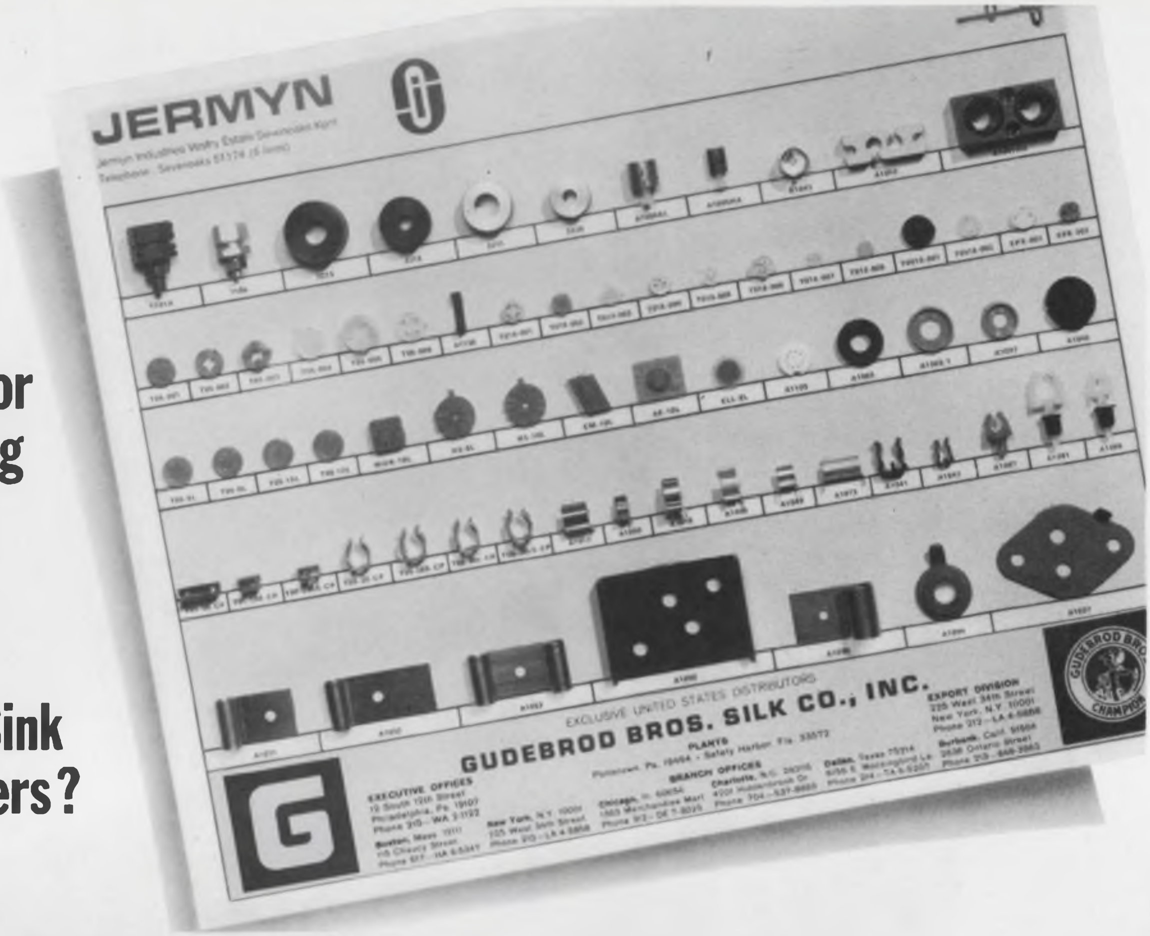

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ON READER-SERVICE CARD CIRCLE 23

New uses for medical ultrasonics reported

Stockholm meeting told ultrasound no risk to embryo or pregnant woman; ultrasonic holography described

Richard N. Einhorn
News Editor

Ultrasonics, a technology usually associated with the cleaning of watches and dentures and the detection of leaks and imperfections in materials, is assuming an important role in a variety of medical applications.

At the Seventh International Conference on Medical and Biological Engineering, now in progress in Stockholm, 17 papers are being presented on ultrasonics—and only one is on cleaning.

The conference is the largest of its type ever held. More than 500 papers, authored by scientists from over two dozen countries, are being presented between Aug. 14 and 19. To accommodate this activity, the conference is divided into 40 specialized sessions, in addition to general sessions. There is also an exhibit of the latest equipment.

Significant advances in medical ultrasonics reported at the conference include these:

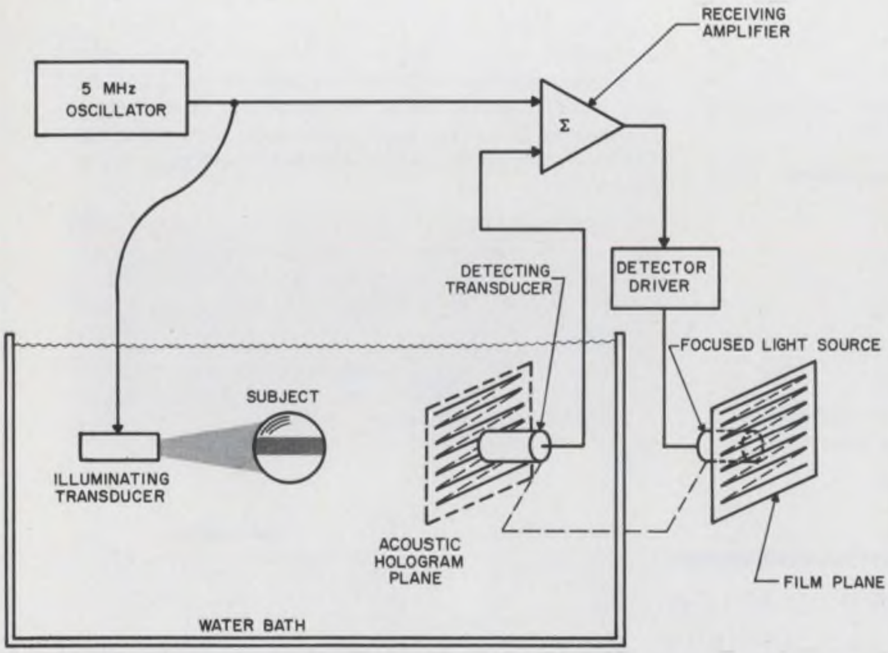
- Imaging of the human body to supplement X-rays in diagnosis. The chief applications are gynecology and obstetrics, since, according to several of the speakers, ultrasound does not damage either the pregnant woman or the embryo.
- Mapping and measuring tissue, such as blood vessels.
- Detecting the sources and types of headaches.
- Locating tumors within the eye.
- Recording heart valve action.

Various therapeutic applications have also been tried. For example, ultrasonic surgery is reported to be used for clinical treatment of certain diseases—but not tumors, because it may cause malignancies to spread. And, according to Dr. H. W. Buschmann of Humboldt University, Berlin, who presented the general review of medical ultrasonics at Stockholm, it may be possible to move a detached retina back toward its original position with ultrasonic waves, and hence improve the prospects for retinal surgery. However, he cautioned, this method needs further development.

The most promising application of ultrasonics is said to be imaging, including the production of ultrasonic holograms.

Frederick L. Thurstone, a scientist experimenting with ultrasound holography and reconstruction at the Bowman Gray School of Medicine, Winston-Salem, N. C., explains in his Stockholm paper[1] why there is a need for such techniques:

"The relative transparency of tissue structure to sonic energy and the reflectivity of soft tissue interfaces . . . have led to the development of numerous diagnostically useful imaging techniques." This means that the sound waves readily pass through soft tissue, but there is a distinct transition between parts—even between two adjacent tissue layers—because a portion of the energy travels forward as one wave through the second medium while another portion is reflected back into the first medium, usually with a phase change.[2] Thus the ultrasonic imaging of body sections provides good contrast of hard and soft tissue and no risk to patients.



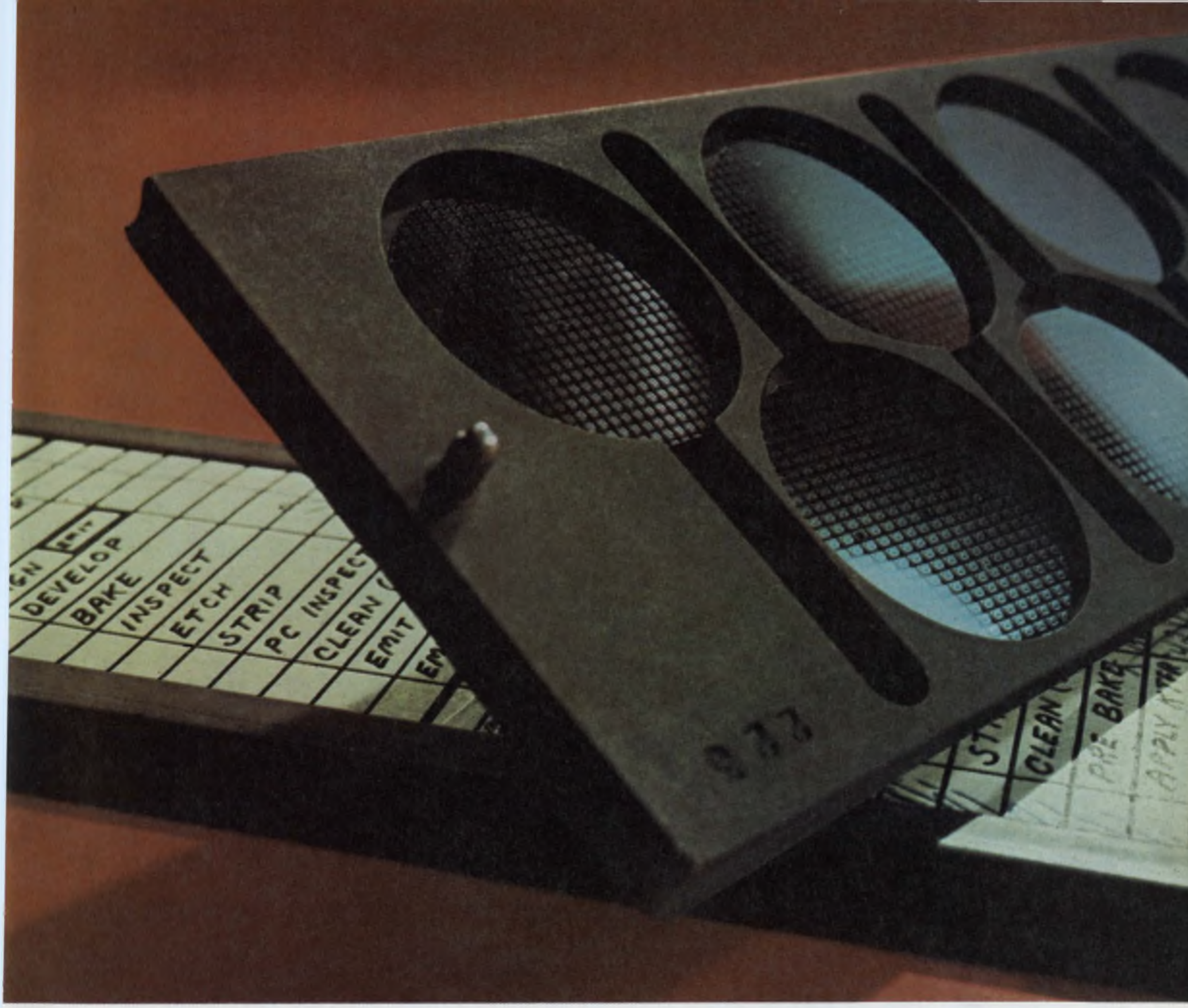
1. **Ultrasonic holograms** are formed on film by light scanned mechanically at same rate as detecting transducer. Nonlinear electronics are required for mapping magnitude and phase of a coherent sound field.

Ultrasonic holograms tried

However, Dr. Thurstone reports that the characteristics of ultrasonic transducers limit the resolution of images, and that conventional scanning systems present only a cross-sectional image of the subject. This, he says, led him to investigate three-dimensional imaging.

Dr. Thurstone devised for experimental purposes a mechanical scanning system (see Fig. 1) that generates optical transparencies which are holographic reconstructions of sonic fields. The ultrasonic holograms could be illuminated with quasi-coherent light in the visible spectrum to produce three-dimensional images of the object.

As shown, a 5-MHz electrical output from the oscillator drives a pie-



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zoelectric transducer, which is immersed in a water bath. The acoustical output of the transducer propagates in a narrow beam through the water and strikes the subject that is being recorded—a biological specimen, for example. (Ultrasonics generally requires a liquid medium because the losses in air would be too great.) The subject passes, absorbs or reflects the sonic energy, depending on its nature. The amount of absorption of ultrasound goes up with frequency.

A detecting transducer, which is also immersed in the bath in order to avoid diffraction effects at the air-water interface, is scanned mechanically at a constant rate through a two-dimensional plane that represents the plane of the sonic hologram in the sound field. This transducer has a very narrow aperture to give a good approximation of coherence. The mechanical scanning rate is completely independent of the oscillator frequency.

The electrical output of the detecting transducer is fed to an amplifier which has as its second input the direct output of the oscillator. A phase difference always exists between the two inputs because of the delays imposed in the water bath. Since the subject lies in the acoustic path, its properties affect the magnitude and the phase difference.

The reference signal applied directly to the amplifier is analogous to a plane wave field in the water bath impinging directly on the plane of the sonic hologram with a normal angle of incidence. This is similar to the function of the reference beam in ordinary holography using a laser for illumination, so that an interference pattern is generated. The output of the amplifier is used to control the intensity of a focused light source through a nonlinear system.

The light source, which has a narrow beam, is driven at the same rate as the detecting transducer, to which it is mechanically coupled. It scans a photographic emulsion placed in its path. In this way, the magnitude and phase of a quasi-coherent sound field are mapped into the photographic material to give a three-dimensional picture of the subject. The ultimate resolution of the optical image is said to be comparable to the sonic wavelength.

Ultrasonic holograms could be especially useful in analyzing tissue that is not highly differentiated, such as layers of muscle, he says. Dr. Thurstone hopes to experiment on animals in the coming academic year, and emphasizes that his results are only preliminary, and that he does not foresee immediate medical applications.

Progress has been made in upgrading more conventional methods of diagnostic ultrasonics, too. According to scientists from the United States, the Netherlands and West Germany, the one-dimensional A-scan method is common in many hospitals because it requires relatively simple equipment. However, they point out that B-scan techniques, which give two-dimensional images, should be able to provide better information on soft biological tissue because the clinician would be able better to identify the part of the anatomy he is seeing.

Imaging uses sonar principles

A Dutch scientist, J. C. Somer of the Institute of Medical Physics TNO in Utrecht, says that previous attempts to implement B-scan ultrasonics generally involved a moving probe.[3] The movement of the transducer is by means of translation (ordinary B-scan), rotation (sector scan) or a combination of the two (compound scan). He says that all of these have the following disadvantages:

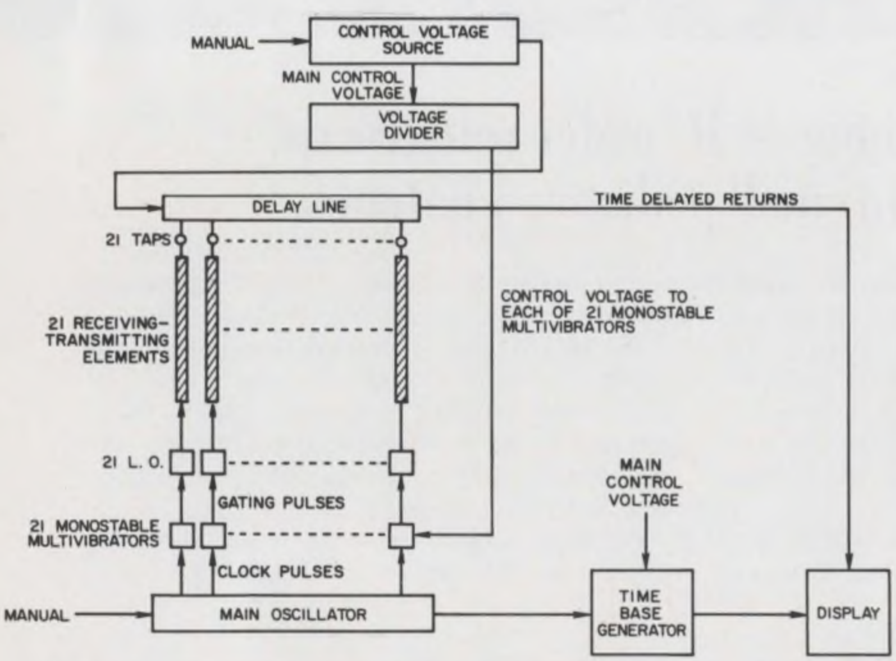
- In contrast with A-scan, it is not possible to find the best position of the probe for every line in the picture.
- Acoustic coupling between probe and issue is erratic, especially when a water bath is not used.

The result is that the pictures are difficult to interpret and reproduce, he says. This is especially disadvantageous in examination of the brain.

He proposes as a solution a two-dimensional scanning technique without moving probe. His approach draws upon the array techniques of radar and sonar, in which many small elements are used instead of a large single element. Somer's elements are individually steerable, so that he has found it possible to generate ultrasound pulses in arbitrary directions within a sector.

The array consists of 21 elements, each 0.5 by 10 mm, arranged side by side to form a strip 11 by 10 mm (see Fig. 2). The elements resonate at 1.3 MHz.

Each element is fed by its own local oscillator, which is gated on and off by a monostable multivibra-



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- Maximum reliability and stability.
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- Any number of levels or planes of tungsten or molybdenum metallized patterns.
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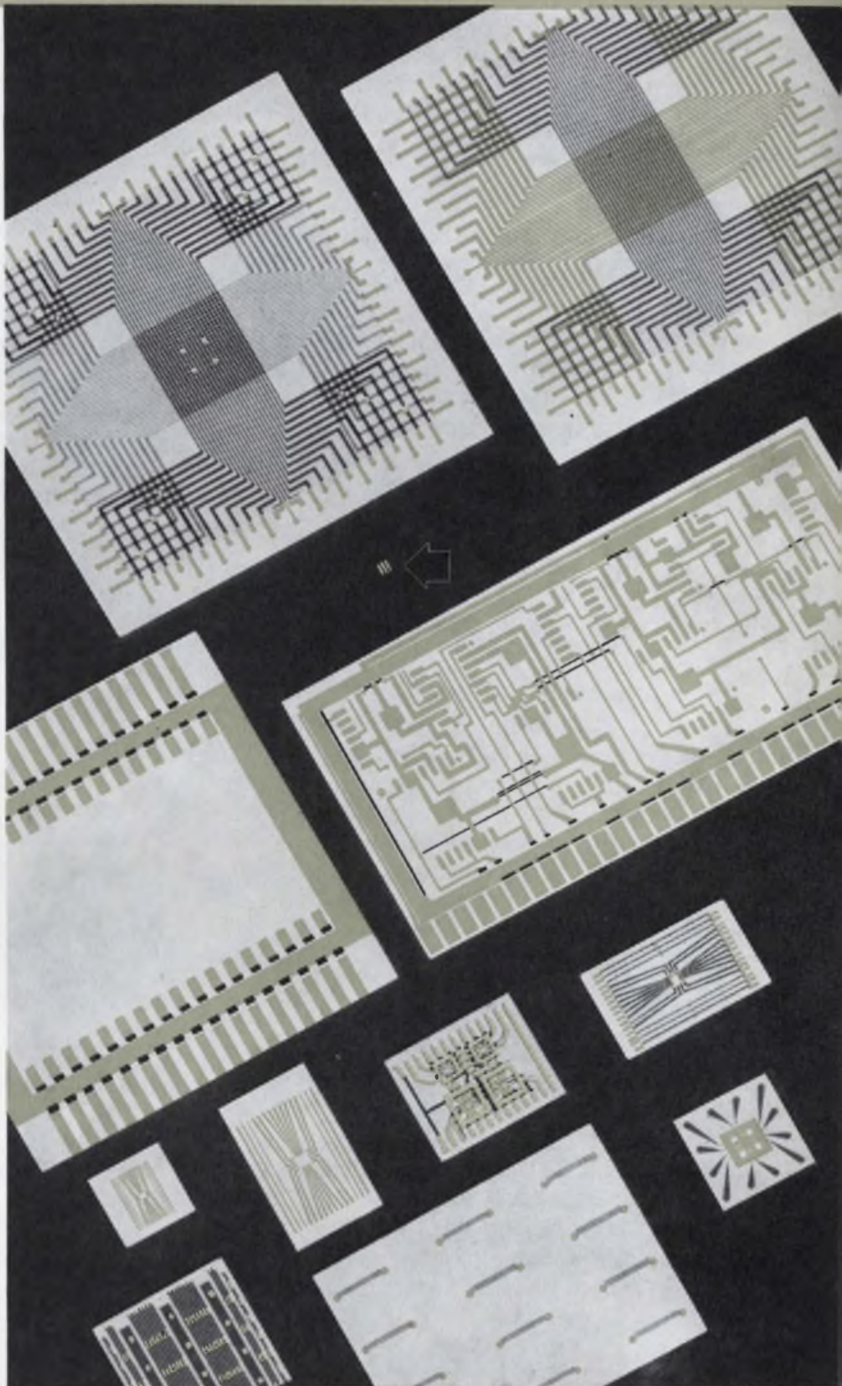

Illustrations about actual size.

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(ultrasonics, *continued*)

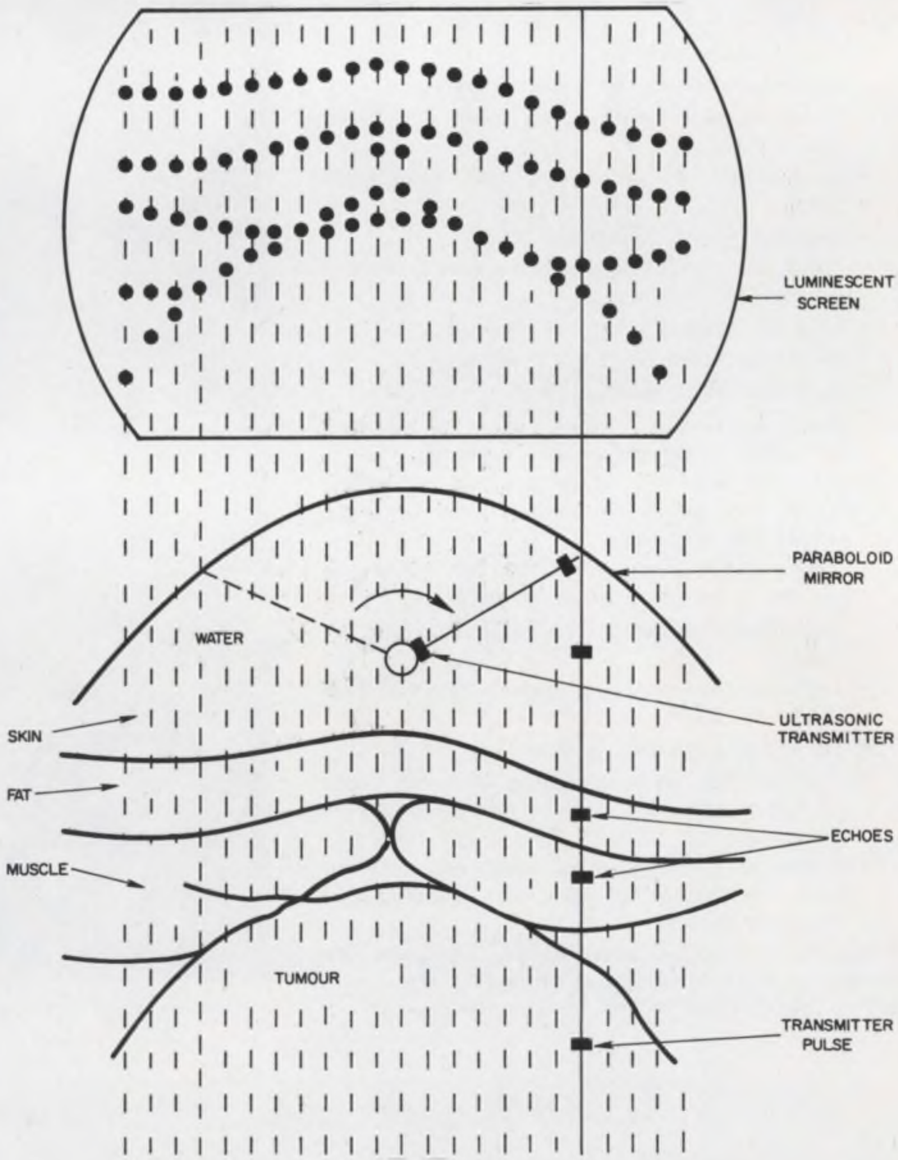
tor. All 21 multivibrators are triggered simultaneously by a clock pulse from the main oscillator. The output pulse of each multivibrator can be varied individually by means of a control voltage. Somer derives the control voltages from a voltage divider which routes individual voltages from a voltage source to the 21 multivibrators.

The control voltages set the pulse widths of the multivibrators. Since the local oscillators are gated on when the multivibrator pulses end, the pulse width determines the phase of the corresponding element. The voltage-dividing action in effect controls the direction of the sound beam. The array has a linear phase taper, and a sector is scanned by varying the main control voltage. The time intervals (hence phase differences) between the sonic pulses of adjacent elements are constant, but have different values for different directions.

The echoes are received by the 21 elements in the array, which are connected to taps of a delay network. This network consists of fixed and electrically variable delay lines that compensate for the time intervals with which a wave front arrives at the various elements. Therefore, the variable delay lines are controlled by the main control voltage. The echoes are received directionally in order to optimize angular resolution of the system.

The echoes are displayed at the

(continued on p. 52)



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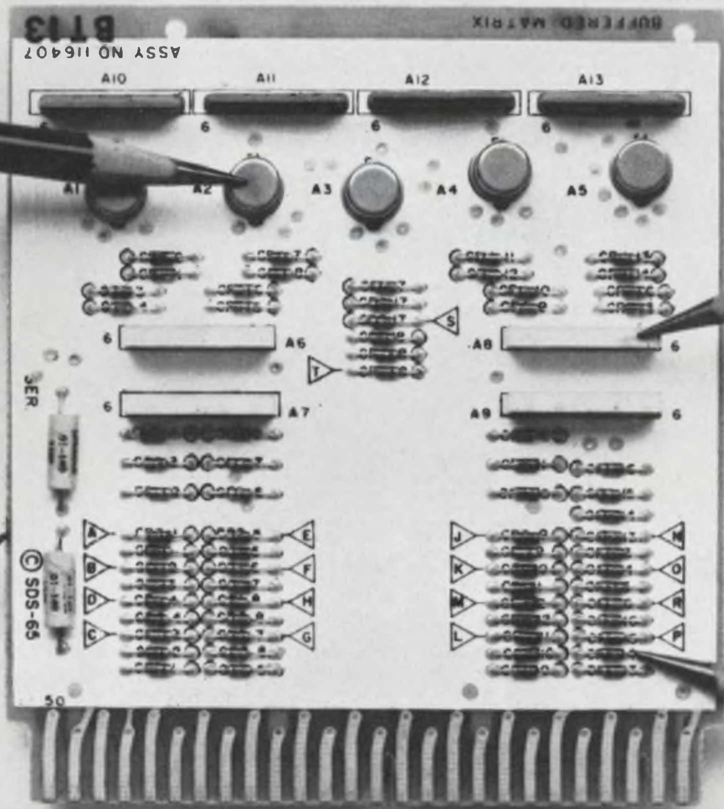

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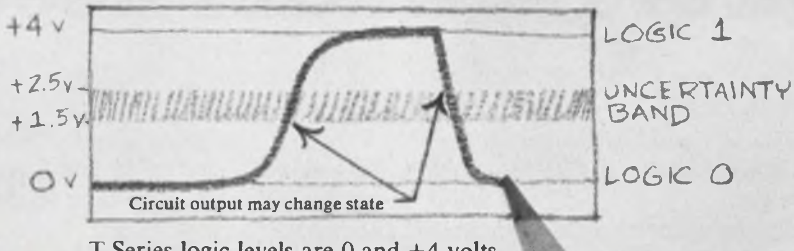

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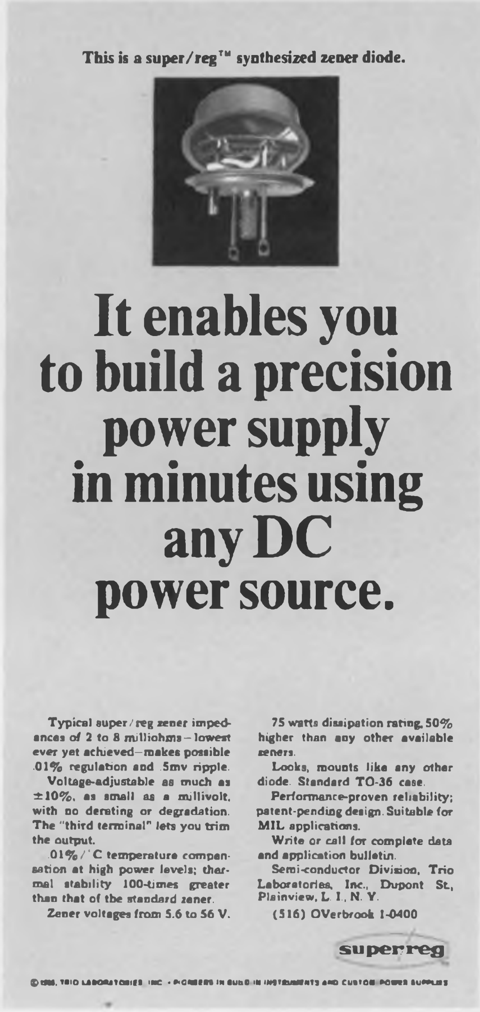

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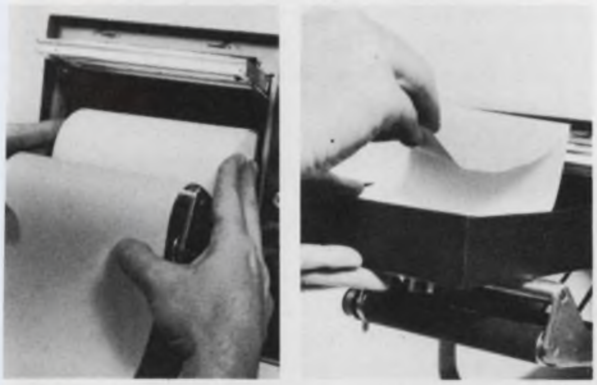

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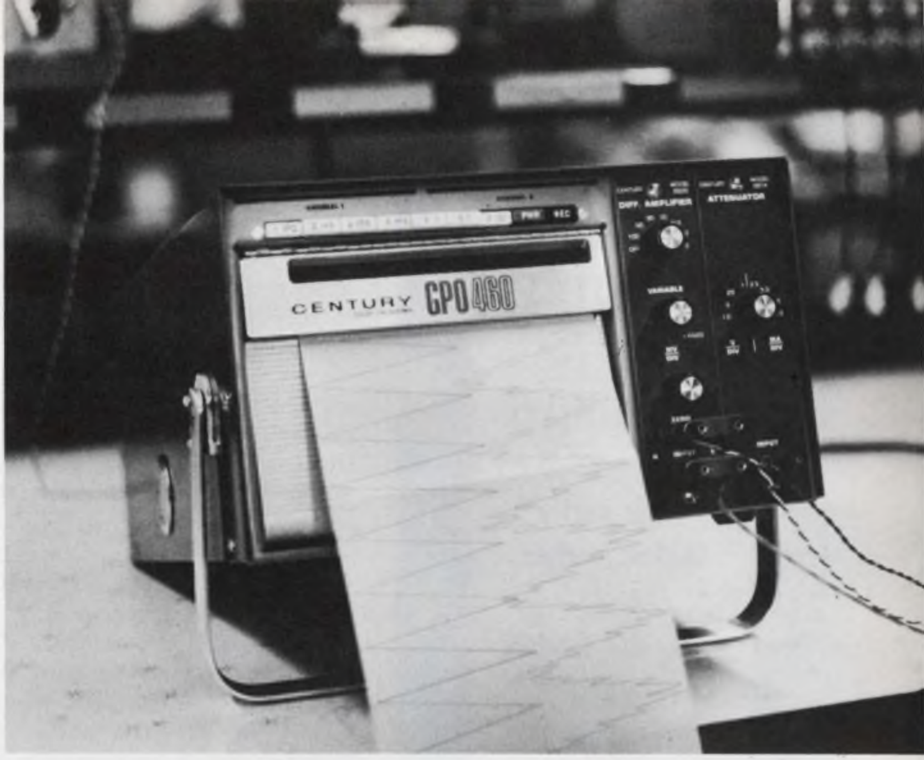

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(ultrasonics, *continued*)

appropriate places on a cathode-ray tube. For synchronization purposes, the time base generator is under the control of both the main oscillator and the main control voltage. In the present design, the system scans 30 times a second. Each scan is constructed from 32 different beam directions within a 90 degree sector. Thus both instantaneous and continuous pictures are derived with a stationary transducer.

Somer says he has obtained good pictures of simple reflecting objects immersed in water. He points out that other scientists have recently reported useful diagnoses from mechanical sector scanning of the heart and brain. He predicts that by modifying his equipment to improve the beam shape and to suppress undesirable side lobes he should be able to get far better results with his electronic sector-scanning technique.

Tumors displayed ultrasonically

Two West German scientists at Stockholm report on another method of applying sonar principles to B-scan ultrasonic imaging to eliminate the time-consuming image buildup of conventional imaging. W. E. E. Krause and R. E. Soldner of Siemens AG, Erlangen, say that for the first time it is possible to display ultrasonic sections of the human body in short time intervals and in rapid sequence, so that it is possible to observe not only stationary conditions in real time, but also kinetic processes. They brought a photograph of an ultrasonic view of the abdomen of a woman suffering from a tumor. In the photograph the skin, fatty tissue, muscle and tumor stand out.[4]

Their method, too, takes advantage of the fact that sonic energy is reflected from each tissue interface through which the beam passes. The reflected echoes are converted into electrical pulses which are displayed on a cathode-ray tube as a brightness-modulated potential. The pulses form the image points of a vertical line on the screen that is traced in about 200 μs. This interval corresponds to a penetration of about 150 mm in soft tissue. The horizontal deflection of the electron beam is synchronized with the lateral displacement of the ultrasonic scanning beam and has a sweep time of approximately 70 ms. The picture frequency is about 15 Hz, just high enough to give the illusion of a stationary image.

About 140 vertical lines are traced for each image. The cross section is about 14 cm wide by 13 cm long. Rapid lateral parallel displacement of the ultrasonic scanning beam is achieved by means of a rotating ultrasonic directional beam transmitter in conjunction with ultrasonic mirror optics. As shown in Fig. 3, the transmitter is positioned in the focal path of a cylindrical paraboloid mirror. The transmitted sonic energy is reflected as a beam that is displaced laterally in a parallel manner. The echoes follow the same path, but in the opposite direction. The transmitter and the mirror are immersed in a water bath. The vessel containing the water is sealed by means of a plastic foil; the patient is coupled acoustically to this foil by a thin film of oil.

Krause and Soldner say that with this method it is possible to determine the position of the embryo and placenta in the uterus, the size of the infant's head and the presence of twins at an early stage. They estimate that the output has a mean ultrasonic power density of 10 mW/cm^2, a safe figure.

Three reports concern the use of Doppler-shifted ultrasound. One is on the measurement of blood pressure, another on the condition of blood vessels and a third on the location of clear scanning paths. ■ ■

References:

1. F. L. Thurstone, "Three-Dimensional Imaging by Ultrasound Holography," *Digest of 7th International Conference of Medical and Biological Engineering*, (Stockholm, Sweden: Organizing Committee of 7th ICMBE, 1967), p. 313. (Copies are available from Almqvist & Wilksell, 25 Gamla Brogatan, Stockholm 1, for 95 kronor.)
2. Benson Carlin, *Ultrasonics* (2nd ed.; New York: McGraw-Hill Book Co., 1960), p. 9.
3. J. C. Somer, "Electronic Sector Scanning for Ultrasonic Diagnosis," *Digest 7th ICBME*, p. 314.
4. W. E. E. Krause and R. E. Soldner, "Ultrasonic Imaging Technique (B-Scan) with High Image Rate for Medical Diagnosis," *Digest 7th ICBME*, p. 315.

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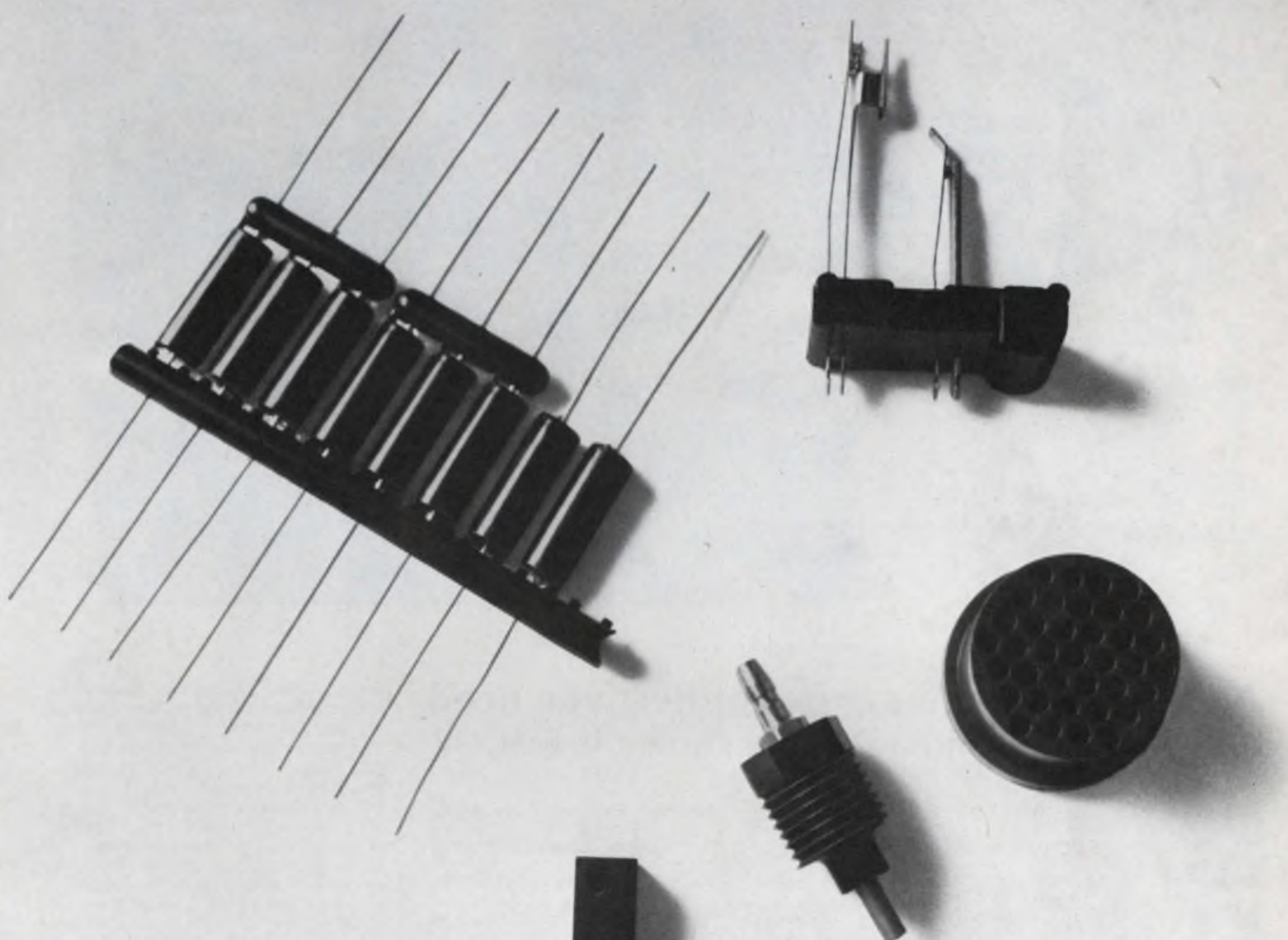

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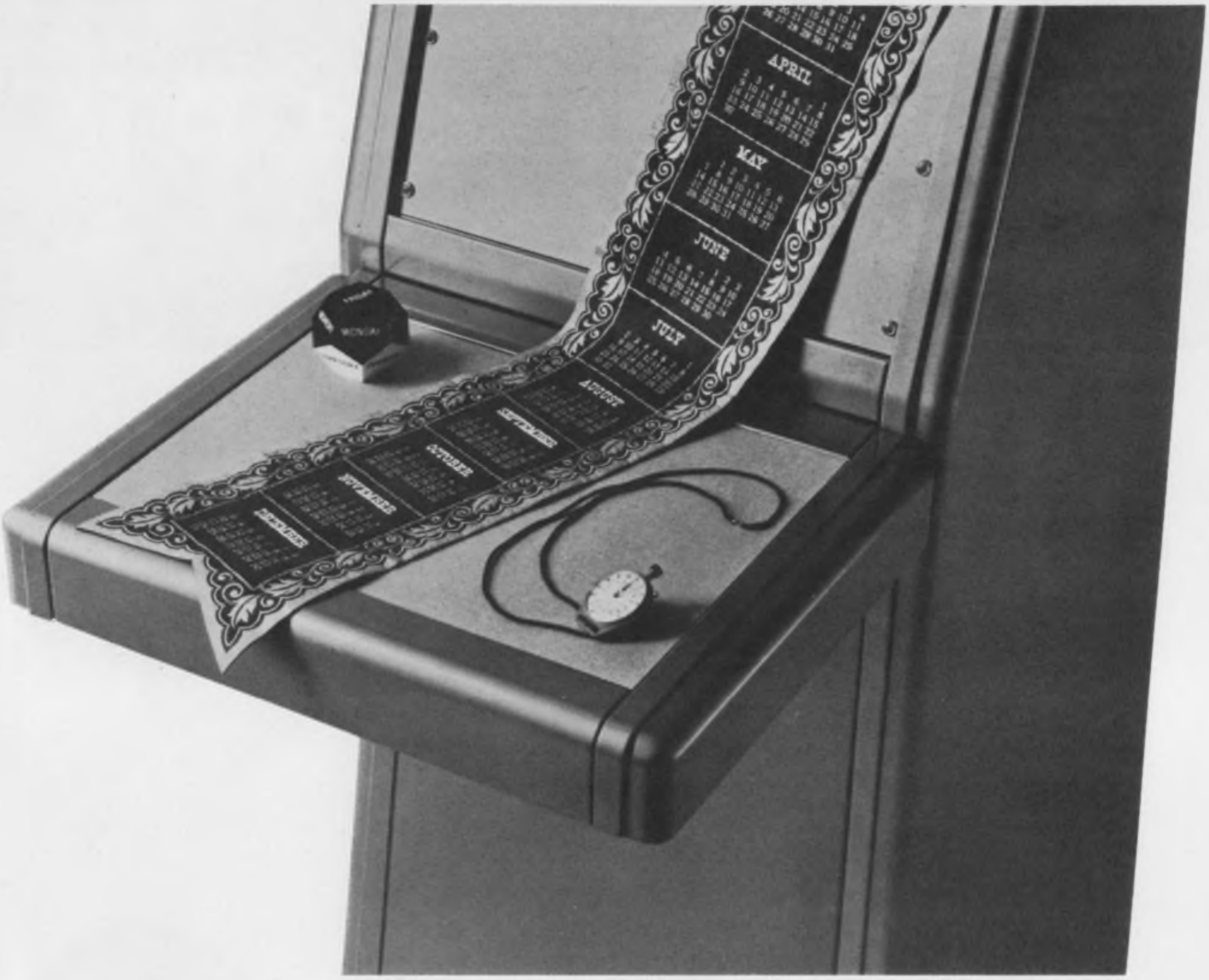

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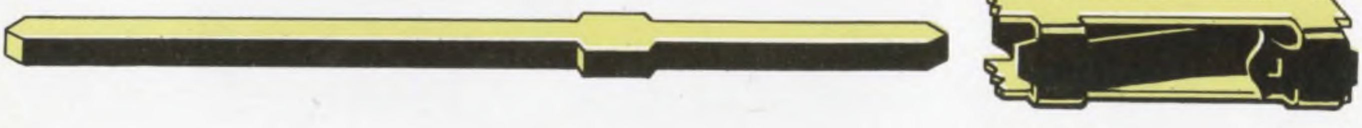

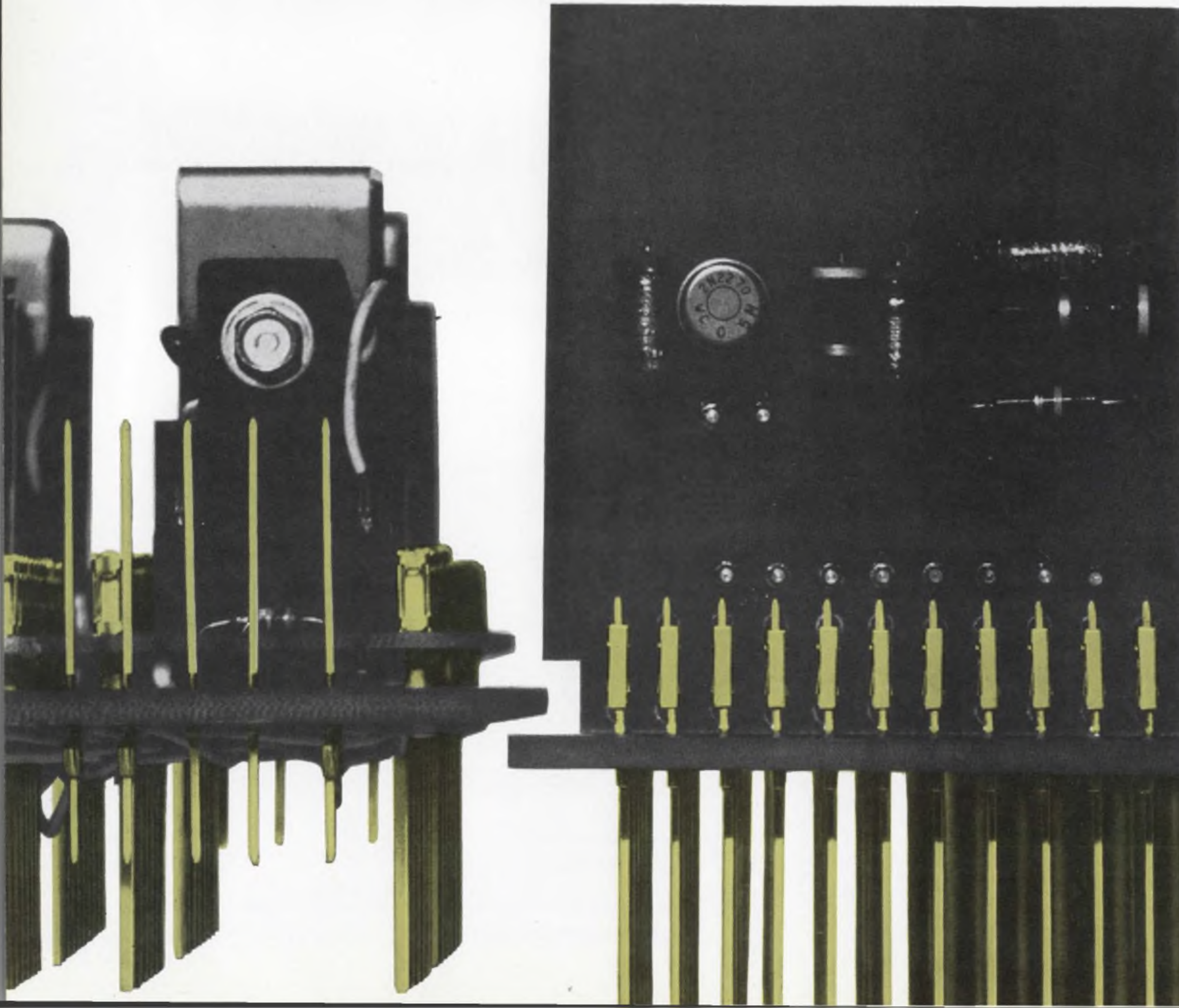

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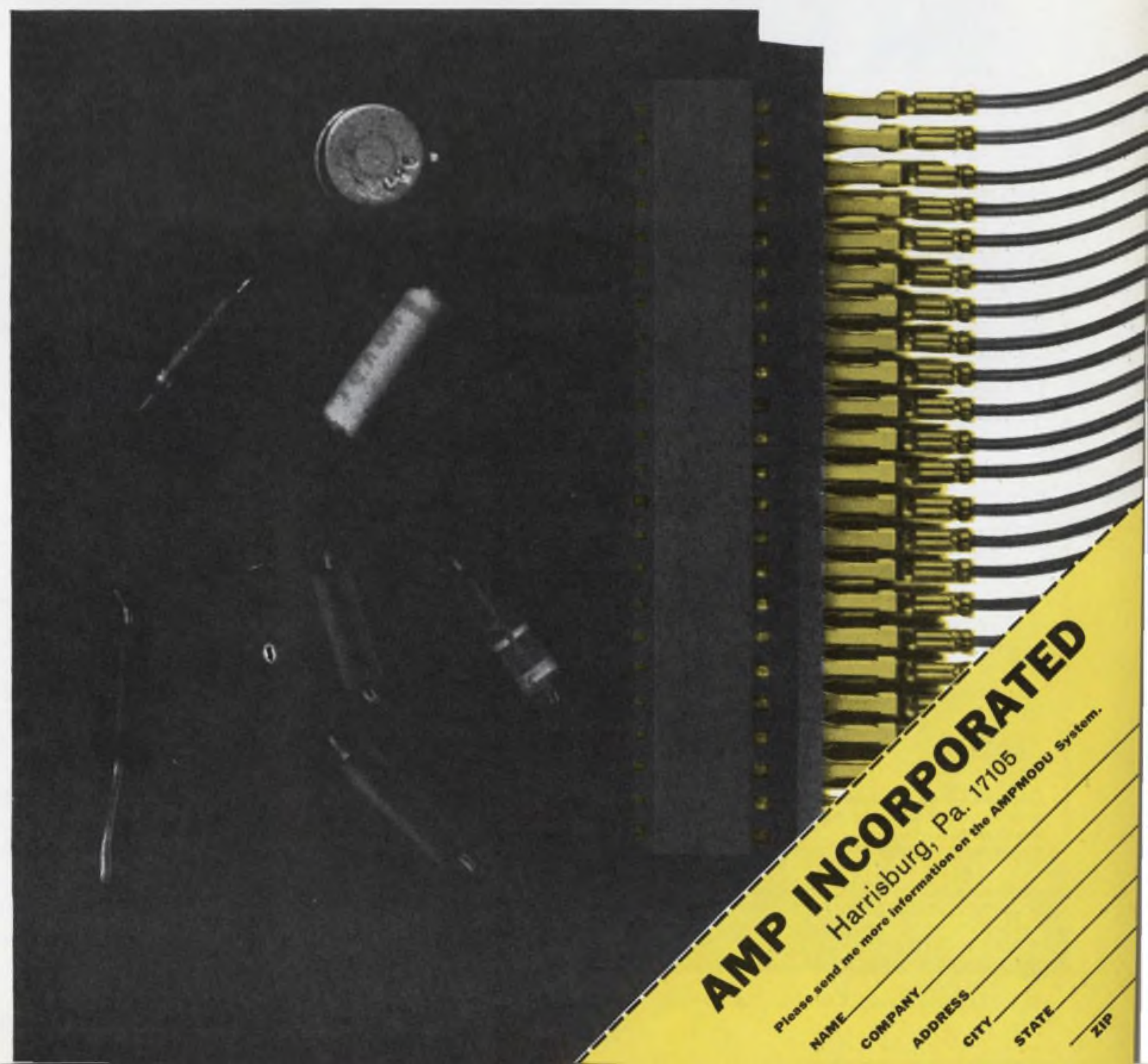


Quartz disk detects powerful microwaves

A virtually burnout-proof quartz disk able to rectify and mix higher-power microwave signals than conventional semiconductor diodes has been developed in a U.S. Air Force laboratory.

Two scientists in the Microwave Physics Laboratory of the Air Force Cambridge Research Laboratories, Bedford, Mass., demonstrated that a 0.1-mm-thick (0.004 inch) quartz disk has a burnout rating more than three times higher than a crystal diode.

The developers, Dr. Paul H. Carr and Andrew J. Slobodnik, Jr., have used the disk to absorb more than 30 ergs of input energy. The 1-watt input signal was square-wave modulated. The disk, mounted in a tunable resonant cavity, has a diameter of about 1/4 inch.

The piezoelectric quartz disk has a practical application in monitoring the performance of transmitters, according to Dr. Carr. He said that considerable attention must be given to handling and using diodes to prevent their burning out. Burnout is likely to occur when input power is about a tenth of a watt. He added, however, that the sensitivity of the quartz disk is much less than that of a diode.

The researchers evolved the technique during studies of the nonlinear microwave acoustic properties of dielectrics such as quartz. They found that the output frequency depends on the disk surface quality and, if it is too rough, there will be no acoustic resonance.

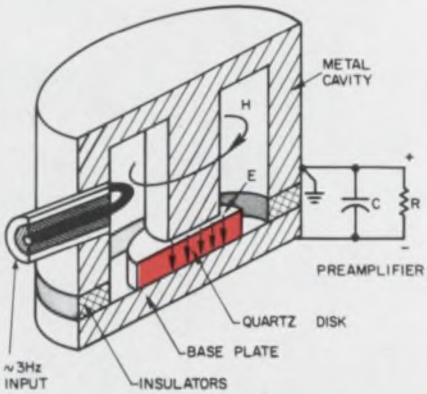
In their experimental setup a quartz disk with a resonant frequency of about 29 MHz was located in a 3-GHz tunable reentrant cavity. Dr. Carr said that a dc voltage is produced across the disk by the radiation pressure or Maxwell-Faraday stress, nonlinearities in the material coefficients, and thermal effects.

The modulation envelope of the voltage across the disk, he says, is capacitively coupled to the two insulated halves of the cavity. Voltage is measured across these electrodes.

In order to obtain the largest rectified voltage, Dr. Carr said that the optically polished X-cut disks must be excited at an overtone acoustic resonance frequency. This, he said, occurs when the microwave frequency is an odd multiple of the fundamental acoustic frequency of the disk. He says that this property may be of use in microwave frequency-control applications.

The scientist said that the sensitivity of the disk is measurable in millivolts for each watt of input power. He predicted that 1 volt dc would be obtained if the input signal had a 1000-watt peak with a 2-microsecond duration, assuming a duty cycle of about 0.001.

Both researchers have also demonstrated that the piezoelectric disks permit mixing higher-power microwave energy than is possible with diodes. When a disk is used in a reentrant cavity excited by two separate microwave sources, an intermediate frequency is obtainable. Dr. Carr said that maximum output is observed when the difference in the frequencies of the two sources equals the fundamental frequency of the quartz disk. The bandwidth obtained when the disk with the 29-MHz fundamental frequency was used varied between 10 and 40 kHz. Dr. Carr said that the mixers may be of use in high-power radar systems, to eliminate the elaborate switches and attenuators used at present. ■ ■



Thin quartz disk is microwave rectifier in Air Force experiment. Modulated signal is introduced into reentrant cavity and dc output appears across disk. It can withstand higher rf power than semiconductor diodes.

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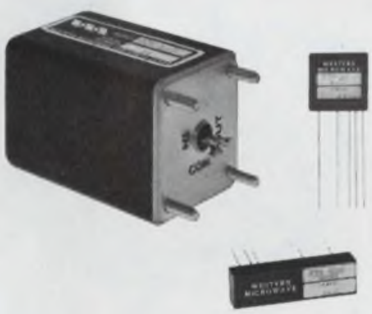

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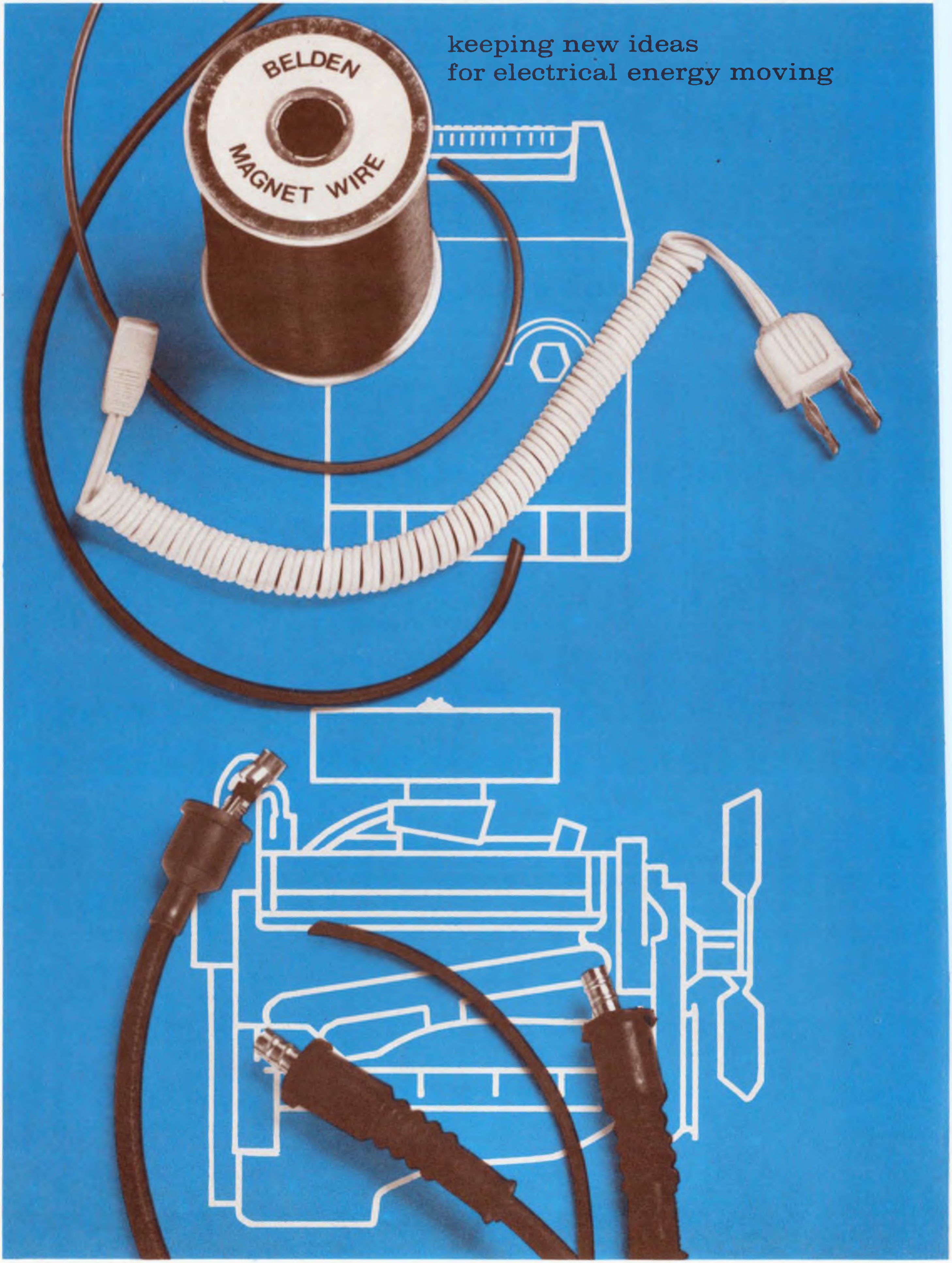
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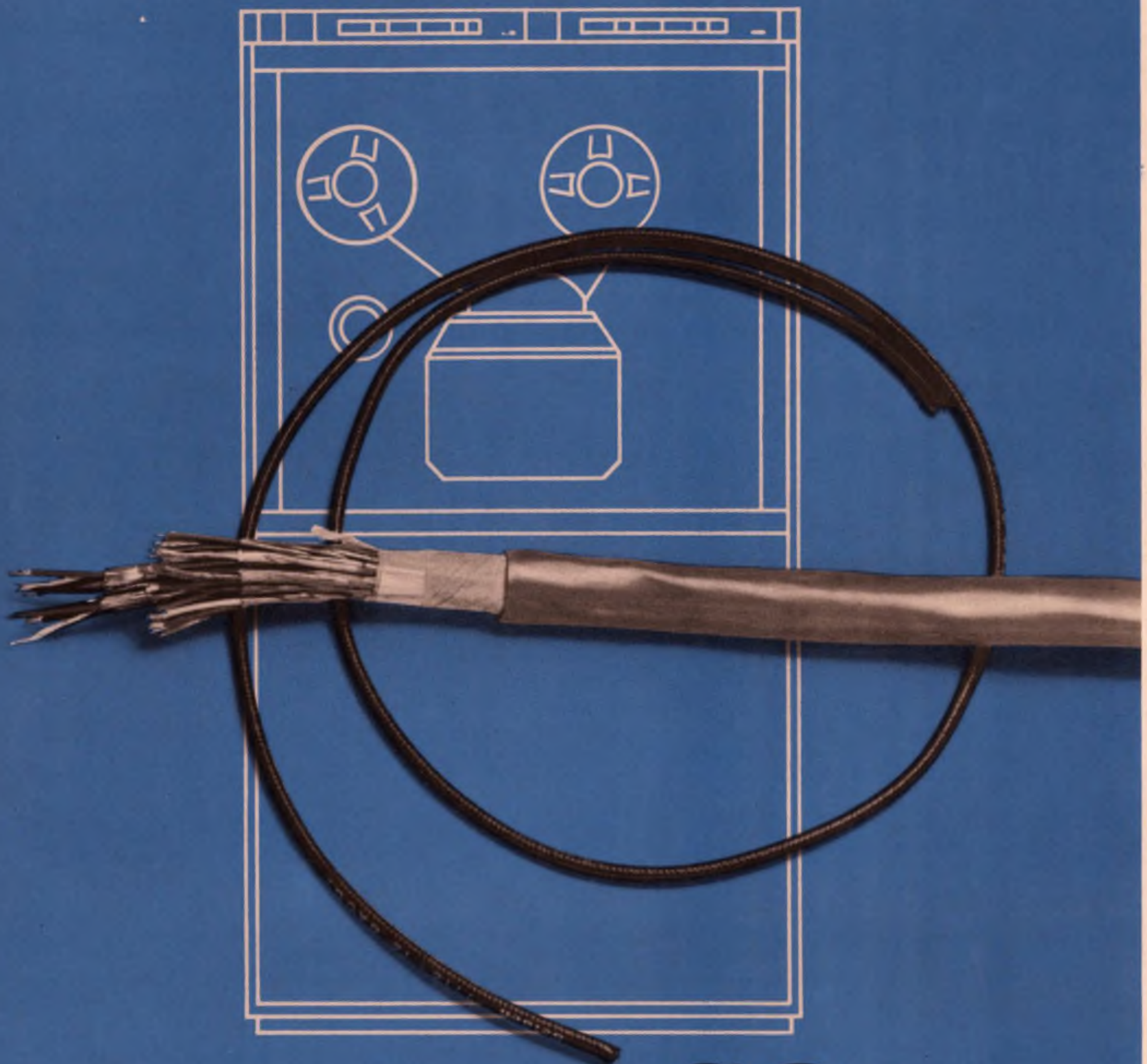


Reading machine spells out aloud to the blind at 80 words a minute

A research version of a machine that can read aloud to a blind person from an ordinary printed page has been implemented by three scientists at the Massachusetts Institute of Technology. They predict that, when perfected, the reading machine will give the blind access to almost everything in a library, including newspapers and periodicals, instead of only Braille and talking books.

The device discriminates individual characters and spells them out at an average speed of approximately 80 words a minute, according to D. E. Troxel, F. F. Lee and S. J Mason of MIT's Research Laboratory of Electronics. This rate is said to be comparable to that of Braille reading.

The system includes a document handler, a flying-spot opaque scanner, a special-purpose digital system known as a scanner controller, a data link to a medium-sized general-purpose digital computer, displays with which a sighted person can make adjustments of focus and threshold, and an audio system.

An oscilloscope, which has deflection voltages supplied by the scanner controller, serves as the light source for the opaque scanner. A dot of light from the cathode-ray tube is beamed onto the paper by a single lens, and the diffuse, reflected light is collected by two photomultiplier tubes. The beam is gated on and off when it is desired to interrogate the material. The absence of signal from the photomultiplier tubes indicates that a particular spot on the page, as specified by the oscilloscope deflection voltages, is blank.

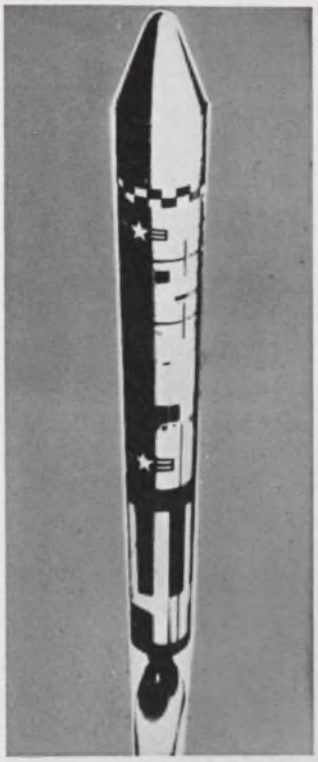
Once the machine has been initially adjusted, the blind person begins to "read." Under computer command the material is scanned, and the base and mid lines of a line of text are established as a reference for character discrimination. Next, the first letter of text is acquired, its contour is traced and a list of edgepoint coordinates is fed to the computer. Then the quadrants in which the character lies are mapped. Finally the computer, using both the height with respect to the mid and base lines and the horizontal extent of the contour, searches a code table, which is a summary of the machine's previous training.

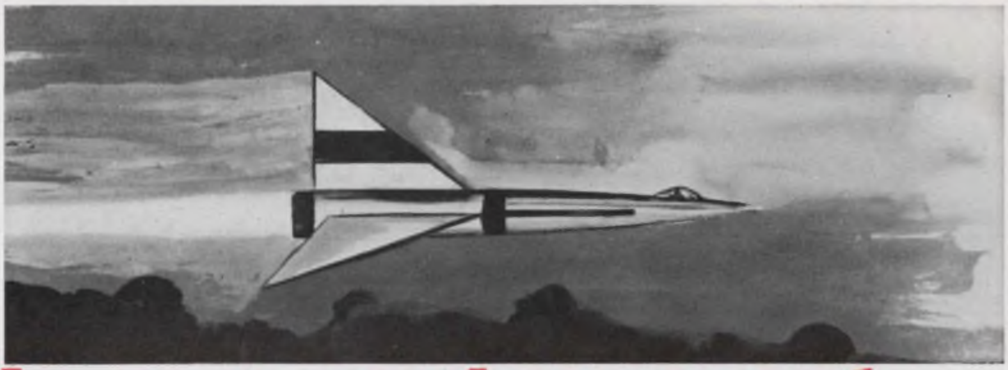
The immediate applications of the reading machine program, which was supported by the National Institutes of Health, Bethesda, Md., are:

- Development of character-recognition algorithms.
- Determination of methods to enable the blind person to make his own adjustments.
- Investigation of alternative output formats, such as Braille or synthesized speech.

Prof. Troxel says he and his colleagues are devising algorithms that will enable the machine to read more than one type font, and perhaps even typewritten material. In tests, the machine typically performs at better than 99.5% accuracy. It is an improvement on the PRM-1, an earlier MIT reading machine for the blind. ■ ■

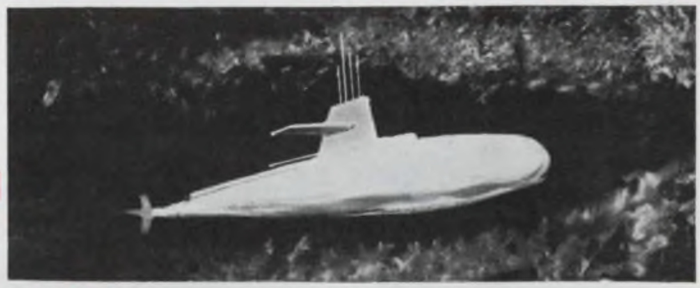
MIT reading machine for the blind has flying-spot scanner (left) that uses oscilloscope as light source. It reads type aloud, one letter at a time.





In any environment...

U.S.C.



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One of the reasons is the versatile U.S.C. standard and simulated closed-entry female contact that's designed for continuous reliability. Its unique flange assures positive re-entrancy of the male connector pin on each insertion because the wider countersink on its upper end aids connector pin alignment. And U.S.C. UMI and SMI four-slotted contact design minimizes any possibility of distortion, holds float between contact and molded body to .005 in. maximum in any direction, when mated.

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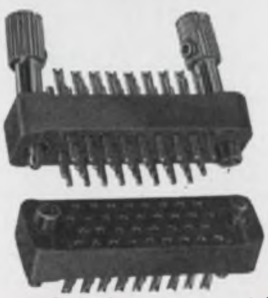
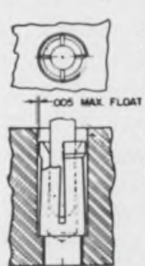
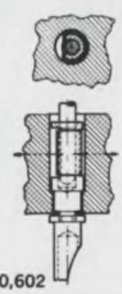
Actual Physical size UMI-34-(approx. ¾ that of SMI-34).



Actual Physical size SMI-34



cross-section 4-slotted flange controlled entry female contact
SMI
UMI



cross-section closed entry female contact
CSMI
CUMI

U.S. PAT. NOS. 2,761,108 & 3,030,602

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NO. OF CONTACTS	5, 7, 9, 11, 14, 20	5, 7, 11, 14, 20, 26
VERSIONS	26, 29, 34, 44, 50	29, 34, 42, 50, 75
CONTACT DIA.	.030	.040

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ON READER-SERVICE CARD CIRCLE 41

IBM® Circuit Design and Packaging Topics

☐ General Radio relies on IBM reed switches

☐ Suppression circuits extend reed switch life

☐ General Radio relies on IBM reed switches

General Radio Company, West Concord, Mass., maker of test instruments, demands the best for their customers knowing that they can't tolerate equipment failure that will interrupt inspection or production routines.

That's why IBM reed switches go into General Radio's instruments.

General Radio uses reed switches in test instruments because they offer lower contact resistance than transistors, are smaller and more reliable than conventional relays.

General Radio confirms through its own vendor-component evaluation program that IBM reed switches show zero failures after 25 million operations.

GR's Service Department claims they can't afford anything less since tests prove that the IBM switch "just keeps on going."

As a result, General Radio relies on IBM reeds in nine varieties of instruments, including the GR 1680-A Automatic Capacitance Measuring Assembly, the 1770 Scanner Systems and four different models of Coherent Decade Frequency Synthesizers.

☐ Suppression circuits extend reed switch life

The miniature dry reed switch possesses characteristics which make it applicable to an extremely wide range of low power switching applications.

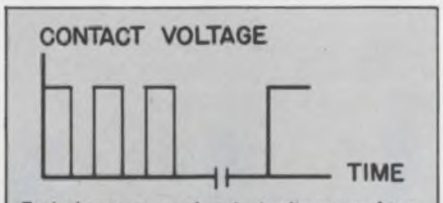
The reed offers rapid response, low actuate power, small size and a contaminant-free, adjustment-free contact arrangement. All of this provides the switching circuit designer with a highly adaptable device for modern, low-power, high density applications.

However, the construction of the miniature reed, with its small air gap and low-release spring force, makes it more susceptible to failure from contact degradation than any previous common contact switching device. Accordingly, special precautions must be taken when applying the miniature reed switch.

IBM conducts a continuing study to learn as much as possible about the reasons for contact degradation. Once we know why, we can take steps to prevent it—and, in some cases, prolong switch life by a factor of 10 or more.

What causes a reed switch to fail after 20-million cycles in one application yet continue to function after several hundred million cycles in another?

Failure in the reed switch can be caused by material transfer which occurs each time the contact makes or breaks current. This material transfer, plus any magnetic particles caused by wear, form a mound in the contact area. The mound eventually causes failure by increasing the contact resistance or bridging the air gap.



Typical unsuppressed contact voltage waveform.

Bridge transfer occurs whenever two current-carrying conductors start to separate. The cross section of the contact point becomes increasingly smaller, giv-

Letters

Bidirectional counter is completely synchronous

Sir:

Most of Kay Smith's comments on my letter challenging his bidirectional-counter design ["Bidirectional counter said to have serious drawback," ED 10, May 10, 1967, pp. 46-50] are correct.

However, concerning the main point I made, i.e., the possibility of changing counting direction in a reversible counter regardless of the level at the *Advance* input if a synchronous scheme is adopted, Smith states that "a synchronous design would not solve the problem, and the only solution is to change directions while the *Advance* input is low."

It is true, as Smith writes, that I did not give any details concerning the carry from one decade to the next. The purpose of this letter is to fill this gap and to show that a synchronous design does indeed solve the problem.

Consider the reversible counter circuit below. This is essentially the same circuit printed and described in ED 10, pp. 46 and 50. Only slight modifications have been incorporated to obtain an inhibit input (*I*) to the decade. When this input is made high *all* the *J* and *K* inputs of *all* flip-flops go high, so that the decade is inhibited.

Now the carry function is taken as:

$$carry = \overline{F\cdot Q_1\cdot Q_4 + R\cdot \overline{Q_1 Q_2\cdot Q_3\cdot Q_4}}.$$

This uses the opposite convention to that of Smith's original article ["IC bidirectional counters cost less," ED 2, Jan. 18, 1967, pp. 58-63], i.e., high = logic *1* and low = logic *0*.

In a complete reversible counter made of several decades, the carry from each decade must be connected to the inhibit input of the next. All decades, and hence all flip-flops, have a common *Advance* input, so that the counter is completely synchronous.

Clearly, with this scheme, changing the counting direction does not affect any of the flip-flops, whatever the level at the *Advance* input.

Thinking about it, I should have been smarter: had I submitted the above solution as an "Idea for Design," I might have gotten twenty bucks out of it . . . .

S. Iannazzo
Applications Dept.
S.G.S. Fairchild
Milan, Italy

(ELECTRONIC DESIGN *is pleased to send Mr. S. Iannazzo a check for $20.00 for what indeed would have been a fine Idea for Design.*—Ed.)

The last word . . .

Sir:

It looks like Iannazzo has finally come up with a decent design, five months after my original design was published ["IC bidirectional counters cost less," ED 2, Jan. 18, 1967, pp. 58-63]. Iannazzo's second design is indeed synchronous. Of course, the price paid for a synchronous design is increased cost, since more logic is required compared with my original design.

I would also like to note that Iannazzo apparently has inadvertently omitted to synthesize the carry function. Also, his carry function should be:

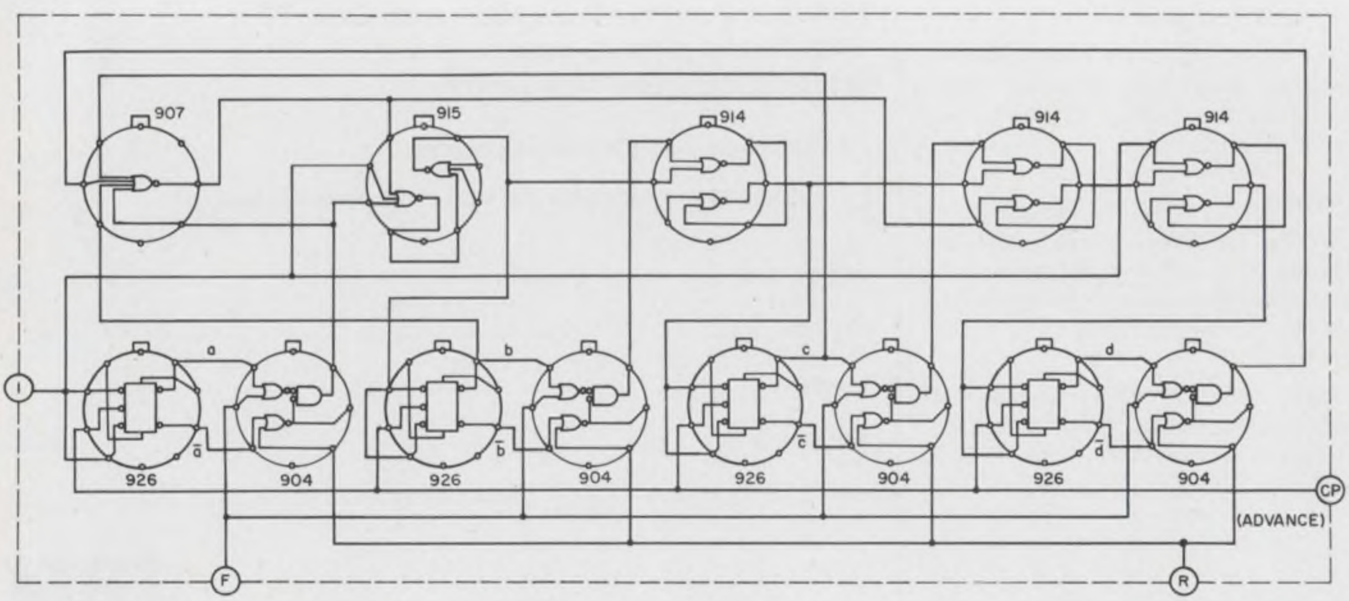
$$carry = \overline{F\cdot a\cdot d + R\cdot \overline{a\cdot b\cdot c\cdot d}},$$

instead of:

$$carry = \overline{F\cdot Q_1\cdot Q_4 + R\cdot \overline{Q_1\cdot Q_2\cdot Q_3\cdot Q_4}}.$$

Kay D. Smith
Sr. Design Engineer
General Instrument Corp.
Salt Lake City, Utah

(Letters continued on p. 70)



FOWARD: F HIGH; R LOW
BACKWARD: F LOW; R HIGH

Synchronous 1-2-4-8 decimal counter changes counting direction accurately regardless of Advance input level.

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And if you wanted to count wire sizes, or figure the twisted pairs our sub-min coax can accommodate, or leave some contact holes open, the possibilities would truly be endless. Probably most of them haven't been used yet. Surely some of them will solve your problems.

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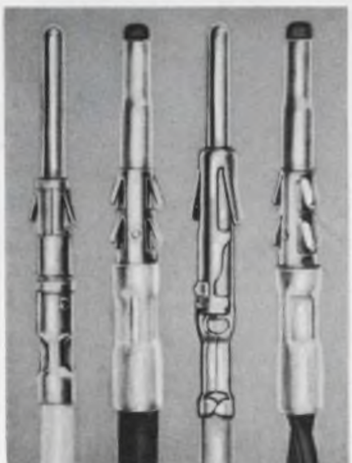
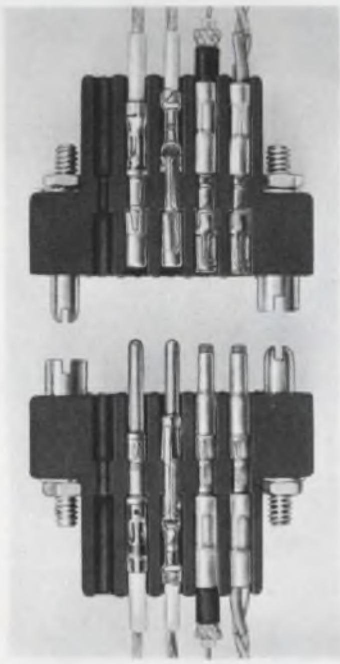


Machined Sub-min Coax Strip Hyfen Twisted Pair



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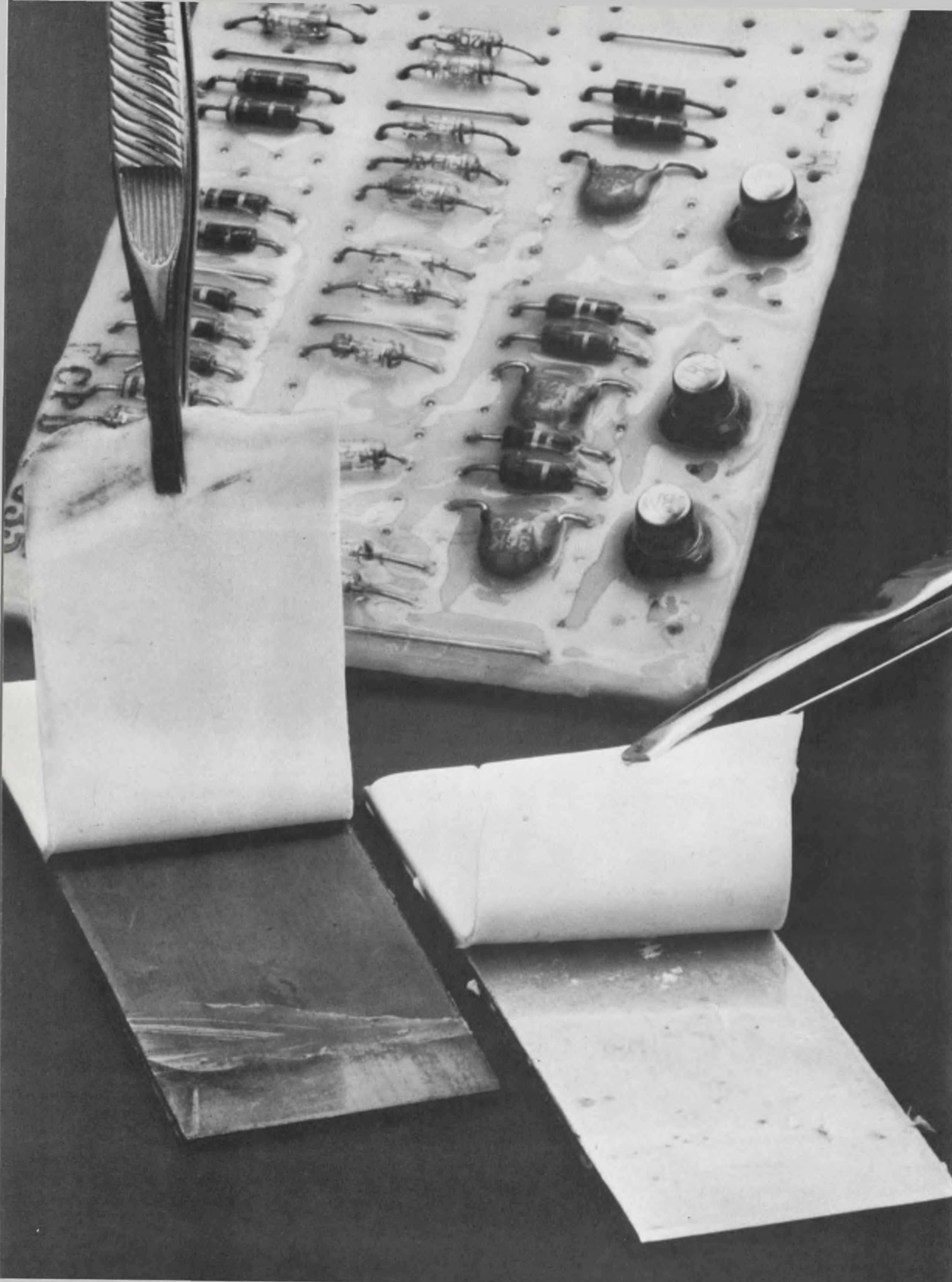

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We're a materials producer exclusively. Let us tailor a material to your need.

(continued from p. 66)

How about publishing technical 'classics'?

Sir:

I read your editorial "It isn't the retrieval, it's what you retrieve" [ED 14, July 5, 1967, p. 59] with much interest, particularly because it hits very close to one of my pet peeves. How many times does the engineer reach into his file for information on a particular subject and come out with not one, but a half dozen articles on the subject, none of which is comprehensive in itself? The engineer must search out a little information from each of them for a complete picture.

I would like to invite ELECTRONIC DESIGN to sponsor a new series of articles, "classics" if you wish, on the subject they treat. Let each article be compiled from all known information about a particular subject and updated when the need arises to include information gathered from comments from readers. By "updated when the need arises," I don't mean simply publishing an addendum or "Accuracy is our policy" type of thing. I mean republishing the entire article, so that the engineer can throw everything else he has on the subject away, confident that the article is the best in existence on the subject.

The subject treated need not be revolutionary to be useful—just having all the information on a subject published in a handy form is sufficient reason for publication and would be a welcome aid in information retrieval. As an example, consider the article published in the November, 1964, issue of *EEE* by Mr. Geffe on the subject of resistive attenuators. This is one of the few articles in recent years that I consider a classic in its field. I do not know of anything of usefulness to add to Mr. Geffe's article. When I need a resistive attenuator, this is my sole source of reference. Unfortunately, it is one of the few subjects on which I am able to use a single reference.

Trade journals have advantages undreamed of by the textbook writer in publishing this type of information. Foremost among these is

(continued on p. 74)

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EiD's Function Generator makes any wave you want a permanent wave.

As a general-purpose signal source, it's designed to make quite a splash: you get sinusoidal, square and triangular waveforms – simultaneously. Frequency is continuously variable from 0.005 Hz to 1 MHz in eight ranges. And you get dc offset controls.

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And finally: the price won't curl your hair. Comb your local EiD Sales Representative for all the facts ... or write direct to our nearest regional office, listed at right.

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ON READER-SERVICE CARD CIRCLE 46

DYNAMIC DUO!

X-2: *Holy Accuracy, X-1, how do you do it? . . .*

X-1: Fear not, *X-2*, if you don't become a college dropout, you too, can achieve .005% *Accuracy.*

X-2: *You were designed to compete with those $4,000 voltmeters, but I've got IC's.*

X-1: When I was in school, *X-2*, those IC's were costly and unavailable; however, with all your IC's, you can't give 23 millisecond readings!

X-2: *Well, X-1, I haven't had my logic courses yet. Can you integrate?*

X-1: I don't need to integrate, *X-2*, because I have an Active Filter that saves customers (who think they need a 5-digit integrator) $1,700.

X-2: *You got me there, X-1, but if the customers don't need your .005% accuracy and high speed for $2,450, they can buy me for $980, and I'm half rack size too!*

X-1: Naturally, you're half rack size because you don't have Scan Counter, Range Memory, Range Hysteresis, Range and Polarity memory logic, and my Exclusive Threshold control.

X-2: *Holy features, X-1! Those other DVM's* must be *overpriced!*

X-1: We must not cast moral judgments on the integrity of our competition, *X-2.*

X-2: *You're such a good teacher, X-1 . . .*

X-1: Remember, *X-2*, that together, that is, you at $980, and me at $2,450, can conquer 80% of the requirements in DVM city.

X-2: *What do you think that joker is up to?*

X-1: It looks like he's trying to be a VTVM.

X-1 *Check 237 Reader Service Card*

X-2 *Check 238 Reader Service Card*

NLS

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The Joker Replaces all (VTVM's)

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DC Volts:
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10 Microvolts resolution

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It's No Joke . . .

LOOK AT THESE EXTRA TRICKS

100% Over-range Digit
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Automatic Polarity
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Check 239 Reader Service Card

Yes, the Joker wins out. All these tricks for $695 (including probes)...but wait, there's many more especially the one behind that ?.

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LETTERS

(continued from p. 70)

thousands of critics to supply information for updating future editions of the article. In most cases, an article would have to "grow" from the contributions of the readers before it would truly become a classic in its field. It would even be desirable to publish a preliminary draft of the article for comments from the readers before final publication.

The responsibility for information retrieval belongs not only to the Federal Government, but also to readers, authors, *and publishers.* Will ELECTRONIC DESIGN do its part?

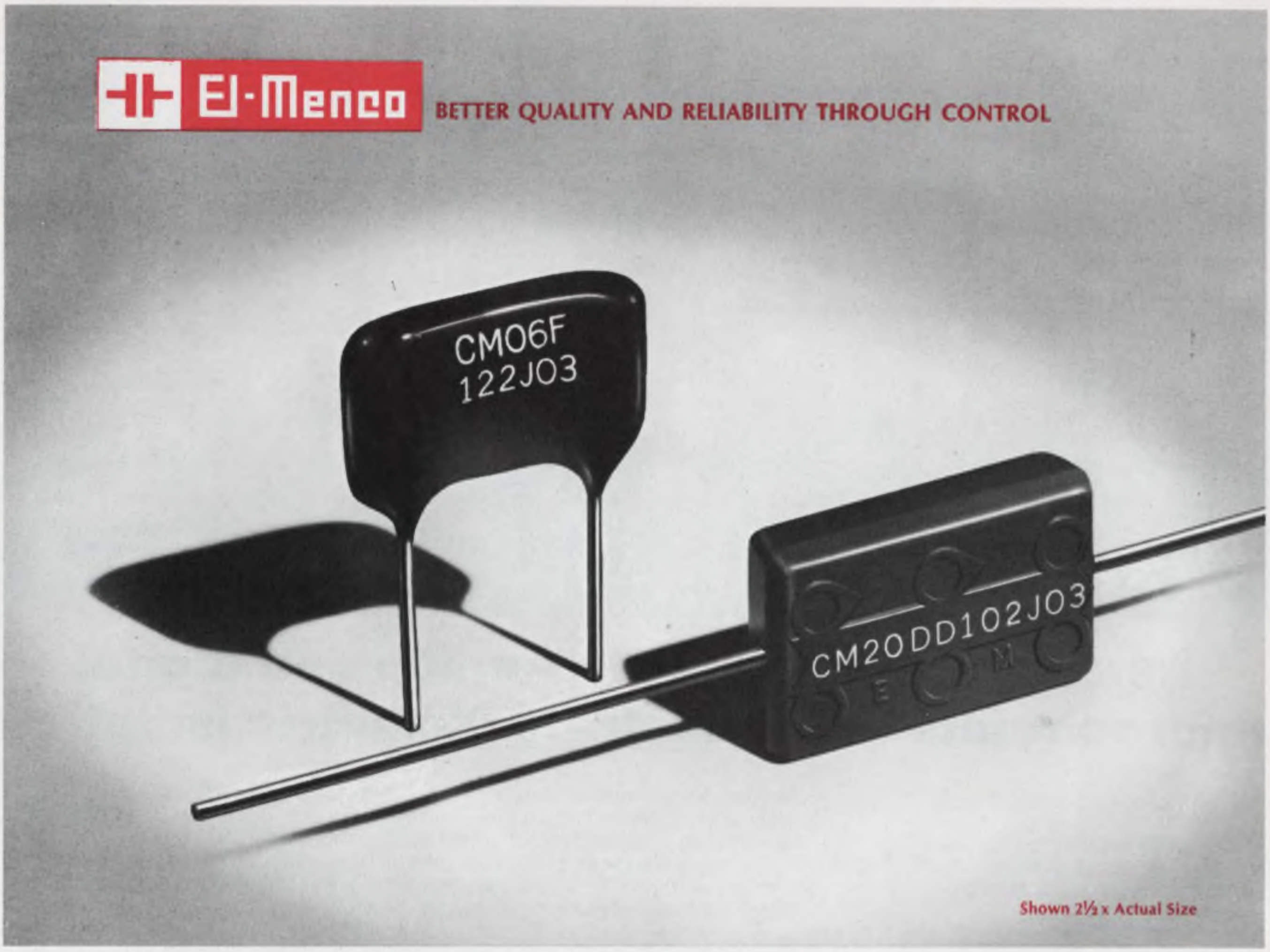
Vernon R. Cunningham
Design Engineer
Collins Radio Co.
Dallas

(Editor's Note: The sort of "classics" called for here would be nice to have, whether in trade-magazine or textbook format. Unfortunately there are few subjects narrow enough for such an approach to be feasible in a brief magazine article. We have published such articles, or series of articles, in ELECTRONIC DESIGN *when the subject was appropriate. But many subjects require so much detailed discussion that books must serve as references. Nevertheless, we take our responsibility for clarity and completeness very seriously, and appreciate hearing from readers when we fall short.)*

Accuracy is our policy

In "Make a filter out of an oscillator," ED 10, May 10, 1967, pp. 56-58, in the first paragraph after the first subhead, on p. 56, the sentence, "The transfer functions must have poles only on the negative real axis of the *s* plane," should be deleted.

In "Pulse oscillator puts out 35 kW," in the Microwaves listing of the Products section of ED 12, June 7, 1967, Applied Microwave Lab., Inc., points out that its device has an input power of −8.5 (not −85, as printed) kV at 9 A (peak).



Capacitor Problems That Require A Lot Of Self-Control...Chemically Speaking

Problem 1: How to make sure the silver paste composition used for electrodes provides the best results for each electrical parameter in a given capacitor design?

Problem 2: How to improve the recognized moisture reliability of our dipped mica capacitors without adversely affecting life reliability?

Problem 3: How to upgrade the reliability of molded mica capacitors to equal that of dipped mica capacitors so designers can take advantage of body uniformity and axial lead design?

Solution: Chemical self-control! To do this we operate our own chemical manufacturing plant where we formulate silver pastes, phenolic dipping compounds, and epoxy molding compounds — all under strict controls.

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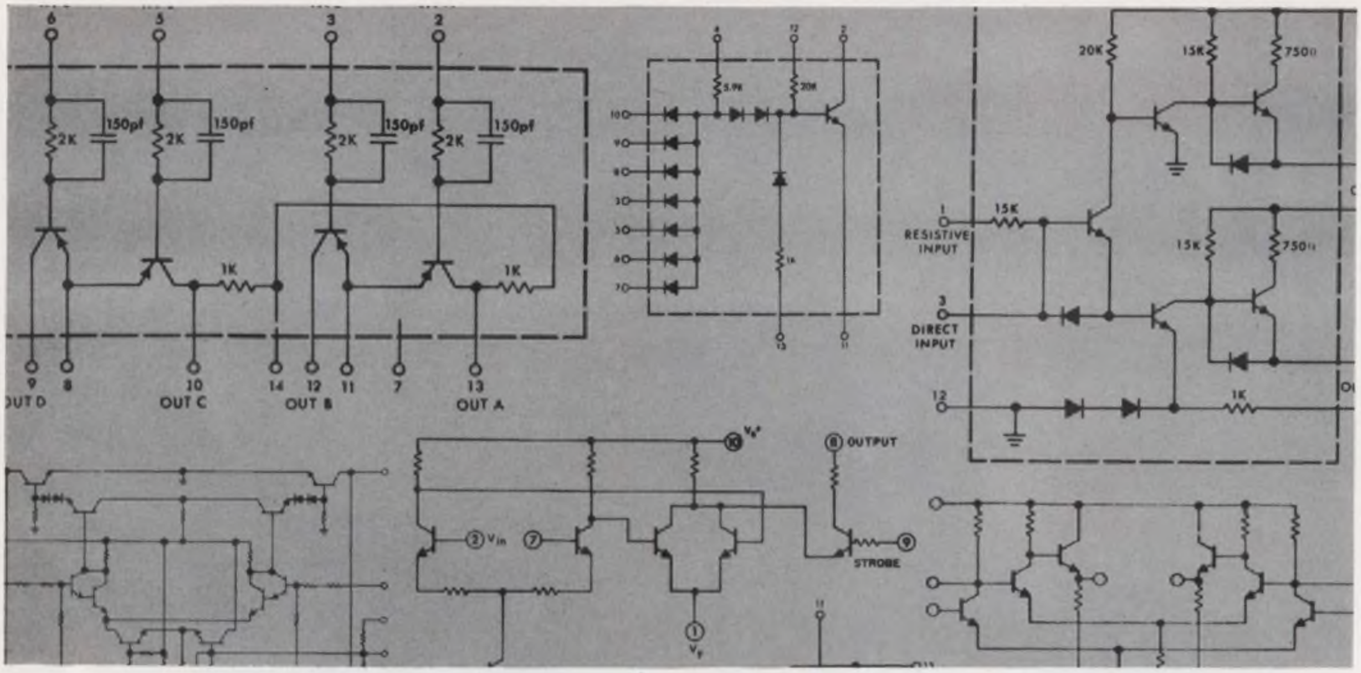
ON READER-SERVICE CARD CIRCLE 50



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NM 1032 General purpose amplifier
NM 1038 Driver switch
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NM 4014 Dual 4-input clocked DTL NAND/NOR gate
NM 4015 Dual 4-input DTL NAND/NOR gate
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NM 4017 7-input clock DTL NAND/NOR gate
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Norden announces off-the-shelf availability of high-performance, dielectrically isolated analog and digital microcircuits produced to Minuteman specifications, guaranteeing you highest quality and reliability.

Norden's *Glastrate* process of dielectric isolation reduces leakage current and capacitance to substrate, prevents unwanted PNP action, eliminates "latching," and improves radiation resistance.

If you have special circuit design problems, use Norden's NM 3025 Master Dice Breadboard. Circuit interconnections can be made to your requirements, and your new circuit can be tested in a matter of days.

For more information about Norden's off-the-shelf circuits, or custom circuit service, write to Microcircuits Department, Norden Division of United Aircraft Corporation, Norwalk, Conn. 06856, Phone (203) 838-4471, TWX NWLK 21.

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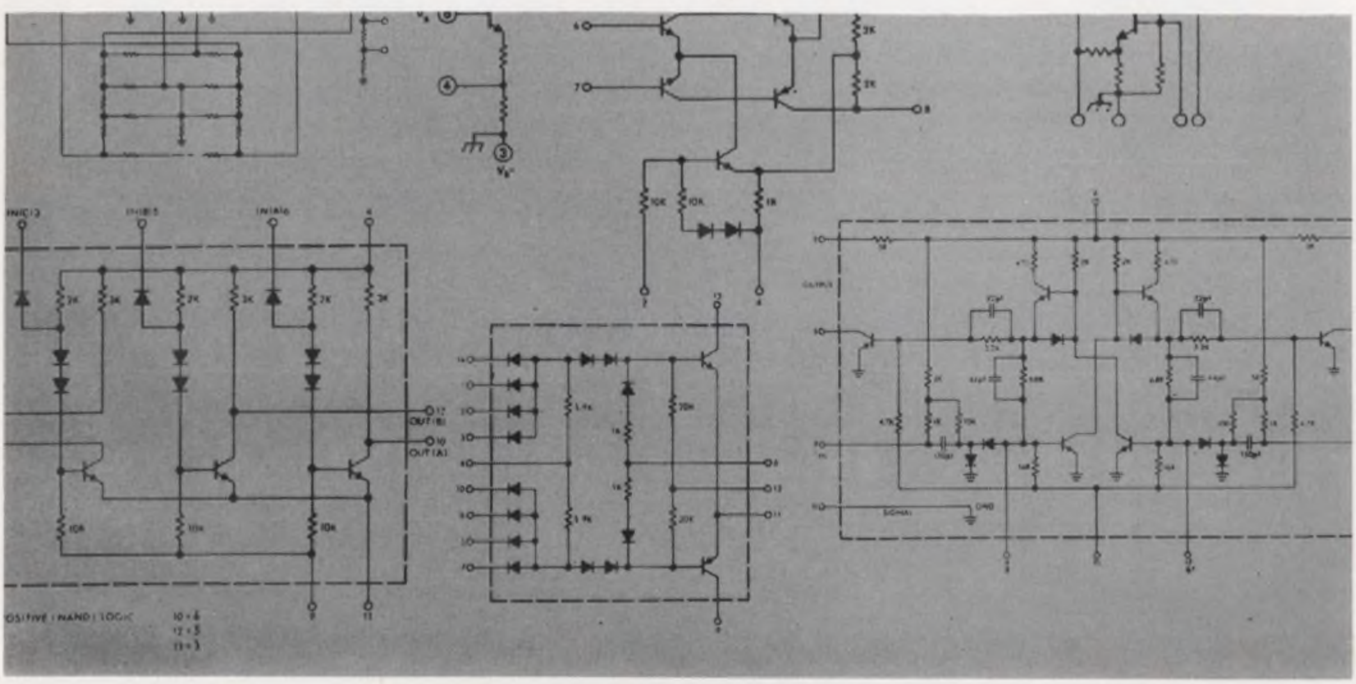

ON READER-SERVICE CARD CIRCLE 51

New Model 3111 Relay by Bourns

{ SMALL IN SIZE }

BIG IN SPECS

The Bourns Model 3111 TRIMPOT® Relay is a high performance, 0.5 amp, Double Pole Double Throw unit that answers the demand for higher reliability and greater miniaturization. It is hermetically sealed in a 1/6 size crystal can, with convenient 0.1" pin spacing.

The Model 3111 has an operating temperature range of −65°C to +125°C. Contact rating is 0.5 ampere resistive at 28 VDC, with a pick-up sensitivity of 130 MW. Operate and release time is 4 milliseconds maximum. Contact bounce is 2 milliseconds maximum. This model also features a self-damping return sring and balanced armature design assuring excellent shock (50G) and vibration (20G) performance. All requirements of MIL-R-5757 are met or exceeded by the Model 3111.

For further data and detailed specifications, contact your nearest Bourns sales office or representative, or write the factory direct.

Coil Operating Table

Standard Coil Resistance	VOLTAGE ADJUSTED Nominal Operating Voltage	Maximum Pull-In Voltage at +25°C	Maximum Pull-In Voltage at +125°C	Drop-out Voltage Min.
70	6.0	3.0	3.9	0.3
280	12.0	6.0	7.8	0.6
1500	26.5	14.0	18.0	1.4

Coil characteristics applicable at +25°C unless otherwise specified.

Various terminal types and mounting styles are available adding flexibility to fulfill your design requirements.

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EDITORIAL

Let's raise our voices against noise pollution

Did you ever hear a swallow burp?

Probably not.

You know why?

Because your neighborhood and your plant are gradually becoming polluted by noise. And noise pollution can be a problem if you have ears.

Noise pollution is what fills your ears when you open a window. It is the din of traffic, the chatter of a jackhammer, the blaring squawk of a neighbor's radio. It assaults us in every part of the audio spectrum: the rumble of a punch press, the painful bang of a riveting machine, a pressure nozzle's hiss.

Noise is not just annoying. Continued exposure to noise permanently impairs hearing. And an employer who fails to protect workers from hazardous noise environments can expect to pay workman's compensation for damages. Noise, just like uncaged gears, is now a hazard in the eyes of the law.

What can the designer do about noise pollution, you ask?

Four things:

- Learn about acoustics. The interaction between sound and the human ear is a complicated physiological and psychological matter. The editors of ELECTRONIC DESIGN suggest that you start with two books, *Acoustical Engineering* (Princeton, N. J.: D. Van Nostrand Co., 1957,) and *Music, Physics and Engineering* (New York: Dover Publication, 1967), both by the dean of acoustics, RCA's Harry F. Olson. A marvelous sound film on noise pollution is available free of charge from Wallace Waterfall, Secretary, Acoustical Materials Association, 335 East 45 Street, New York, N. Y. 10017. A booklet, *Acoustics and You*, which outlines career opportunities in acoustical engineering, is available from the same association.
- Include in your design of industrial equipment those shapes and materials that control and damp the most offensive portions of the audio spectrum. Use audible signaling devices only where there is no alternative. Design with your ears as well as your slide rule.
- Specify and purchase quiet production equipment. Don't look only at the specifications and the finish when you buy a machine—listen to it.
- Help the city nearest you control its noise pollution. ELECTRONIC DESIGN stands ready to assist and to report the efforts of any firm that will underwrite a project that aims to accomplish this goal.

There is no question that it will take effort and money to control noise pollution. But you'll sleep a lot sounder if the people whose lives are affected by your designs can hear their alarm clocks tick.

ROGER KENNETH FIELD

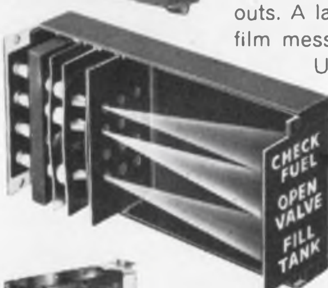
Reader's Choice

IEE bright, legible, wide-angle readouts:

Any characters desired
Any colors or combinations
Any input, BCD or decimal
Any input signal level
Any mounting, vertical or horizontal

Many sizes
Many configurations
Many lamp lives (to 100,000 hours)
Many brightness choices
Many options and accessories

Standard Readouts: Rear projection principle, like all IEE readouts. A lamp in the rear of the unit illuminates one of the 12 film messages, and projects it to the front viewing screen. Unbeatable readability and versatility.

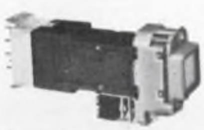


Large Screen Readouts: For reading distances up to 100 feet. Maximum character size $3\frac{3}{8}$".

Miniature Readouts: Only 1" wide x 1-5/16" high, yet can be read at 30 feet because of clarity of one-plane projection. Character size: $\frac{5}{8}$".

Micro-Miniature Readouts: Only $\frac{1}{2}$" wide x $\frac{3}{4}$" high, but 20 foot viewing distance and maximum 175° viewing angle because of front-plane display. Character size: $\frac{3}{8}$".

Hi-Brite Readouts: Special lens system increases character brightness 50%. Particularly good when high ambient light conditions exist.



Cue-Switch Readouts: Rear projection readout with push-button viewing screen. Combination switch and display device.

Bina-View Readout: Accepts binary or teletype code, decodes, and displays the proper character.

Status Indicator Readout: Displays up to 12 different messages, individually or in combination. Viewing screen only 3 sq. in.

Indicator Assemblies: Available with up to 11 rear projection readouts, for indicating seconds, minutes, hours, days, etc.

Driver/Decoder Module: Designed to work with IEE Readouts. Accepts a variety of binary codes for decimal conversion.

The new IEE Display Devices catalog gives complete information and specifications on these products, and their accessories. Ask for it.

IEE

"I-double-E", the world's largest manufacturer of rear projection readouts.
Industrial Electronic Engineers, Inc. 7720 Lemona Avenue, Van Nuys, California

ON READER-SERVICE CARD CIRCLE 54

WESCON USA

Whether you're a showgoer or a 'no show,' check this compact preview of the highlights

HURRY, HURRY...

It's called "Eight Shows in One." It runs from Aug. 22 through 25, and it features performances by more than 600 companies in 1100 booths.

WESCON, 1967, is open.

The Cow Palace at San Francisco has been transformed into a dazzling electronic spectacle that is expected to draw 40,000 engineers and managers.

Along the colorful aisles, products are grouped in eight broad categories. These are the eight shows of WESCON.

WESCON IS STARTING

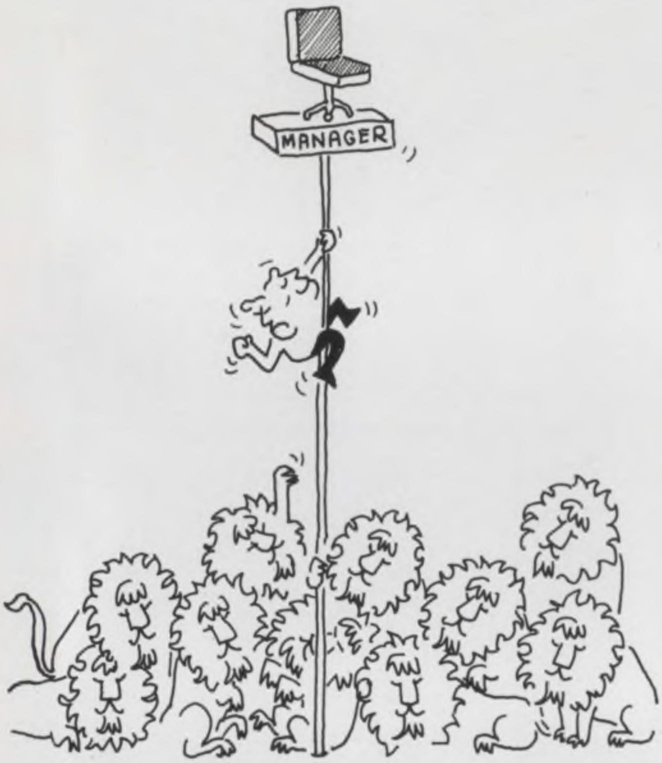
And there's more in the wings. Technical sessions are planned on 20 subjects. In addition, the Eighth International Electronic Circuit Packaging Symposium opens Aug. 21 in the San Francisco Hilton. And a major symposium on microelectronic developments, "Microelectronics Comes of Age," starts Aug. 23 in the same hotel.

Join ELECTRONIC DESIGN's guided tour of the significant at this year's WESCON. Begin here:

Design trends in the major engineering disciplines, as reflected in new products on display and technical papers

SUDDENLY, YOU'RE A MANAGER

And for the many engineers who find themselves unprepared, WESCON considers some remedies



Manage or Perish: Many engineers must make the choice of moving into management or reaching the dead end!

Meet the Financial Department: Many engineers move into management with little or no financial training. Personnel in the two departments should get to know each other.

Howard S. Ravis,
Careers & Management Editor

More and more engineers are moving into management positions, with little or no management training.

"It is a situation the engineering field has known for a long time," notes a WESCON official, "but no one wanted to talk about it. The industry is finally recognizing the fact that the technical man can no longer stay completely technical."

Engineering colleges have been partly to blame: they have trained future engineers to be engineers only. Several years after graduation from such schools, many have found themselves suddenly at a turning point in their careers. Like the professor in college who is commanded to "publish or perish," engineers in many instances face this prospect: "Manage or perish!"

Often with little or no preparation, the engineer must ask himself and must answer quickly: Am I qualified and will I be happy as a manager? Will I find myself spending most, if not all, of my time as an administrator instead of as a creative engineer? What will happen to me if I refuse the management position? Will the company let me go? Will I become professionally stagnant?

Recognizing the need for more engineering management discussion in the industry, WESCON this year is incorporating for the first time a section on the nontechnical side of engineering management. WESCON officials expect the subject to take on increased emphasis in future conventions.

"Business Management: The Engineer Becomes Manager" is the title of this year's session, designed to help both the engineer in management and the one who may make the move.

Managing people

"Once the engineer becomes a manager, he is part of the team which must manage the company resources in a manner that will ensure survival of the business," notes one of the WESCON panelists, James F. Riley, president of Signetics Corp., Sunnyvale, Calif. He lists "technology, capital and people" as the three main company resources.

"There is more than enough emphasis on the technical and capital resources," Riley contends, "but less than adequate emphasis on people resources. More than anything else, the success of a manager depends on the functioning of his people and the direction and retention of them."

Riley is convinced that on-the-job training is best for developing managerial talent. "The home environment is the best training ground," he says. "The company can train the manager in the same environment in which he will manage. Thus top management sees him actually working with the people he also will work with in the future."

If the manager or potential manager attends an outside management session, Riley argues, he is dealing with people he has never seen before and probably will never see again: "Thus, how he works with and supervises these people is of limited value when he returns to his home plant."

Managing money

As the engineer becomes a manager, he becomes more directly involved in capital matters. He now is responsible for a budget; the costs of the project must be watched.

Another panelist, Daniel G. White, president of the Commonwealth National Bank of San Francisco, lists the "pitfalls in money management":

- Ideas alone have little real value. They will assume value only when the idea is translated into a product or service that fulfills a need.
- Avoid overoptimism. Confidence alone does not sell the product. Beware of the unexpected. Expect the worst—it may happen. Plan at the outset for a second line of defense.
- Bankers look at cost projections rather than sales projections. There is often a tendency to let costs get out of hand. Keeping them down will influence the later economic life of the product.
- Engineers must be motivated to the concept of making money. Too often the engineer is aloof to this aspect of the business. Idea must be translated into dollars and cents.

White admits there is no sure-fire way for an engineer to gain this economic education.

"A good way to start, however," he says, "is for closer correlation between the engineering and financial people of a company. Too often they are in different worlds within a firm. They're on different floors and never see each other, except perhaps for a chance meeting at a coffee break. The departments should know each other."

Managing technology

A third panelist, Charles H. Keller, president of Illumination Industries, Inc., of Sunnyvale, Calif., says that company management must ask itself: "Why does the company exist?"

He continues: "A company cannot have technical superiority as a goal. This sounds very nice, but it is unreal, if not impossible. The electronics field is too vast for one company to achieve complete technical superiority, and the company management must realize this."

The answer, according to Keller, is that the company exists "to satisfy the demands that others make of it." He cites these six groups that make demands on a company: customers, employees, owners, suppliers, the Federal Government and the local community.

"A successful enterprise must utilize its demand-meeting capabilities to meet these demands in the stated order," Keller says. "When the demand-meeting resources are consistently misapplied, the enterprise will either fail or be set back until the proper order is established by pressure from the displaced group or recognition by management of the error of its ways."

Once the company knows the demands, it can manage its technology to meet these demands. "It is equally as dangerous to overestimate as to underestimate these demands," Keller adds.

Managing a turnaround

All three of the company's resources—people, money and technology—are put to the test when a company is forced into a major turnaround.

"The entire technological function of the company needs a change," notes Martin H. Dubilier, executive vice president of Friden, Inc., of San Leandro, Calif., who is also a panelist.

"Perhaps the most important thing a manager can do during this transition," says Dubilier, "is to keep the engineer completely informed when making the change. The management of most companies is reluctant to inform its engineers, fearing it will give away secrets, which the engineers in turn will give away.

"Management cannot afford to be reluctant, however. It is of greater significance to the company that their engineers be made part of the change so that they can conform or adapt to the new process."

Management must expect morale to drop during a changeover, Dubilier condedes. But he adds:

"By keeping your engineers informed, the drop can be lessened. And, finally, and perhaps more importantly, the engineer can be of great help to management—first, in recognizing the need for change and then in helping to achieve this change successfully."

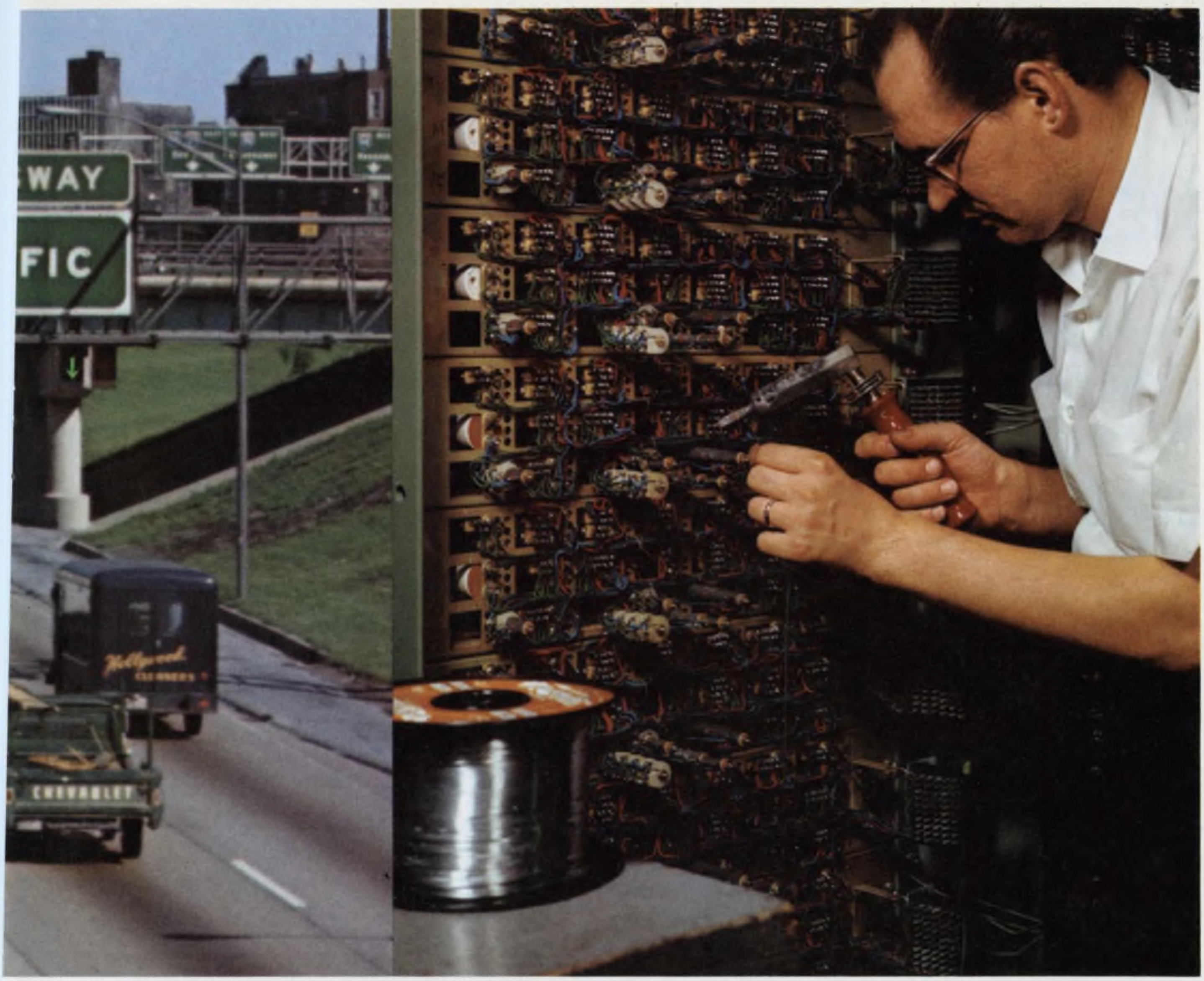
Donald C. Hoefler, columnist for *Electronic News*, is the panel chairman of the WESCON session. ■ ■

The Kind of Knowledge that makes traffic control possible...

Every year more cars join the traffic scramble. As congestion thickens, bottlenecks occur more often. And traffic flow screeches to a halt.

How can we help keep the nation's expressway traffic moving from coast to coast? One way is with remote traffic control systems, like the one pictured above on the Kennedy Expressway in Chicago.

This system reverses lane directions as changes occur in traffic density during morning and evening rush hours. Through a system of gates, signal arrows and directional lights, an express lane can be changed from inbound to outbound—and vice versa. To date, this unique system is doing a great job helping keep Chicago traffic moving.


WAY
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THE TECHNICAL SIDE OF WESCON

Here is a summary of the significant papers and trends evident at the show, arranged by engineering specialty

Circuit designer

FETs and plastic devices are finding wide use

Field-effect transistors, still relative newcomers to design, are now more practical than ever. This is evidenced by the fact that a complete session at WESCON (No. 8) is devoted to the design of rf circuits using FETs. Each paper presents practical design procedures and considerations, readily usable by a design engineer.

Of particular importance is the paper entitled "High-Frequency Power FETs," by J. B. Compton of Siliconix, Inc. He shows how the high input impedance and lack of secondary breakdown characteristic in FETs are used in the design of rf power amplifiers to get outputs of 0.5 watt.

A year or so ago one criterion for good circuit design was considered to be the number of active (transistor) devices used—the fewer the better. The major reason for this goal was the high cost of active devices.

This approach now appears to be obsolete. Plastic devices are rapidly coming down in price to the point where some compare favorably with the price of a resistor. Even such "sophisticated" devices as 400-MHz, 10-dB FETs can be bought for 95 cents. A unijunction transistor costs only about 65 cents. Silicon small-signal transistors sell for a dime or less.

Today the circuit designer need not worry about adding a transistor or two. He can achieve better reliability by increasing the number of active devices in the circuit, thereby avoiding the need to work a minimum of transistors at their highest limits. In fact, it is possible today for the designer to keep an assortment of his "pet" transistors in boxes (just as he would his resistors) above the laboratory bench.

With the prices of plastic devices so low, the obvious question is will they make a reliable package? Two researchers from the Army Electronics Command at Fort Monmouth, N. J.—Edward B. Hakim and Roland Canepa—ask and partly answer this question in their paper, "A Preliminary Investigation of Plastic-Encapsulated Transistors," to be delivered at the Eighth International Electronic-Circuit Packaging Symposium. The paper presents a summary of various tests carried out on seven types of plastic-encapsulated transistors.

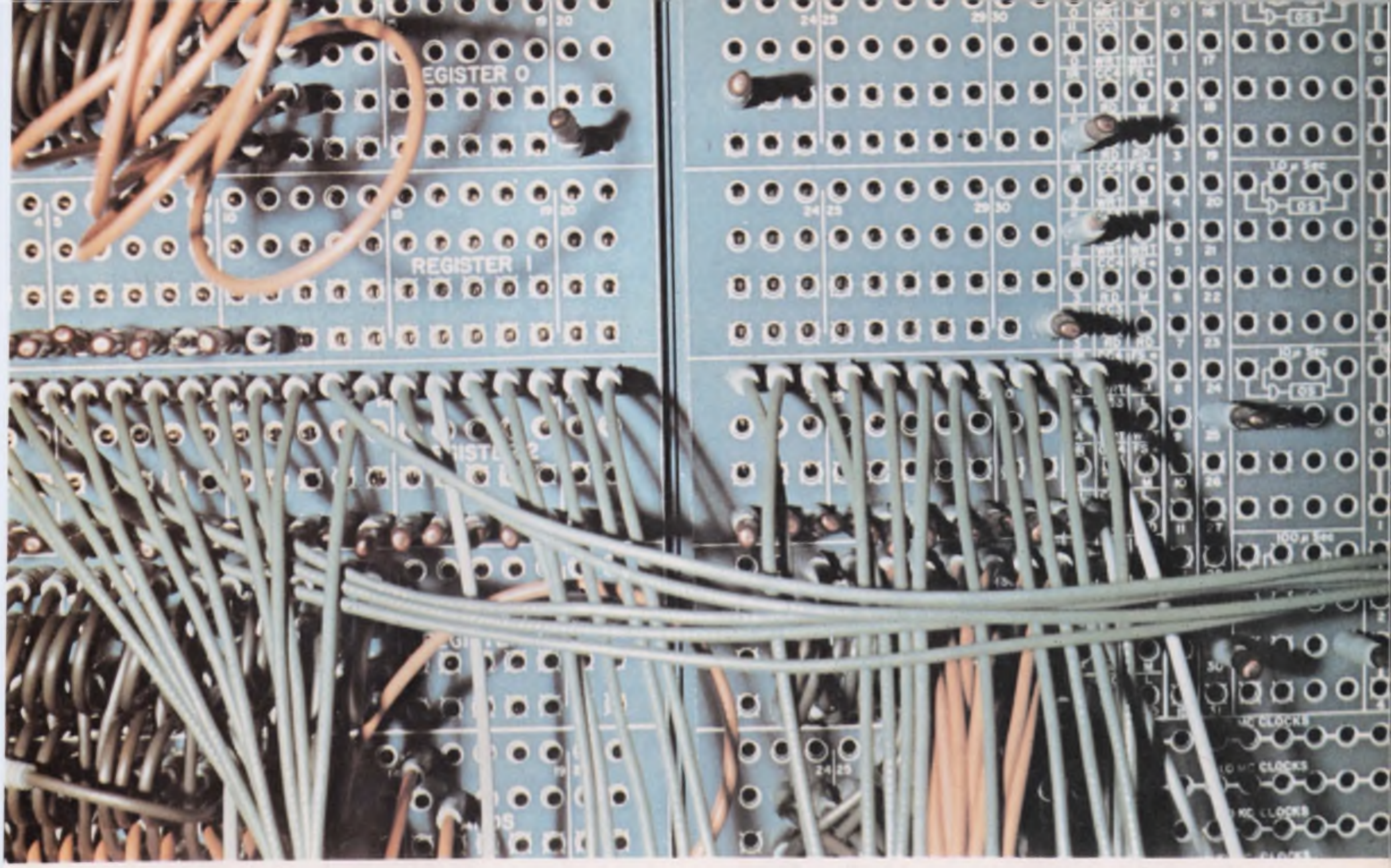
Several important conclusions have been reached by the authors as the result of their evaluation project. It was found that plastic devices pass present short-term military tests. The question of long-term effects, however—and whether plastics will introduce increasing failure rates, compared with metal packages—was not explored.

Two tests were found particularly helpful. One was a high-humidity and- temperature test, with an applied electric field across the device. In relatively short periods of time (less than four weeks) significant deterioration was observed in the plastic devices.

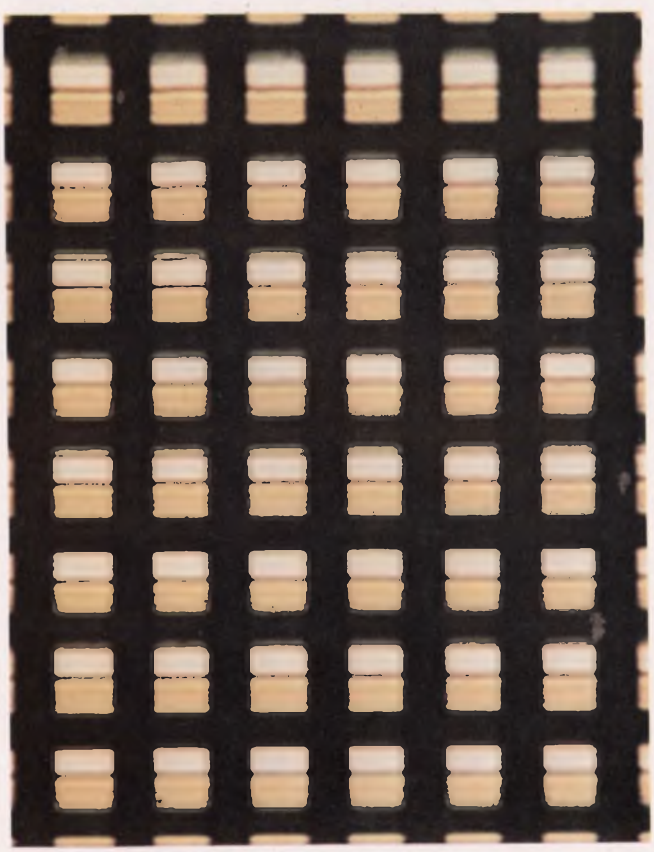
Another test, checking ionic contaminants, was the standard inversion layer test used on most pnp metal-encapsulated devices. It included high-temperature storage (150°–200°C) and 50 to 75 per cent of rated BV_{CBO} or BV_{CEO} of the transistor. The parameter measurements were made after the devices had cooled to room temperature and the voltage was removed. Again, deterioration was observed in the plastic devices.

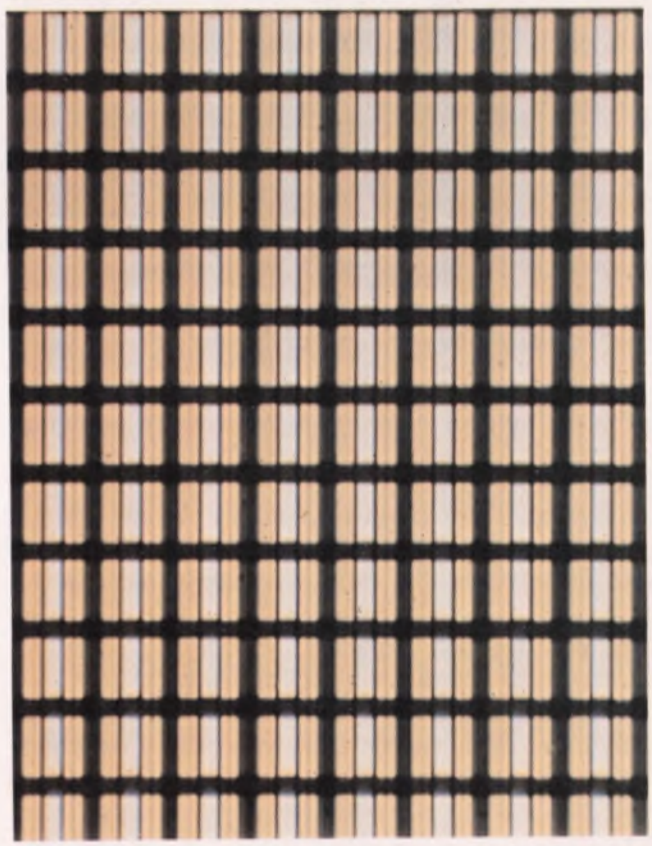
Specifically, the following tests were performed:

- Temperature storage: +200° C.
- Temperature cycling (1/2 h at each temp.): −48°C to +200°C.
- −40°C and power cycle (1.5 min on, 30 min



General-purpose interface, looking like a telephone switchboard, enables experimenters at Michigan University to transfer digital or analog signals to and from a nuclear-physics laboratory and a computer. (Paper 16/2).





Photoconductor array at left contains 32,400 elements (180 by 180) and is part of a self-scanned image sensor for an experimental, tubeless TV camera. A 360-by-360-element array is shown at the right (Paper 13/3).

off).
- −40°C and voltage cycle (1.5 min on, 30 min off).
- Humidity cycle and power: +25° to 65°C; 80% to 98% relative humidity.

The report points to rapid improvements in plastic materials. Thus the authors state: "The testing of plastic-packaged transistors initially indicated that with plastics available at the start of this program silicone was more desirable than epoxy. However, epoxy devices are now available which appear as good as silicone in both high-temperature and moisture stability."

Communications engineer

Communicate, don't travel, is the goal of designers

A dozen or so years from now, the engineer too busy to travel to electronic shows across the country may pick up his picture phone and scan the exhibits. If a booth looks interesting, he may dial the engineer on duty and talk to him. Such are the possibilities envisioned by communications specialists.

The idea of substituting communication for transportation in many situations of daily life is not fancy, says Dr. Timothy Healy of the University of Santa Clara. It began, he notes, when telephone calls replaced trips across town. The questions now are how far and how fast.

According to Dr. Healy, the opportunities are virtually limitless. For example, attempts are being made today to eliminate the exchange of money through data links between a customer's bank and the places where he buys goods.

Psychological and economic problems

But there are formidable obstacles, Dr. Healy says. As he sees it, the two biggest are economic and psychological.

The most urgent problem is economic: data transmission is expensive. One minute on a video phone costs up to $200 at present—out of reach of most would-be users. But Dr. Healy believes in the spirit of private enterprise. The cost of phone calls has dropped considerably over the years, he notes; video phones will follow suit.

The psychological problems are mostly long-range, Dr. Healy says. Can we really do without our work environment, for example? Can salesmen sell without face-to-face confrontation? Can housewives shop by television? Can executives give up the battles at round tables? There is no answer yet to these questions, but he will attempt to shed light on ways to look at these problems in Session 9.

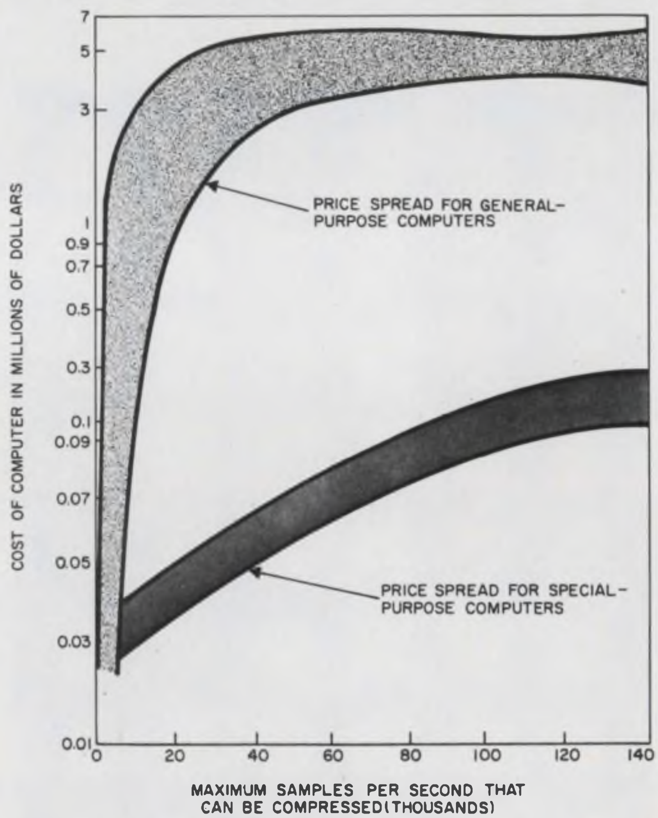
Curiously enough, Dr. Healy does not see any serious technological problems. He realizes that the expected increase in transmitted data will be astronomical, but he observes: "Obviously radio waves are out of question on the long range. Satellites will be a terrific boost for the next 10 to 15 years, but after that we'll have to use cable lines for data transmission. If you want to be really futuristic, then modulated light in cables may be the real answer."

For the next decade, he envisions "belts" of 15 or 20 satellites with highly directive antennas in S band, for instance, to handle data traffic with spatial multiplexing.

Cut cost of data compression

But before these ideas can be realized, designers must find more efficient ways of transmitting data. Already hardware capabilities are being strained. Straightforward approaches to increasing the capability of links run into trouble quickly because of cost, says a group of engineers at the Lockheed Missiles and Space Co., Sunnyvale, Calif. (Session 6).

At the transmitting end of systems, one solution



1. **Cost-performance trade-off** of computers for data compression clearly indicates the advantages of special-purpose types. Data-compressing computers are now developed that can handle many input types and allow the selection of processing that offers the best compression ratio.

lies in data compression—in the rejection of redundant data before transmission. The Lockheed group has come up with a hardware approach that can compress a variety of telemetry data, reconstruct the result when needed and display any selected two channels on a strip recorder. According to John J. Dowing, supervisor of the data-compression group, the technique avoids the need to design a special instrument for each application and manages to keep the cost far below that of a general-purpose computer (see Fig. 1 for cost comparison).

The compressor accepts 10-bit parallel digital input words that identify the channel and contain the data. This input may come directly from the telemetry multiplexer or from a decommutation station at a rate of more than 50,000 words a second. The experimental model can accept 1024 data channels, and separate tolerance levels can be established for each channel. To obtain the best compression ratios, each channel can be set for either averaging or exponential digital filtering and for one of several popular compression methods. The output is pulse-code modulated. It may be recorded and fed back to the machine, which then reconstructs the original uncompressed data.

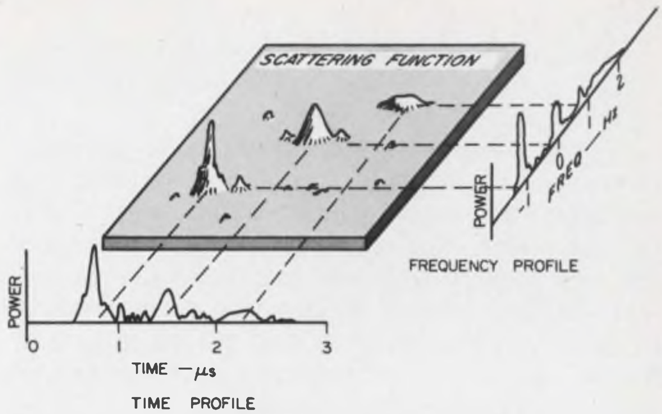
How to predict fading

But even the most efficient data-compressing system will not do much good, if the data get lost in the propagation media. Robert F. Daly, a scientist at the Stanford Research Institute (Session 9), points out that theories abound on channels where the noise is assumed to be Gaussian or nearly Gaussian, but not much is available to help engineers deal with signal fading.

Fading, or signal distortion, becomes significant in high-speed digital data transmission, Daly says, since the loss of even a small data segment can be critical.

The communication problem in the presence of fading differs in several ways from the problem with additive noise only, but one difference is particularly important to system designers, according to Daly. With only additive noise in the channel, any desired small error can be achieved by increasing the transmitting power level, whether optimum or suboptimum receivers are used. This is important, says Daly, because it is easier to increase signal power than to obtain a better receiver.

But fading channels do not go by this rule. Without an optimum receiver, the transmission suffers an irreducible error, due to self-jamming. The channel distorts the signal so that some of the energy interferes with the desired transmission. Higher power levels increase both the signal and the interference, so nothing is gained, points out Daly. For the same reason, more sensitive receivers do not help either.



2. **Time-frequency plane of scattering function** in communication channel for hf signals show nodal nature of the function. It introduces both frequency and time variations in the signal.

Daly sets up a model for the fading channel that allows the accurate prediction of error rates over an hf link.

When setting up the model, he assumes that the signal undergoes both time dispersion and frequency dispersion, because of scattering in the channel.

The received signal is scattered by irregularities in the dielectric constant of the channel (particles, for example, are such irregularities). The energy from these scatterers arrives by a different path, causing a differential time delay, or time dispersion and resulting in frequency-selective fading. But the scatterers are in motion, which results in a Doppler shift. Since the Doppler shift is different for each scatterer, frequency dispersion is also introduced. Thus, both the time and frequency structure of the transmitted signal will become smeared out, and the transfer function of the channel displays both frequency and time dependence. Such a scattering function for an hf link is shown in Fig. 2.

He models this channel as a linear time-variant filter, and introduces some design points for optimum receivers that help reduce fading errors.

Computer engineer

Computers as components or will it be vice versa?

The computer engineer finds himself at a crossroads today: there is a wide road, along which computers are merely components, parts of a larger system; and there is a narrower road, along which components are computers, formed by large-scale integration (LSI). Which way does he have to go?

Knowledgeable computer engineers are preparing to zigzag between the two paths, by adding to their skills along the way.

System design calls for the ability to integrate hardware and software, to optimize systems that use computers as components and to solve interface problems. Not only man-machine interfaces but also machine-machine interfaces are important, as, for example, in digital control systems. LSI requires an appreciation of the techniques of fabrication and, in particular, of the economics of large- and small-volume production.

Bob L. Ryle of the Planning Research Corp., Los Angeles, presents a strong case for considering software as another engineering discipline for the computer engineer (Session 16). He believes that the idea of software as an "esoteric art form" must be dispelled; it must be treated as a scientific discipline, he says. This will become even more necessary if, as seems likely, the software of operating systems is handled by hardware. An example of this is the use of LSI as a read-only memory storing an executive system.

Optimum design is needed

Maximum effectiveness of third-generation computers is the concern of authors David L. Stein and Joe L. Glaser of Scientific Data Systems, Santa Monica, Calif. They define third-generation computers as variable combinations of control units—memory and input/output units communicating freely with each other through standard interfaces.

Now a system designer can produce a whole range of systems to do a specific problem, according to the authors. The art is to find an optimum design, one that will do the job faster, more accurately or, perhaps more importantly, more cheaply. Although the criteria may be easy to determine, the effect of altering a system design may not. Simulation of proposed systems is likely to be one way out of this particular difficulty. The authors admit they do not have all the answers.

In the same session, Dr. J. V. Kane of Michigan State University shows how, as a nuclear physicist, he has had to solve an interface problem to use a third-generation time-sharing computer as a component of his laboratory. His general-purpose interface enables experiments to control not only a cyclotron but also several independent experiments. Dr. Kane cites the advantages of his system as follows:

- Experiments will be able to record and analyze data whenever they wish.
- The time required to set up and alter experiments will be reduced.
- Experiments may be operated remotely by researchers in distant or small institutions.

Computers help improve patient care

The computer as an element in the medical environment is the concern of Dr. Shannon Brunjes and his colleagues at the Los Angeles County Hospital. In their paper, the authors describe a system of out-patient prescription-information storage that uses remote CRT displays on line to the hospital's IBM 360/30. Envisaged is a larger information system, including in-patient drug orders and clinical information entered directly by the physician. Dr. Shannon notes that the hardware to do this is available now but that the programs are not. Specialized software is a necessary part of system design, he indicates. (If you want to hear more about the use of computers in medicine take a look at Session 7, where Dr. Donald C. Harrison of the Stanford University School of Medicine discusses on-line patient care.)

LSI is nearing reality

The effect of LSI on computer system design will be examined by a panel in Special Session B. Opening the discussion will be Richard Petritz of Texas Instruments, Dallas, who will be covering the state of LSI technology principally in monolithic integrated circuits, hybrid arrays and large arrays with discretionary wiring. Another enthusiastic proponent of LSI is Gordon Moore of Fairchild Semiconductor, Palo Alto, Calif. He predicts that LSI will be a reality by 1970, with costs of 5 cents a gate and memory costs of 2 or 3 cents a bit. He hopes to be able to establish a set of economic ground rules for the computer designer, in terms of quantities for feasible production runs and turn-around times for changes to designs in production. Debating the applications of LSI for large-scale systems will be Gene Amdahl of the International Business Machines Corp., San Jose, Calif., and covering small systems will be L. C. Hobbs of Hobbs Associates, Corona del Mar, Calif.

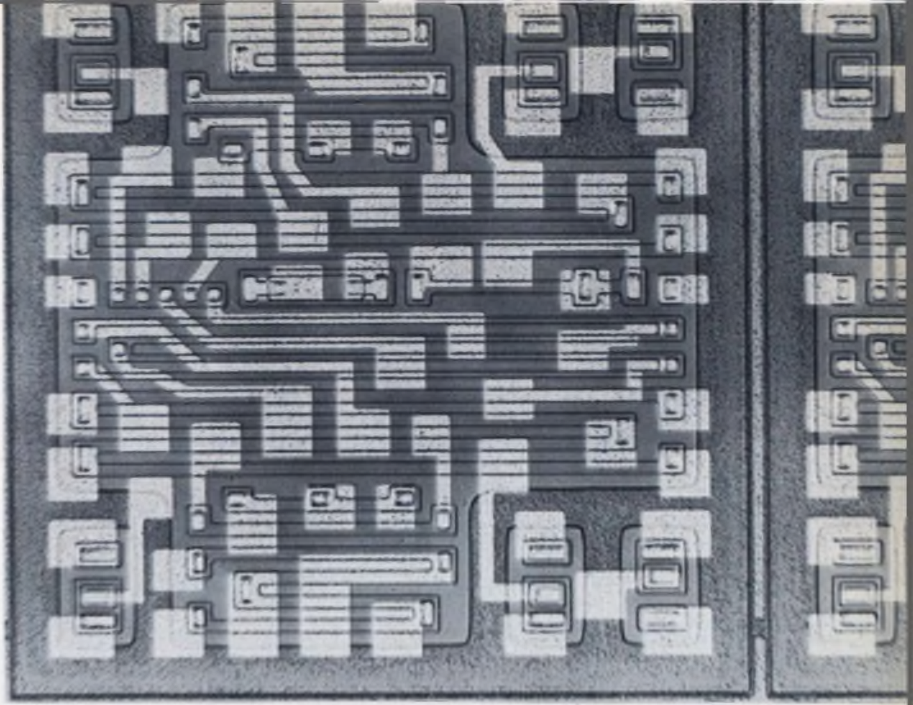
In the debate that will follow the presentations, some of the questions the computer engineer might like to hear answered could be these:

- When will there be some industry agreement on what constitutes LSI?
- When are the manufacturers of integrated circuits going to produce examples of LSI that are nontrivial and economic for the computer manufacturer?
- When and how is the problem of multilayer interconnection on a chip going to be solved?

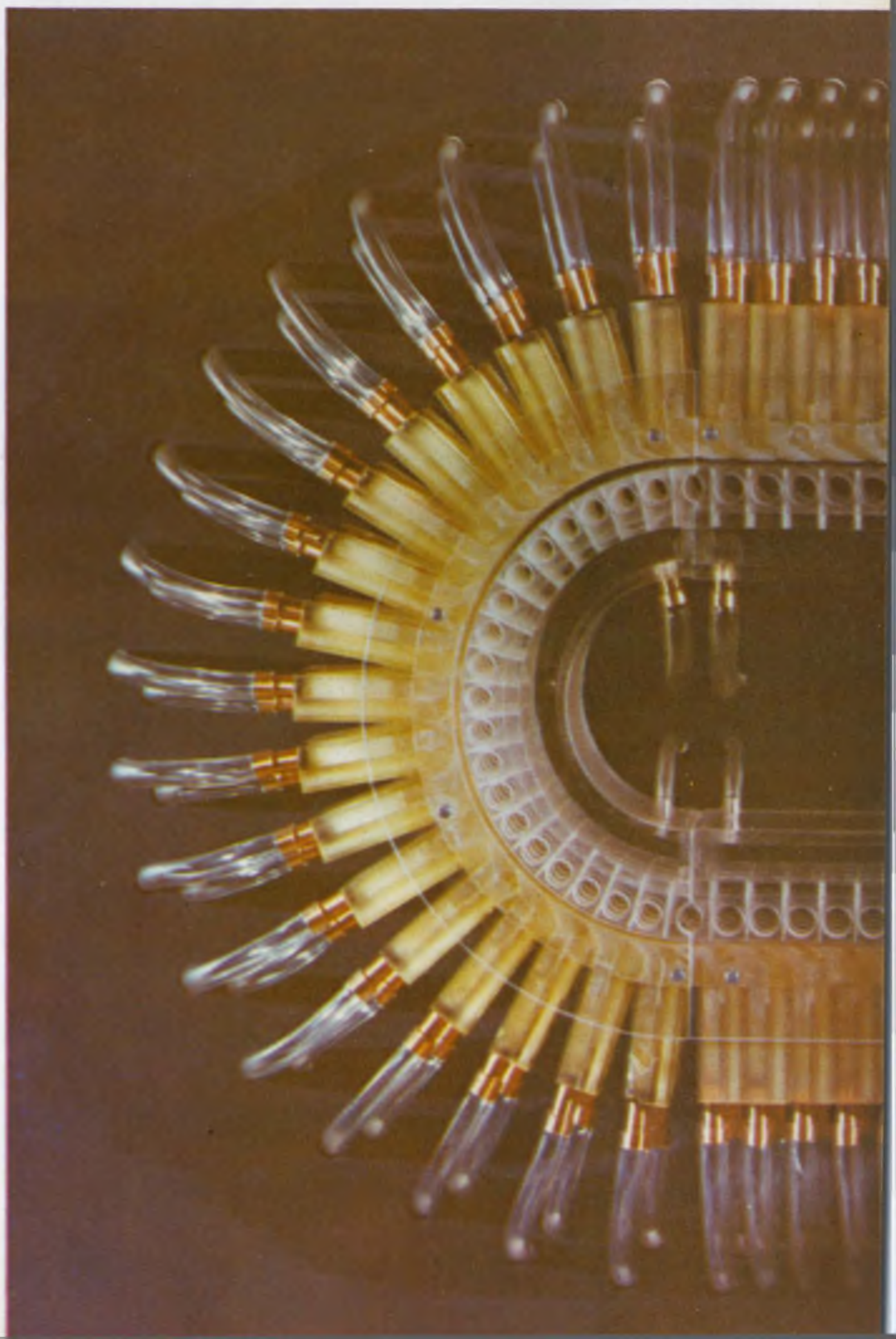
Design automation will reduce costs

Both semiconductor and computer manufacturers agree that the problems of the design of LSI arrays will require automated design techniques to allow economic use. Thomas F. Prosser

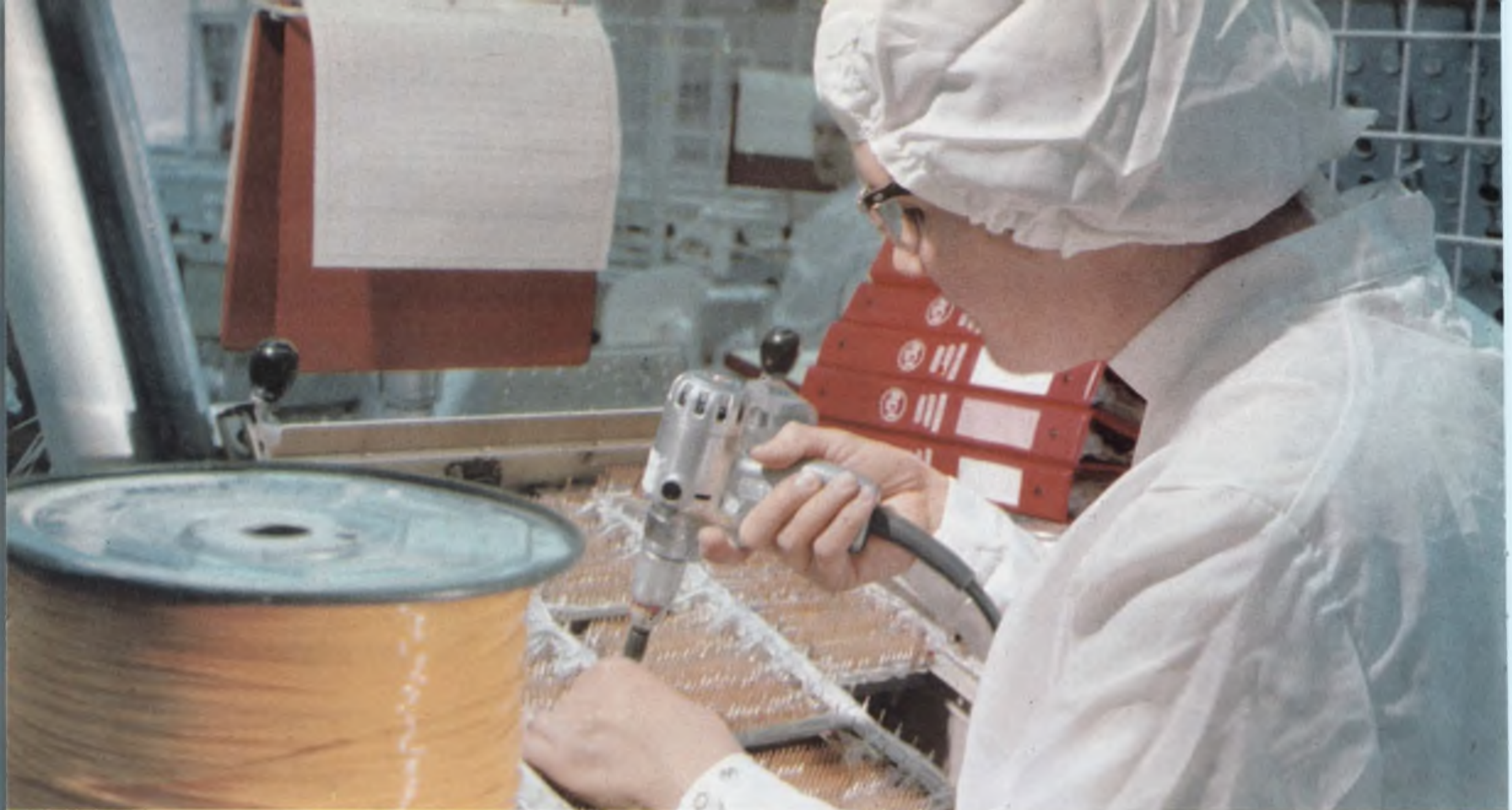
(continued on page U96)



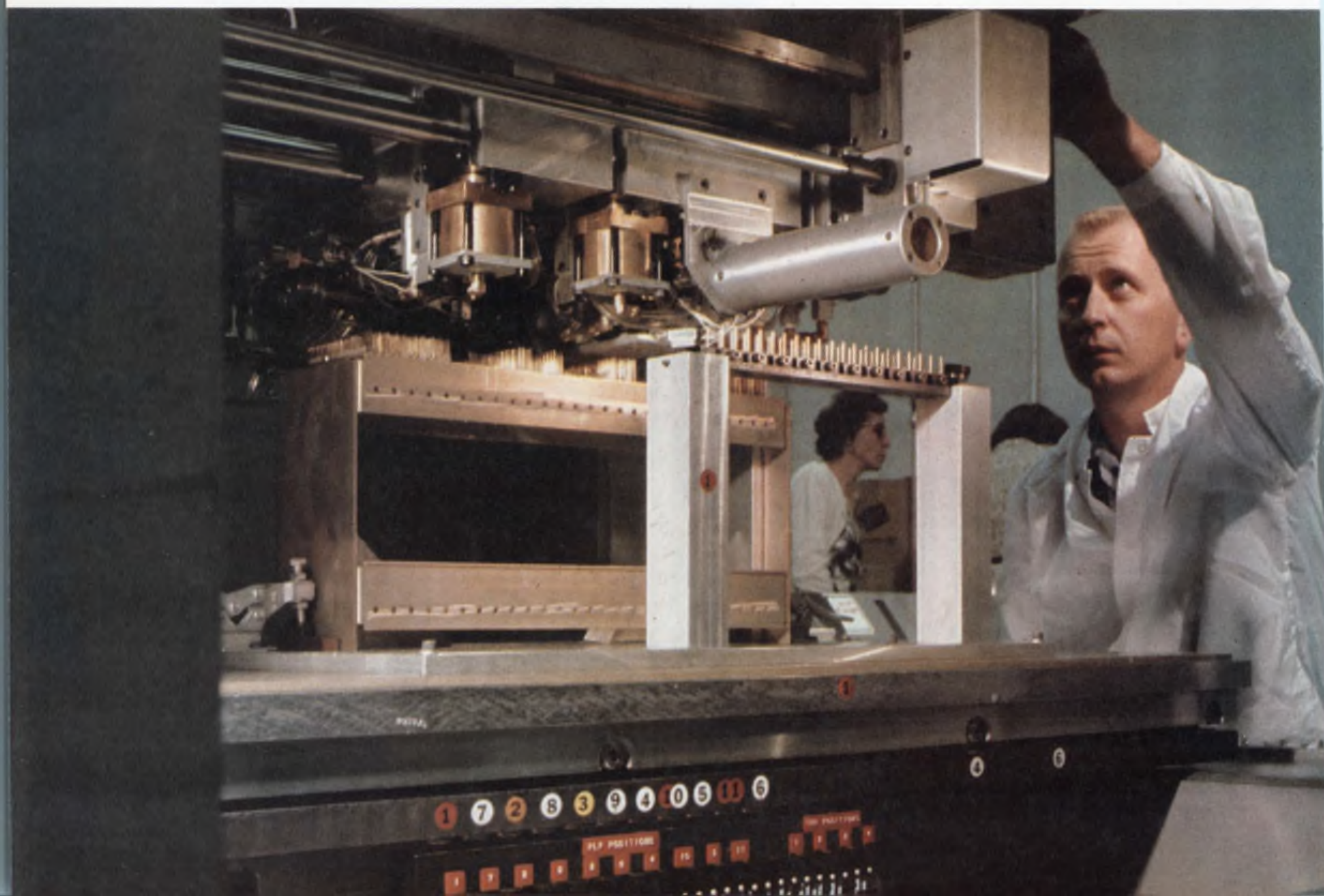
Engineers can design their own microcircuits by means of Norden's Master Dice Breadboard. The monolithic integrated layout contain 6 transistors, 33 resistors (Booth 5031).



Fluidic control is used in Univac's pneumatically controlled document-handling system. A motion control track is shown (Paper 11/5).



Reliable electrical connections



Solderless electrical connections are wrapped to stay . . . wrapping time is less than one second each . . . Using Gardner-Denver "Wire-Wrap"® tools. You save hours of handwork. You save inspection and rework time as well, because "Wire-Wrap" tools make reliable connections, even in inexperienced hands. Widely used for wiring television, instruments, communications equipment, computer panels and missile guidance systems.

Your choice of power for hand "Wire-Wrap" tools . . . electricity, compressed air, or rechargeable battery. We also make manual tools for field servicing. Bulletins 14-1, 14-3 and 14-7.

in less than one second each

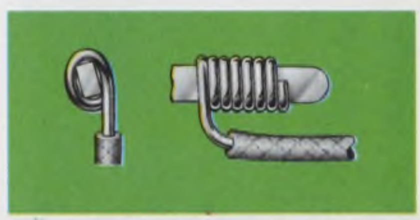
Modular panels are quickly and securely wired on Gardner-Denver automatic "Wire-Wrap" machines, which are programmed with punched cards for maximum flexibility. Bulletin 14-121.

Reliable! More than 40 billion solderless wrapped connections have been made with "Wire-Wrap" equipment without a single reported electrical failure.

Film is scraped from wire and terminal at contact points. High pressure metal-to-metal contact invites solid state diffusion, maintaining low connection resistance.

Solderless wrapped connections remain gastight even when exposed to severe changes of temperature and humidity . . . so they're not affected by atmospheric corrosion.

Initial pressure may go as high as 100,000 psi. Pressure drops as wire relaxes, but stabilizes at a value greater than 29,000 psi.



Flexible lead-off absorbs vibration and handling shocks . . . permits wrapped connection to stay tight and mechanically stable.

SEE WHAT AIR IS DOING NOW...SEE

GARDNER - DENVER

Gardner-Denver Company, Quincy, Illinois

ON READER-SERVICE CARD CIRCLE 56

(continued from p. U92)
of the Philco Ford Corp., Santa Clara, Calif., in a paper in Session 4 of the Eighth International Electronic-Circuit Packaging Symposium cites a component cost reduction factor of 10 or more through the use of computer-aided design. Proponents of LSI are painting a rosy future for it, by citing the advantage of tremendous computing power at very low cost. However, opponents are likely to retort that for large systems, the circuitry costs are likely to be only 5 per cent of the total, so that even a 50 per cent reduction in circuit costs will not significantly reduce the total system cost.

High-density recording packs them in

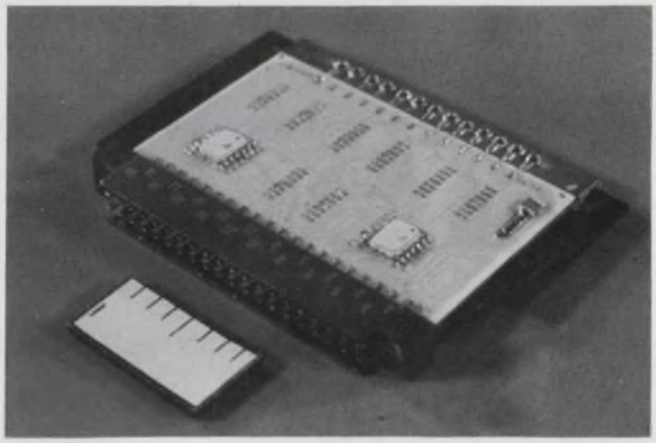
Bulk storage has always been important to computer users and designers. The cheapest bulk storage device is still the magnetic-tape unit (less than 0.001 cents a bit), although it is being hard-pressed by the other electromechanical storage devices, principally the magnetic disk (0.02 cents a bit). As a result there is considerable pressure on tape-unit manufacturers to improve the performance of their products.

Reporting on their work in Session 12 are Donald T. Best of the Ferroxcube Corp., Saugerties, N. Y., with a paper on magnetic head design, and Kermit Norris of the Leach Corp., Azusa, Calif. Norris describes a novel technique that uses a relatively simple one-track system, yet achieves a density of 10,000 bits an inch with an error rate of less than 1 in 10^8 bits. More unusual are the electron-beam and laser recording methods to be reviewed by Charles F. Spitzer of the Ampex Corp., Redwood City, Calif. These methods use modulated electron and laser beams on thermoplastic and siver halide films, which are developed and then coated with a plastic scintillator. When scanned with electron or light beams, the scintillator emits light that is detected with photomultipliers. Much of the work is still in the developmental stage, although a large computer manufacturer hopes to deliver an electron-beam system shortly. The author looks for a factor-of-10 improvement over magnetic tape and cites densities of the order of 10^7 bits a square inch.

Materials engineer

Microelectronic packages: The approaches fan out

The revolution in electronic components in the last decade has been accompanied by an upheaval in packaging and in the methods used to interconnect components.



Four-layer digital logic module from Sylvania is formed by firing and screening metal and glass layers alternatively on alumina substrate. Thermal characteristics are reportedly some 50 times better than glass-epoxy.

The stamped metal chassis needed to hold tubes, and the wire, installed by women with soldering irons, have been superseded by printed-circuit boards with their plated interconnection patterns. Dip soldering fastens scores of components in place, allowing one worker with a tub of boiling peanut oil to do the work of a dozen girls with soldering irons.

Now, the popularity of integrated circuits makes even greater demands on packaging and interconnection techniques, and designers are meeting this challenge by creating multilayered interconnections in packages that can be batch-processed.

The simplest approach to multilayer interconnections is the double-sided printed-circuit board. Here, plated wires are photoformed on both sides of the printed-circuit board. Where current must flow from one side of the board to the other, eyelets, or plated holes in the board, provide the paths. Components can be mounted on either or both sides of the board.

More complex boards can contain several insulated layers of plated interconnections on one side. The additional interconnection density afforded by multilayered boards costs considerably more than lower-density wiring approaches.

Another approach to the solution of sophisticated wiring problems is the numerically controlled installation of ordinary, flexible wire. Here, a machine working under the direction of a set of programed instructions automatically interconnects a rack of contact pins.

Designers encounter problems amenable to a similar solution in the pursuit of large-scale integrated arrays: LSI requires the development of a flexible, automatic interconnection method that can operate in a microscopic framework. At present the individual sub-circuits of a wafer are probe-tested and then interconnected by a special metalization pattern that is automatically generated by a computer. Unfortunately the computer time expended on the generation of a mask for one wafer is not applicable to the interconnection of the next wafer.

These and other aspects of interconnection and packaging technology are reported at WESCON's Technical Session 4.

Medical electronics engineer

Better cardiac monitors sought to cut death rate

The engineer attending the medical electronics session will hear that his efforts are needed to save the lives of 200,000 persons a year—cardiac-care patients who die from heart failure and shock because the doctors' stethoscopes cannot pick up the danger signs in time. Improved electronic monitoring must be developed to cut the toll.

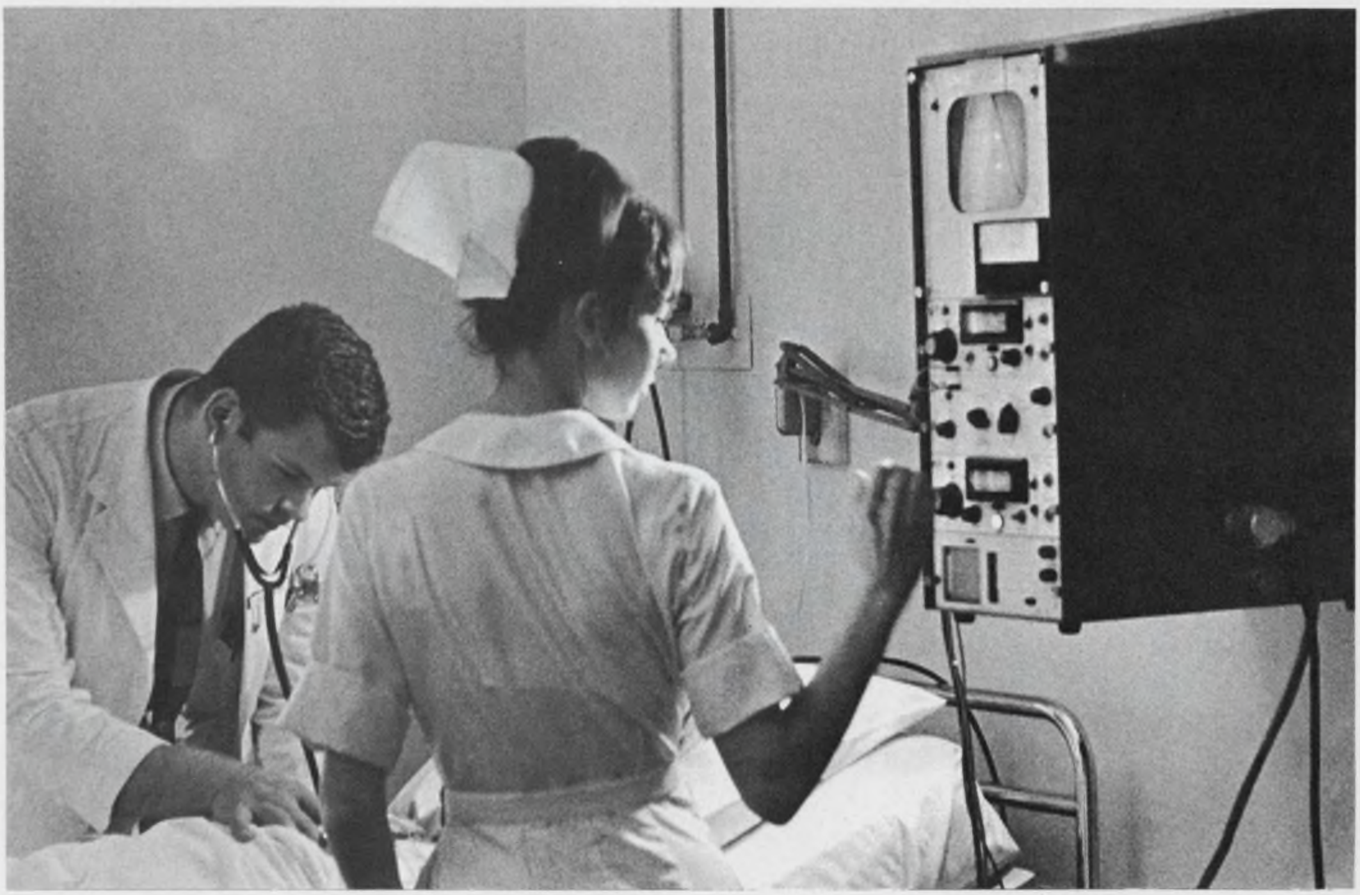
Patient-monitoring systems are proliferating because their value in around-the-clock observation of persons who have been stricken with coronary occlusions—heart attacks—has been dramatically demonstrated. Already more than 300 of the approximately 7000 hospitals in the United States are reported to be equipped with coronary-care wards—most in the last year or two. As Dr. Curtis E. Miller, head of medical research at Beckman Instruments, Inc., Fullerton, Calif., and chairman of the WESCON session, says: "Many people who have heart attacks are candidates for further trouble within two weeks after their attack."

Before electronic monitoring, about 40 per cent of the coronary patients admitted to hospitals died before medical help could be marshaled. Patient-monitoring systems are said to have cut this mortality in half.

Dr. Eliot Corday, a cardiologist at Cedars-Sinai Hospital in Beverly Hills, Calif., who will deliver the opening paper at the WESCON session, underlines the importance of these systems:

"We know that we are going to save the lives of 100,000 coronary patients a year when we get every patient who has a coronary monitored with electrocardiographic equipment minute by minute, and I read this into the *Congressional Record* in April," he told ELECTRONIC DESIGN.

"We are still losing 200,000 lives due to heart failure and shock, and it's obvious that to save those patients we're going to need other types of monitoring equipment to measure blood pressure, cardiac output and various pressures on the right



Cardiac parameters are displayed on oscilloscope at Columbia Presbyterian Medical Center, New York. Many lives are saved, but more are lost because the ubiquitous stethoscope cannot reliably predict further trouble.

and left sides of the heart."

Dr. Corday says that the greatest need right now is for a simple apparatus that can record blood pressure from within an artery from second to second (it would be left inside the patient), and for something that will measure cardiac efficiency externally (an indirect measurement which does not require anything to be implanted).

"This is what we're shooting for," Dr. Corday says, "and I hope we can have it in a few years. . . . We're not recognizing the danger signs of heart failure and shock; we're not picking them up on our stethoscopes."

Another WESCON panel member, Dr. Donald Harrison, chief of the cardiology division at the Stanford Medical Center, says:

"It is useful to be able to measure cardiac output. One way of gaining some idea of this output is to measure the oxygen content of the central venous system by means of fiber optics. This gives an insight into how well the heart is functioning. The devices are not now practical for cardiac-care units, but I think they will be. The problem is one of size: it is necessary to get them small enough. I think that within a year or two they will be used widely.

"However, I have given up, after several years of intensive study and discussion with engineers, on getting useful indirect measurements. We're going to have to live with catheters and tubes and fiber optic bundles. I don't believe there is much capability in a year or two for indirect measurements. In five years, perhaps."

Dr. Harrison's mention of catheters and tubes was a reference to the devices now being developed by such companies as Statham Medical Instruments, of Los Angeles, to measure blood pressure accurately. These involve the insertion of a tube into a blood vessel, so that a transducer can produce a continuous waveform output. In the fall Statham plans to introduce a subminiature blood-pressure transducer—less than 0.060 inch—that can be implanted for at least the duration of the patient's stay in the cardiac-care ward. Present catheter-transducer devices must be replaced after a few days. However, transducers such as Statham's are regarded as only an intermediate step.

The more general purpose of the WESCON session is to permit doctors who have had direct experience with patient-monitoring to give a critical review of this healing art: its problems, progress and prospects.

According to Dr. Miller, many hospitals think they need patient-monitoring systems but are uninformed about what they need. At WESCON the speakers will try to provide information both to the medical profession and to the instrument manufacturers.

For example, equipment should be designed with personnel in mind. Will engineers be in attendance in the hospitals? Or will the equipment be operated by nurses? What about maintenance?

There are other types of patient-monitoring

Cardiac pacemaker restores a patient's heart beat when the monitor detects an irregularity. The unit is used in the intensive care ward of University Hospital, NYU Medical Center, New York.

systems besides the cardiac units. Beckman Instruments is developing a device to protect premature babies against a common tendency for them to stop breathing. Nowadays a nurse walks around the incubators and checks. With the Beckman device, an alarm goes off when respiration stops.

Intensive care is another form of monitoring for patients who are seriously ill from a variety of causes: shock, traumatic surgery, brain damage, burns. These patients have to be checked extremely closely to detect the onset of difficulties that are secondary to the major illness.

Still other monitoring devices are used mainly in diagnosis. For example, a person may complain that his heart is fluttering or causing him pain. The electrocardiogram taken in the doctor's office may not show anything abnormal. But the physician knows from experience that patients have walked out of his office in similar circumstances, only to succumb to heart failure a day or two later. Now there are on the market portable tape recorders that, attached to a person, permit continuous recording of an electrocardiogram for up to 10 hours. The tape can be played back very rapidly under computer control to reveal pathological symptoms.

The computer itself has not yet begun to reach its full potential in patient-monitoring. In a very few hospitals time-shared computers are used for monitoring arrhythmia—irregular heartbeat—from electrocardiographic inputs. Dr. Harrison is confident that they will come into wider use, particularly when the number of parameters that have to be monitored increases.

"I think the next generation of time-sharing computers will lend themselves to monitoring," he says. "The data could be preprocessed on analog systems before they are run in the digital machines."

Publicity accorded the introduction of computers in the hospitals seems to have been misdirected, in the opinion of some experts. A spokesman for Montefiore Hospital in New York City says that the first things hospitals have done with the machines were the housekeeping chores—payrolls, purchase orders and the like. But many have been at a loss to use the computers in direct medical applications. Programing is said to be a problem. One doctor's description of symptoms might differ from another's.

Some of the computer applications instituted by Montefiore are:

- A daily printout on every floor of laboratory tests run for patients on that floor. Instead of laboriously copying reports by hand, a nurse could post the printout at the foot of the patient's bed.
- Storage of all X-ray records going back four years. Any time an unusual condition occurred, records of similar conditions could easily be tuned up.
- Analysis of the results when two different radioisotopes are administered to the same patient. To separate the results, it is necessary to solve equations. The computer can accomplish in 2 minutes what it took a mathematician a day and a half to solve.

Microcircuit systems designer

MOS arrays and linears are reaching maturity

There are four important trends in microcircuits today: the proliferation of stable, producible MOS arrays; the explosion of linear microcircuits—monolithic circuits that perform analog functions; the tendency to perform these analog functions with inexpensive digital microcircuits; and the spiraling of microcircuit complexity. The latter trend, semiconductor manufacturers believe, will lead to development of large-scale arrays and will place in the manufacturers' hands responsibility for the design of a substantial portion of future electronic systems.

WESCON does not pretend to be a microelectronics show. Yet, its technical sessions and an accompanying two-day symposium touch on each of these four important areas. Unfortunately, two of the most interesting technical sessions 8B and 10 conflict with the two-day microcircuit symposium. There is, however, a profitable recourse.

The experienced designer can attend Session 1 ("Linear Integrated Circuits"), Session 8B ("Large-Scale Integration of Computer System Design") and Session 10 ("Digital Approach to Analog Functions").

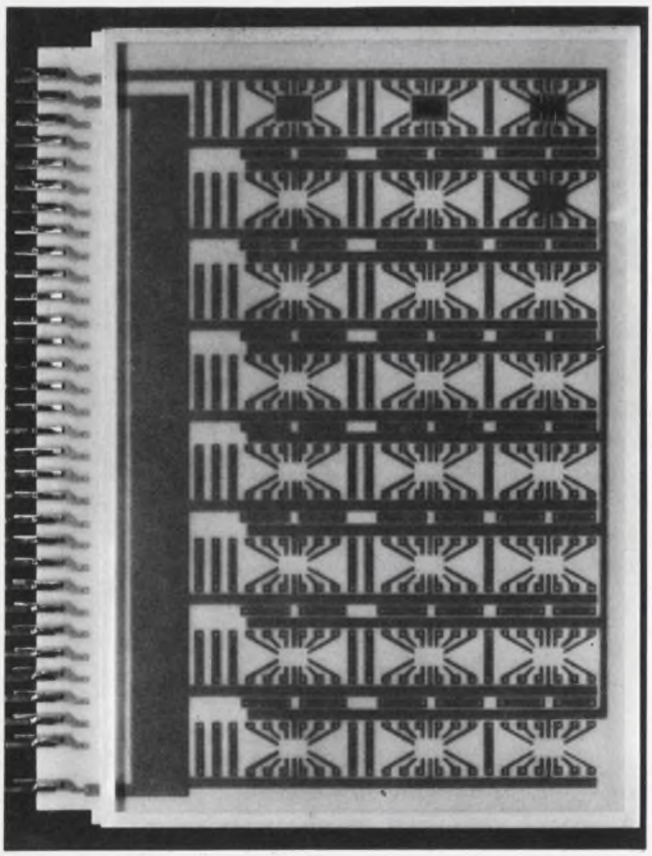
The beginner can attend the two-day symposium, "Microelectronics Comes of Age."

Four of the five papers at Session 1 describe the design and application of a specific microcircuit made by the author's company. Ralph Seymour of Signetics, for example, discusses the application of a Signetics chip containing two transistor triads (driven by a small bias circuit) for i-f or rf amplification. Similarly Motorola's Leo Wisserman and Bill Ehrsam discuss a dual operational-amplifier microcircuit recently introduced by Motorola. Jerry Gibbs of Amelco Semiconductors, Mountain View, Calif., describes the marketing considerations that inspired Amelco to introduce an inexpensive version of the 709C operational amplifier, which it calls the 809C. He shows those areas where the 809C performs adequately enough for the designer not to have to resort to the 709C, a chip of greater size and complexity. The 809C costs $4.50, but Gibbs feels that its small size will allow the company to drop the price into the $3 range in two to three years and still make a profit. Fairchild's μA709C is presently selling for $4.95.

Session 8B presents a panel of experts conversant in LSI (large-scale integration), that popular conversational gambit usually found at the other end of the digital microcircuit rainbow.

The electronics industry is about to witness a boom in linear microcircuits (see "Tiny exploding world of linear microcircuits," ED 15, July 19, pp. 49-72). The linears are, however, lagging several years in development behind their digital counterparts. Session 10 sheds some light on that area of systems design where it may well be easier to use digital microcircuits to perform analog functions, than to design linear microcircuits.

A paper to watch is the second presentation of the session. It is entitled "Four Digital Arrays Do All Algorithms," by George Sendzuk of General Electric, Binghamton, N. Y. He describes how four digital MOS arrays can simulate an analog filter of any frequency response. Hooking together the four arrays in the appropriate manner can save the designer of a digital system the trouble of converting a pulse train to an analog signal, filtering it, and converting it back to a pulse train.



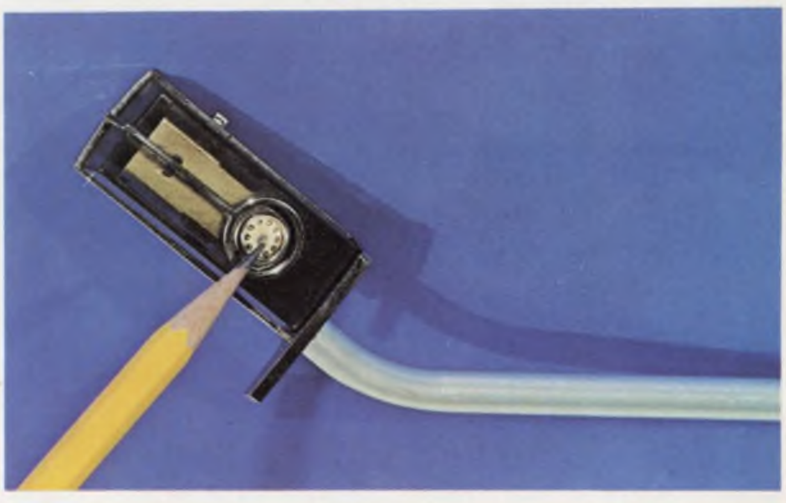
Interim approach to large-scale integration is exemplified by this card-sized ceramic board which is designed to carry 24 uncased circuit chips. Here only two are shown in place—one right side up and one flipped.

The two-day microelectronics symposium offers the designer who lacks experience with microminiaturization more than the technical papers offer the designer who has already acquired a good deal of microcircuit savvy. It covers the basics of every area of production, from thin and thick films to monolithic integrated circuits. It describes the basic theory of the devices of microcircuitry, from bipolar to MOS transistors, and from ordinary thick-film resistors to multilayered, thin-film capacitors. It presents basic applications information for both digital and linear integrated circuits. Packaging and wiring techniques as mundane as mechanical wiring are discussed right after those as esoteric as large-scale integration, which at the moment is an interconnection problem requiring computers for its solution.

The first day's symposium papers are divided, as is the field of microelectronics itself, into the hybrid (multichip) approach and the monolithic (single-chip) approach. A particularly interesting account of an automated hybrid production line is given by Mort Penberg of the Aerojet-General Corp., Azusa, Calif. Using an automatic vacuum deposition system developed at Aerojet-General, the automated production line deposits up to 40,000 thin-film circuits onto substrates in one pump-down; attaches transistors to the substrates automatically, with numerical control machines; and then checks each circuit on computer-controlled test equipment. The Aerojet-General system can manufacture and test a wide variety of thin-film circuits. In another paper, Wayne Moyers, head of microelectronics at the Lockheed Electronics Div., Lockheed Aircraft Corp., describes the design and manufacture of a mass-produced thin-film circuit used in touch-tone telephones. The circuit, developed at Bell Telephone Laboratories for the Bell System's manufacturing division, Western Electric, uses a beam-lead microcircuit as an oscillator.

The afternoon session delves into the monolithic approach to integrated circuits. Several papers deal with the basic theory-processing and design of bipolar microcircuits. Other papers explore those three new stars of monolithic integrated circuitry: the MOS array, the linear microcircuit and the microwave microcircuit. These are presented in papers 3/5, 3/6 and 3/7 by M. Sussman of the General Instruments Corp., Newark, N. J.; Jack Gifford of Fairchild Semiconductor, Mountain View, Calif., and V. Gelnovatch of the Army Electronics Command, Fort Monmouth, N. J. MOS arrays have been around for several years, but instability problems that have prevented their widespread use have been solved and sophisticated circuits that use four-phase logic and complementary transistors have been devel-

Variations in the output frequency of gas lasers—such as this helium-neon setup—may be caused by shifts in the pressure of the constituent gases. Possible solutions to the problem are described in Paper 5/2.



IC preamplifier by RCA replaces magnetic cartridge in phono arm. It's another example of the inroads ICs are making in the consumer products areas (Microelectronics symposium).

Improved communication with reentry space vehicles is the goal of researchers at Kirtland AFB, N. M. The visicorder output provides transmission data on various spacecraft window materials subjected to high temperatures by a 330-kW arc plasma generator in the background (Paper 5/2).

oped since the last WESCON.

Linear microcircuits, long the orphan of the semiconductor industry, are starting to come into their own. Their obvious home is the consumer market, where high volume helps offset the large development costs associated with linear microcircuits. Scores of linears for home entertainment products, like RCA's dual Darlington amplifier designed for a phonograph cartridge (see photo), are starting to appear on the market.

The use of high frequencies can exploit the limited size of capacitors that can be fabricated on a chip. Stripline techniques can even be used to make distributed inductors, which have usable values at microwave frequencies.

The key to microwave microcircuits is the development of good, high-frequency transistors, and that, in turn, requires extremely narrow emitter widths and shallow diffusions. One experimental approach to the fabrication of such fine geometries is Westinghouse's electron-beam etching machine. It operates on the principle that glass tends to etch faster when it is bombarded with electrons. Hence it uses the glass itself as a photoresist in the microcircuit production process.

Production techniques have progressed considerably faster than the education of the design community, says Glen Madland, president of the Integrated Circuit Engineering Corp., Phoenix, Ariz. Madland peers into his crystal ball at the symposium to spot trends in the integrated-circuit field.

The two-day symposium will not make an expert of an integrated-circuit novice, but for $30 it offers working knowledge of the techniques and is a good place to start.

Microwave engineer

Phased-array makers consider mass output

The hottest topic in the microwave industry is phased arrays. If they make it, they can provide a much-needed new market for the microwave industry. The question is, will they? To hear the opinions of experts, drop in on Session 14 ("The Future of Solid-State Phased Arrays").

The problem is not R&D; it is the cost of production, according to at least one member of the session's panel, Malcom Vosberg of the Institute for Defense Analysis.

"We cannot afford the arrays we are building now; we've got to get the cost down," he says, "and mass production is the only way to do it."

Phased arrays are just about the only microwave system where mass-production techniques are applicable, because they have many identical elements. (An element contains the steering circuit, or phase shifter; the drive circuit for the shifter; the transmitter; the duplexer and a low-noise receiver-preamplifier.)

A controversy arises at this point. How many elements should be used in phased arrays? One school of thought in industry leans toward arrays with 10,000 to 100,000 elements; the other favors the use of as few as possible—on the order of hundreds. Both sides will be represented on the panel.

The trade-off revolves around the power-aperture product of the antenna. "With many apertures, we can stop pushing for high powers in each element," says Vosberg, "but this means that their cost must come down to about $100 to $200 per element." If there are 100,000 elements, it does not matter much if 10 or 100 of them stop working; tolerances and reliability requirements can be relaxed. This reduces the cost.

With a few apertures, the power requirements go up, along with reliability and tolerances, thereby increasing the cost. One example of this approach is the radar designed by Bell Telephone Laboratories of Murray Hill, N. J., for the Nike X.

The lack of efficient assembly-line production techniques made the second approach the accepted solution, says Vosberg.

Where are the markets?

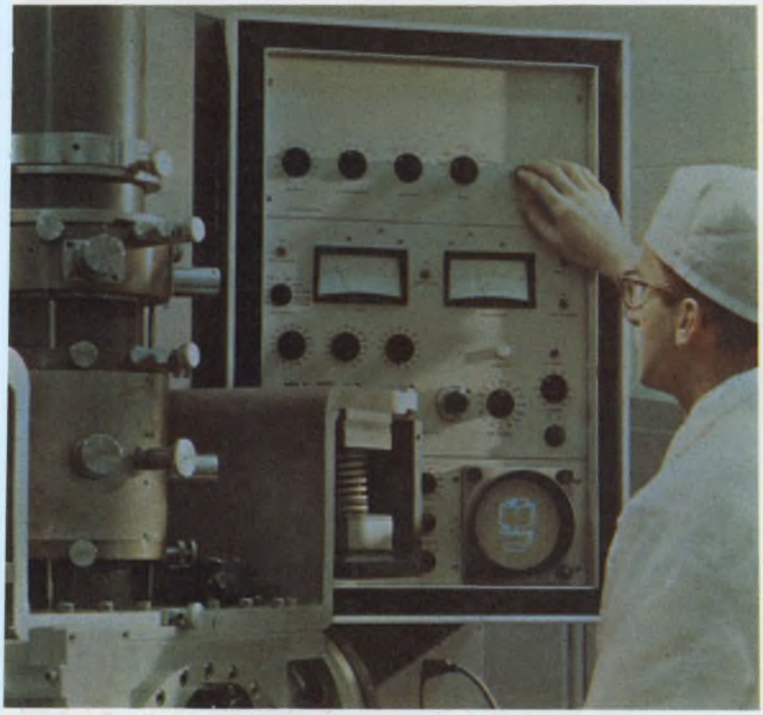
To find the market, the panel will examine the advantages and limitations of phased arrays, as well as three major applications areas that appear to be promising at this time.

The first area is, of course, where the electronically controlled scanning of phased arrays tops other antenna types in providing fast coverage. In ballastic missile radars, phased arrays are already replacing parabolic types.

The second area of promise for phased arrays is when the antenna becomes too large to be moved mechanically—for example, in space tracking. Phased arrays are installed permanently; hence their size is not limited. "You can make them the size of the Empire State Building," says Vosberg.

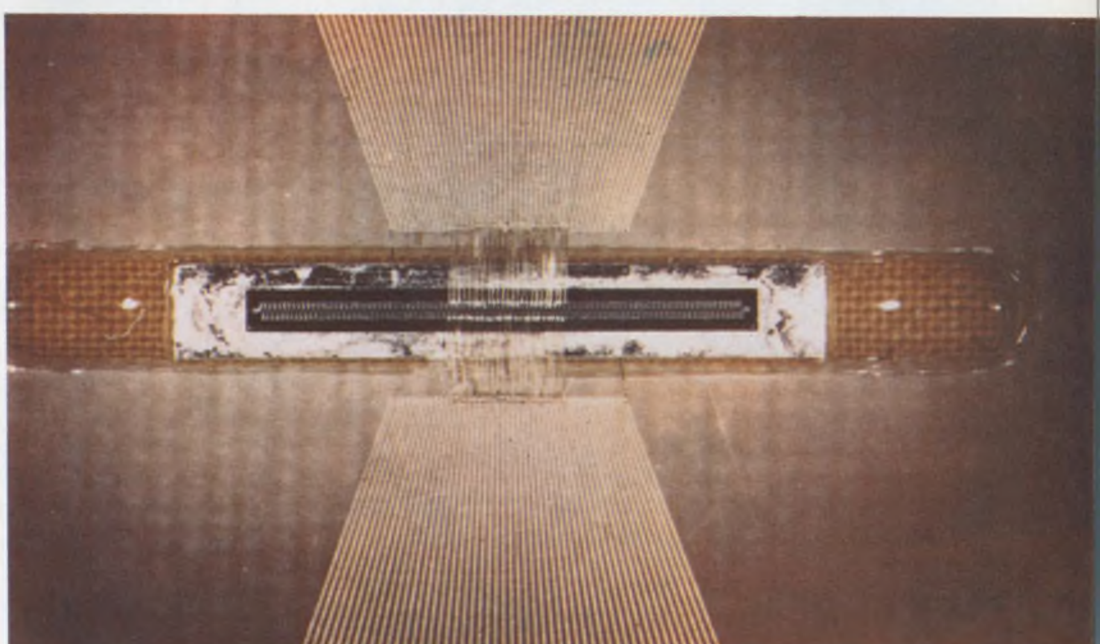
The third applications area may become the most significant in the long run. The idea is to put the array on the outer surfaces of aircraft and space vehicles. This design allows communication in all direction without swinging dishes around on gimbles, which comes in handy in satellite communications. The concept is aptly called conformal phased arrays.

Some members of the WESCON panel feel that these possibilities will hardly be sufficient to start a mad scramble among manufacturers. They estimate that only a few companies will end up in

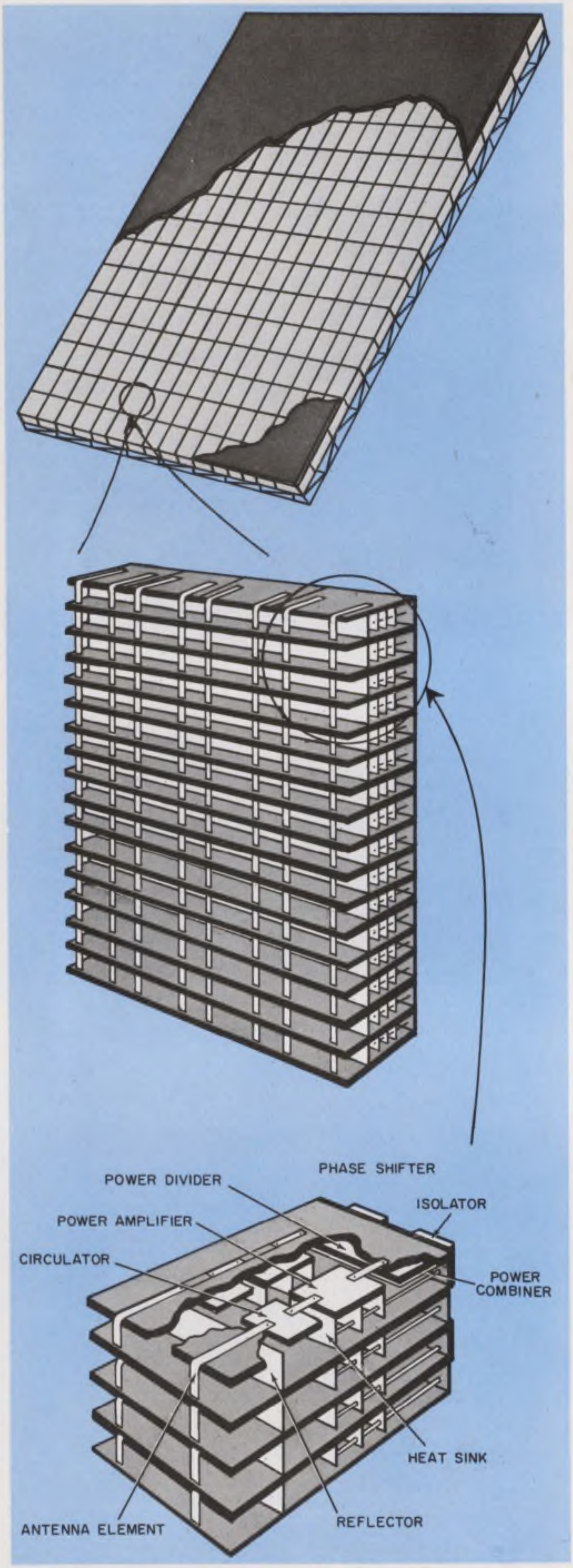


Electron-gun etching machine developed by Westinghouse can be used to etch glass coatings on microcircuits with no photoresist (Microelectronics Symposium Paper 3/1).

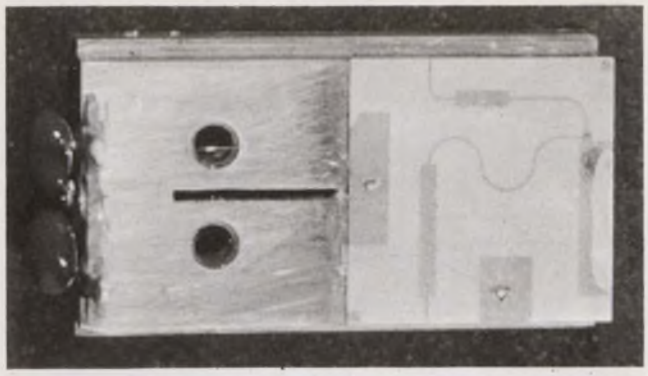
Noise figure measurements on an rf FET mixer are made by Siang Pink Kwok of Motorola Semiconductor, Inc. (Paper 8/1).



Arrays of silicon photo-transistors, operating in a photon flux integration mode, are reported to make it possible to obtain full frame storage at even commercial television rates. The linear array (above), developed by Fairchild Semiconductor, contains 200 phototransistors, although only 50 are hooked up (Paper 13/2).



1. **Design concept of solid-state phased arrays** is based on a modular approach. The array face (top) has plug-in modules that provide 128 solid-state elements (center). Each plug-in unit (bottom) has eight amplifiers, radiating elements and transmitting and receiving circuitry.



2. **Integrated microwave receiver** contains a miniature X-band ferrite circulator that leads to a tunnel-diode rf amplifier (not shown), a mixer, a wide-band i-f amplifier and circuits that generate an X-band local-oscillator signal. A four-times multiplier provides the X-band signal from an S-band input in this RCA unit.

this field. This centralization will change the component supply somewhat, experts say. At the moment, talents are scattered; the designer may want to go to Texas Instruments for a receiver transistor, to RCA for a power transistor and to Microwave Associates for a switching diode. But those who will get into the business of mass production will have to try to combine all these talents under one roof, to make their operation as efficient as possible.

Getting down to the finer points of engineering, the panel will try to establish guidelines for specific system parameters. Frequency and power levels for both solid-state and tube systems appear high on the agenda.

Solid state and the increased use of microwave integrated circuits are of interest, not only from purely engineering considerations but also because they help to reduce cost and facilitate mass production.

Most panel members agree that monolithic fabrication is just not suitable for microwave circuits at present. The transmission lines that constitute the inactive parts can be built only in a hybrid fashion. Microwave integrated circuits mean flat chips on a substrate, which may be ferrite for frequencies where ferrite devices are needed—mostly above S band. Below S band, semiconductor devices seem to take over all switching and beam-steering functions.

At least one panel member says that he would rather hold off the solid-state approach till transistors with 15 to 20 watts' output become available. "It does not make much sense to push development above L band, since we are just beginning to get transistors with a few watts of output in these frequencies and noise figures around 4 dB," says Vosberg, "and I'd like to see 10 or 20 watts before I can get serious about solid-state transmitters."

But it's an even bet that others on the panel will challenge him on this.

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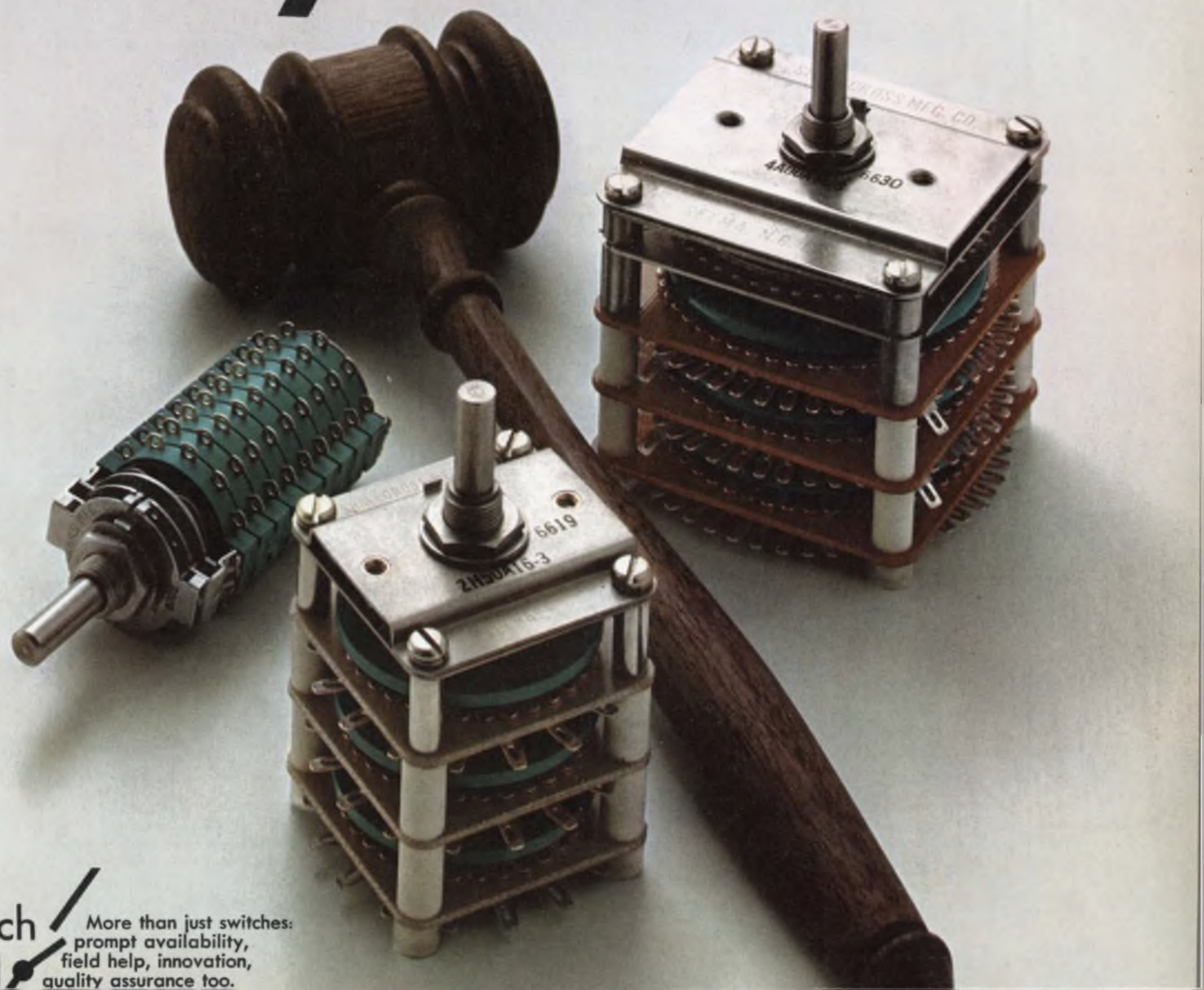

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TYPE	**FUNCTION**				
MEM 5014	A/D-D/A CONVERTER ELEMENT	135 mW	$-27V \pm 2V$	dc to 200 kHz	Complete logic and analog switching for 10-bit successive approximation A/D converter.
MEM 5015	16 CHANNEL RANDOM ACCESS MULTIPLEXER	70 mW	$-27V \pm 1V$	100 kHz	Sixteen Channel Multiplexer with address storage and decoding.
MEM 5021	DDA ELEMENT	100 mW	$-13V \pm 1V$ $-27V \pm 1V$	500 kHz	Ternary type DDA performing rectangular integration.
MEM 5031	SERVO ADDER	25 mW	$-13V \pm 1V$ $-27V \pm 1V$	dc to 1.0 MHz	Shift Register content decision unit
MEM 5035	SIGMA DELTA "Y" SUMMER	25 mW	$-13V \pm 1V$	10 kHz to 1 MHz	2 Input Delta "Y" Summer used in conjunction with the MEM 5021
S-C-100	MINIATURE A/D CONVERTER SYSTEM	300 mW	$-27V \pm 2V$ $-15V \pm 2V$ $+15V \pm 2V$ REF. VOLT	100 kHz	Complete 10-BIT A/D Converter System

MULTIPLEXER CIRCUITS ($T_A = -55°C$ to $+85°C$)		OFF RESISTANCE (Ω TYP)	ON RESISTANCE (Ω TYP)	CAPACITANCE (pf) Cgd	BV_{DSS} (VOLTS)	BV_{GSS} (VOLTS)
TYPE	**FUNCTION**					
MEM 2002	5 CHANNELS (4 Channels —Common Drain)	10^{10}	200	1.1	−30	−30
MEM 2003	4 CHANNELS (Protective Diodes)	10^{10}	200	1.1	−30	−30
MEM 2004	4 CHANNELS (No Diodes)	10^{10}	200	1.1	−30	±60
MEM 2005	4 CHANNELS (Dual 2 Channel)	10^{10}	200	1.1	−30	−30
MEM 2006	3 CHANNELS (2 Channels —Common Drain)	10^{10}	200	1.1	−30	−30
MEM 2009	6 CHANNELS (Protective Diodes)	10^{10}	150	1.9	−30	−30

SERIES SHUNT CHOPPER		OFFSET VOLTAGE	CLOCK ϕ	FREQUENCY (kHz)	ON RESISTANCE PER UNIT (SERIES OR SHUNT) (Ω TYP)	OFF RESISTANCE PER UNIT (SERIES OR SHUNT) (Ω TYP)	SIGNAL VOLTAGE HANDLING RANGE (TYP)
TYPE	**FUNCTION**						
MEM 2008	INTEGRATED SERIES SHUNT CHOP. CIRCUIT	0	1	100	6K	10^{12}	$1\mu V-10V$

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ON READER-SERVICE CARD CIRCLE 58

FLUIDIC LOGIC TAKES TO THE AIR

Control elements that use gases can guide missiles and stabilize helicopters

Roger Kenneth Field
Technical Editor

Despite the great flood of publicity about fluidics, designers find the new technology obscured by the shadow of electronics. Yet fluidic logic and control elements can reliably perform many intricate tasks, particularly where the equipment is expected to work in the face of temperature extremes, stifling humidity, chronic vibrations or violent shock.

Fluidics refers to a technology invented in 1958 in which streams of fluids—liquids or gases—are controlled by other streams of fluids. These fluids travel in channels and passageways that are gouged, etched, molded or milled in many materials, such as clays, glass, plastics, and ceramics as well as metal alloys like beryllium copper and tungsten steel. The reliability of fluidic systems hinges on the stability of the materials that comprise them, and the relatively simple fabrication requirements of fluidic elements allows the use of extremely tough materials.

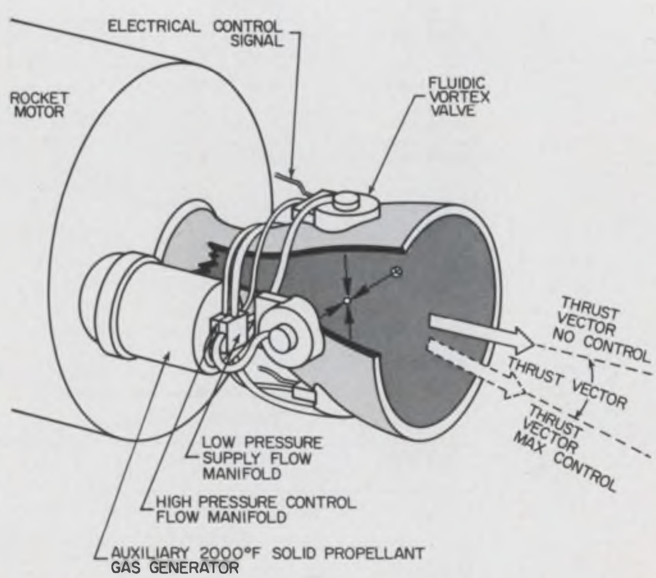
The military needs a flip flop

Fluidics, like many other technologies, was spun off military research. The basic fluidic logic element, the flip-flop, was developed at what was then the Harry Diamond Ordnance Laboratory. For the Department of Defense in 1958, fluidics represented a rocket control system that was immune to radio-frequency jamming; it now represents a missile control system that is unaffected by ionizing X-ray radiation propogated in space by an enemy's anti-missile.

There are two pure fluid systems for the control of rocket engine exhaust. One is an analog system, which uses four proportional vortex amplifiers operating in a push-pull mode at the rocket's exhaust to control the direction of the tail. The other is a digital system which expels a portion of the exhaust through a giant fluidic flip-flop built into the tail. A fluidic guidance system in this missile determines the relative switching time for each of the flip-flop outputs that keeps the missile on course.

The basic theory and design of the proportional system is revealed in a paper presented at the WESCON fluidics session (Session 11). Using a warm gas (2000°F) for the control of the engine's hot exhaust, four vortex amplifiers steer the missile. The injected stream pumped by an amplifier into the tail of the missile creates a shock wave that disturbs the laminar flow of the rocket's exhaust. This induces the cross section of the exhaust to be asymetrical and the resulting force moves the tail of the missile in the direction of the vortex amplifier creating the shock. Jerome Rivard, head of propulsion controls, Bendix Research Laboratories, Southfield, Mich., describes the performance of this analog control system.

The digital missile control was developed by the Honeywell Aerospace and Defense Group, at Minneapolis. This fluidic control system controls the missile's spin by venting a portion of the exhaust through a giant flip-flop, to one side of the missile or the other. The Aerospace and Defense

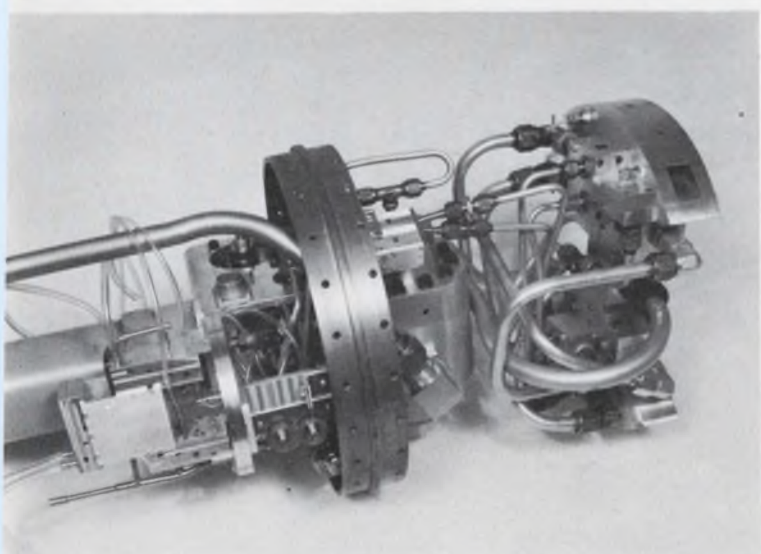


The Bendix analog rocket control uses four fluidic vortex valves to direct the tail.

Group is now developing an all fluidic control system to stabilize a helicopter. The firm hopes to test the system aboard a Navy CH-46A tandem-rotor helicopter at the Patuxent River Naval Air Station, Md., this fall. The system will sense the helicopter's attitude with three vortex rate sensors, amplify and process the information with fluid amplifiers, and adjust the helicopter's attitude by actuating conventional hydraulic control servos with fluidic-to-hydraulic transducers. Honeywell believes that this fluidic stabilizing system will be able to withstand the vibrations of the helicopter's jet engines far better than electronic controls, yet it will be able to respond to sudden instabilities more quickly and reliably than pneumatic and hydraulic control systems, which rely on moving mechanical parts.

Industrial uses for fluidics are hard on the heels of these military applications. The Sperry Utah Div. of Sperry Rand, Salt Lake City, Utah, has developed a fluidic proportional control system to regulate an important step in the extraction of gold. In another paper at WESCON's session 11, Sperry's Robert Blosser describes the operation and design of a system that his company put into service at the Carlin Gold Mine. He encountered two interesting problems: the response of the fluidic controls was so fast that the system oscillated about the ideal operating point and the valve that controlled the flow of gold slurry tended to cycle open and closed; and the slurry kept clogging a probe in the system.

The first problem was solved simply by the addition of sufficient damping to the feedback network. To solve the clogging problem, Sperry had to develop special probes that would sense the slurry level without clogging. One of the problems with fluidics at this early point in its development is the fact that relatively few sensing devices have been designed, and, although there is a more than ample supply of logic elements for the design of many systems, most special sensing requirements almost inevitably demand the design of new transducers.



Honeywell's giant flip flop at the extreme left keeps a small test missile from spinning.

Though the designer of fluidic systems must contend with the dearth of sensors, transducers and interface equipment that accompanies the introduction of any logic technology, there is readily available a number of convenient systems for forming compact fluidic logic circuitry. The goal of these systems is to make it easy for the logic designer to string together the elements required by his design, and to be able to do so confident that it will work.

The latest approach is a system that will soon be announced by Corning Glass, Corning, N. Y. With it, each logic element is connected into the system by screwing it into a common manifold. Thus, rather intricate logic schemes can be implemented with preformed, standard logic elements such as gates, flip-flops and inverters. The final assembly is more than adequately compact for most industrial control applications, and it doesn't look like a prototype, which inevitably sports a maze of plastic tubes running in every conceivable direction.

With fluidics, as with microelectronics, the intraconnection of complex systems is a formidable problem. Already, fluidic manufacturers have developed various methods for integrating logic elements. Corning, for example, stacks glass slides into which fluidic channels have been etched and then fires the slides to fuse them into a solid ceramic-glass circuit.

Martin-Orlando does the same sort of stacking with etched, thin sheets of beryllium copper.

Fluidics' airy humor

For the electronic logic designer, fluidics offers a certain comic relief. After one grows accustomed to nanosecond delays, discussion of the millisecond response time of fluidic elements is often tinged with amusement. Fluidic designers discuss their systems in electrical terms, and it seems almost facetious to speak of the inductance of a long, fine air-tube or the capacitance of a bell jar. Yet just such analogies make it extremely easy for an electronic designer to feel at home in the airy field of fluidics. Sophisticated systems are being built. Fluidics now offers manufacturers of industrial controls a very quick alternative to pneumatics and hydraulics, the two technologies with which they have become thoroughly familiar. WESCON's session 11 sheds some light on to what is to many electronic designers the murky world of fluidics. ■ ■

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ON READER-SERVICE CARD CIRCLE 59

WHEN, WHERE AND WHAT TO HEAR

Here's the complete technical program at the show, by session, including times and places for each paper.

1 Linear Integrated Circuits

(Tues./a.m./D)

Chairman: Jerry Eimbinder, *EEE Magazine.*

1/1 Applications for rf/i-f Integrated Circuit Amplifiers—*Ralph Seymour, Signetics Corp.*

1/2 Dual Integrated-Circuit Operational Amplifiers—*Leo L. Wisseman and Bill Ehrsam, Motorola Semiconductor Products.*

1/3 The Trade-Off Between Cost and Performance in Operational-Amplifier Integrated Circuits:

Part 1—Designing for Industrial/Consumer Applications—*Jerry W. Gibbs, Amelco Semiconductor.*

Part 2—The Performance/Economics/Marketplace Interrelationships—*Jack Gifford, Fairchild Semiconductor.*

2 Business Management: The Engineer Becomes Manager

(Tues./a.m./T)

Chairman: Don C. Hoefler, *Electronic News.*

2/1 Management Is the Direction of People—*James F. Riley, Signetics Corp.*

2/2 Pitfalls in Money Management—*Daniel G. White, Commonwealth National Bank of San Francisco.*

2/3 A Model for Management Action—*Charles H. Keller, Illumination Industries.*

2/4 Managing a Major Turnaround—*Martin H. Dubilier, Friden, Inc.*

3 Radar Performance on Hypersonic Reentry Vehicles

(Tues./a.m./De)

Chairman: Lloyd M. Melick, Sandia Corp.

3/1 Microwave Transmission Studies through a Hypersonic Air Plasma—*D. W. Boyer, Cornell Aeronautical Lab.*

3/2 Effect of Reentry Vehicle Environment on Electromagnetic Transmission—*J. B. Chown, Stanford Research Institute.*

3/3 An Experimental Evaluation Technique for Reentry Vehicle Antenna Windows—*Lt. Bruce J. Benedict, Kirtland AFB.*

3/4 A Technique for Analyzing Antenna Pattern and Radar Return Effects on Spinning Vehicles—*James A. Cooper and C. D. Ouverson, Sandia Corp.*

4 Varactor Tuning of Receivers

(Tues./p.m./D)

Chairman: Johnnie Cochran, Motorola Semiconductor.

4/1 Designing around the Tuning Diode Inductance—*G. Schaffner, Motorola Semiconductor.*

4/2 Application of Electronic Tuning to Tactical Communications Equipments —*E. A. Janning, Avco Electronics.*

4/3 Voltage-Variable-Capacitor Tuning of Radio-Frequency Amplifiers—*Jorge E. Roza, General Dynamics Electronics Div.*

4/4 Varactor Tuning Applied to Radio Receivers—*Rinaldo DeCola, Warwick Electronics.*

4/5 Hyperabrupt Tuning Diode Theory and Application to a-m Radio—*Peter M. Norris, Motorola Semiconductors.*

A Special Session Electronics and Meteorology

(Tues./p.m./De)

Chairmen: Bruce B. Lusignan, Stanford University, and Allen M. Peterson, Stanford Research Institute.

A/1 Feasibility and Utility of Satellite Lidar—*William E. Evans, Stanford Research Institute.*

A/2 Observations of Earth's Cloud Cover from Synchronous Satellite—*Dr. Verne Suomi, University of Wisconsin.*

A/3 Weather Experiments for Apollo Applications—*Dallas Evans, NASA.*

A/4 Meteorological Satellite Elec-

Code to abbreviations

The abbreviations used within this index are as follows:

a.m. — Morning sessions (10 a.m. to 12:30 p.m.)

p.m. — Afternoon sessions (2 p.m. to 4:30 p.m.)

All sessions will be held in the Cow Palace Convention Hall as follows:

D — DuBridge Hall

T — Terman Hall

De — Deforest Hall

E — Edison Hall

Numerals refer to sessions and to papers within a session — for example, 4/1 is paper 1 in session 4.

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Intrinsic Coercive Force (H_{ci})	Oersteds	2400
Peak Energy Product (B_dH_d max)	Gauss-Oersteds	2.6×10^6
Reversible Permeability	—	1.09
Curie Temperature	+°C	450
Temperature Coefficient of Flux Density at B_r	%/°C	−0.20
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tronics Requirements of the Future—*Dr. Harry Press, NASA.*

5
Gas Laser Stabilization

(Wed./a.m./E)

Chairman: D. E. Caddes, Sylvania Electronic Systems.

5/1 The Spectrum of a Laser Oscillator—*A. E. Siegman, Stanford University.*

5/2 Pressure Shifts and Related Effects in the He-Ne Laser—*Arnold L. Bloom, Spectra-Physics, Inc.*

5/3 Frequency Stabilization of Gaseous Zeeman Lasers—*W. Culshaw, J. Kannelaud, and D. G. Peterson, Lockheed Missiles and Space Co.*

5/4 A Frequency Stabilized fm Laser—*Russell Targ and L. M. Osterink, Sylvania Electronic Systems.*

6
Data Compression

(Wed./a.m./D)

Chairman: C. M. Kortman, Lockheed Missiles & Space Co.

6/1 Mechanization of a Digital Compressor for Biomedical Data—*G. M. Loh, Lockheed Missiles & Space.*

6/2 The Effect of Channel Errors on Data Compression—*L. D. Davisson, Princeton University.*

6/3 Adaptive Buffer Design for Data Compression Systems—*G. R. Schwarz, IBM Federal Systems Div.*

6/4 General-Purpose vs Special-Purpose Computers for Data Compression—*D. Hochman, Adcom, Inc.*

6/5 General-Purpose Telemetry Data Compression—*J. J. Downing, W. E. Smith and J. E. Stubbles, Lockheed Missiles & Space Co.*

7
Patient Monitoring Systems: Progress, Problems, Prospects

(Wed./a.m./T)

Chairman: Dr. Curtis E. Miller, Beckman

Instruments.

7/1 *Dr. Eliot Corday, Cedars-Sinai Hospital, Los Angeles.*

7/2 *Dr. C. William Hall, Baylor University College of Medicine.*

7/3 *Dr. Donald C. Harrison, Stanford University School of Medicine.*

7/4 *John Mannes, Methodist Hospital, Houston,*

(Paper titles to be announced)

8
Designing Radio-Frequency Circuits Using FETs

(Wed./a.m./De)

Chairman: Robert Dale, Motorola Semiconductor.

8/1 Field-Effect-Transistor rf Mixer Design Techniques—*Siang Ping Kwok, Motorola Semiconductor.*

8/2 Field-Effect-Transistor rf Power Design Techniques—*J. B. Compton, Siliconix.*

8/3 Field-Effect-Transistor rf Amplifier Design Techniques—*Roy Hejhall, Motorola Semiconductor.*

8/4 Field-Effect-Transistor Design Techniques at Broadcast Frequencies—*Donald L. Wollesen, Philco Microelectronics Div.*

8/5 Using Insulated-Gate Field-Effect Transistors as Versatile Oscillator Elements—*George D. Hanchett, RCA.*

B Special Session
LSI in Computer System Design

(Wed./p.m./E)

Chairman: W. H. Davidow, Hewlett-Packard.

B/1 The State of LSI Technology—*Richard Petritz, Texas Instruments.*

B/2 Present and Future Cost Factors in LSI—*Gordon Moore, Fairchild.*

B/3 Use of LSI in Future Large Computer Systems—*Gene M. Amdahl, IBM Corp.*

B/4 LSI in Small Systems: Practicality and Economic Considerations.—*L. C. Hobbs, Hobbs Associates.*

9
Recent Developments in Communications Systems

(Thurs./a.m./E)

Chairman: John V. N. Granger, Granger Associates.

9/1 Trends in Communications Systems Development—*W. R. Vincent, Stanford Research Institute.*

9/2 Limitations of Radio Propagation Media—*Thomas Kailath and Paul Shaft, Stanford Research Institute.*

9/3 Progress in Modulation and Demodulation Techniques—*W. L. Hatton, Defense Telecommunications Establishment, Ottawa.*

9/4 Transportation or Communications—Some Broad Considerations—*Timothy Healy, University of Santa Clara.*

10
Digital Approach to Analog Functions

(Thurs./a.m./D)

Chairman: James F. Kaiser, Bell Telepone Laboratories.

10/1 Why Use Digital ICs for Analog Functions?—*Donald Breslow, Itek Corp.*

10/2 Four Digital Arrays Do All Algorithms—*George T. Sendzuk, General Electric Co.*

10/3 A Comparison of Analog and Digital Integrated-Circuit Techniques for Sine and Cosine Generation—*James R. Garvey, RCA Aerospace Systems Div.*

A brief summary by Dr. Kaiser will be followed by a panel discussion with audience participation.

11
Progress in Fluidics Applications

(Thurs./a.m./T)

Chairman: D. F. Folland, Sperry Utah Co.

11/1 Secondary-Injection Thrust Vector Control Using Fluidic Vortex Valves—*Jerome G. Rivard, Bendix Research Laboratories.*

11/2 Fluidic Time Optimal Adaptive Control System—*Robert F. Turek, Bowles Engineering Corp.*

11/3 Fluidic Device Testing—*Harold L. Fox, Fluidonics Research Labs. Div. of Imperial Eastman Corp.*

11/4 Proportional Control Systems in Industry—*Robert L. Blosser, Sperry Utah Co.*

11/5 A Pneumatically Controlled Document-Handling System—*R. R. Coleman, Jr., and Richard S. Gluskin, Univac Div. of Sperry Rand Corp.*

12
High-Density Recording Techniques

(Thurs./a.m./De)

Chairman: Roy D. Sturkie, Leach Corp. Controls Div.

12/1 High-Density Electron and Lightbeam Recording—*Charles F. Spitzer, Ampex Corp.*

12/2 Magnetic Heads for High-Density Digital Recording—*Donald T. Best, Ferroxcube Corp.*

12/3 A Technique for High-Density Digital Recording—*Kermit Norris, Leach Corp. Controls Div.*

12/4 Ultra-High Data-Packing-Density Recording Related to Manned Spacecraft—*Donald Ray Smith, NASA.*

C Special Session
The Frequency Spectrum —An International Resource

(Thurs./p.m./E)

Chairman: James D. O'Connell, Executive Office of the President.

A panel of experts led by James D. O'Connell, Director, Telecommunication Management, Office of the President, will discuss various aspects of frequency spectrum management.

13
Solid-State Imaging—An Evolving Technology

(Fri./a.m./E)

Chairman: Carl Huggins, Marshall Space Flight Center.

13/1 100 x 128 Element Solid-State Imaging System—*D. E. Callahan, R. A. Anders, W. F. List, M. E. Wing, and D. H. McCann, Westinghouse Electric Corp.*

13/2 A Report on the Development at Fairchild Semiconductor of Integrated Arrays of Silicon Photodetectors of Image Sensing—*G. P. Weckler and R. H. Dyck, Fairchild Semiconductor Research and Development Laboratory.*

13/3 A Self-Scanned Solid-State Image Sensor—*P. K. Weimer, G. Sadasiv, J. E. Meyer, L. Meray-Horvath and W. S. Pike, RCA Laboratories.*

13/4 Solid-State Image Intensifier—*R. D. Stewart, General Electric.*

14 Panel Session

The Future of Solid-State Phased Arrays

(Fri./a.m./D)

Chairman: Arthur S. Robinson, RCA Missile & Surface Radar Div.

Panelists:

- R. D. Alberts, Air Force Avionics Lab., Wright-Patterson AFB;
- Carl Blake, Lincoln Laboratories;
- Douglas Mather, Rome Air Development Center, Griffis AFB;
- Thomas Hyltin, Texas Instruments;
- Frank A. Brand, Electronic Components Laboratory, Fort Monmouth;
- Thomas Madigan, Bell Telephone Laboratories;
- Malcom Vosburg, Institute of Defense Analysis;
- Arthur S. Robinson, RCA Missile & Surface Radar Div.

15

Static Power Systems: Controls, Inverters, Rectifiers, Power Systems

(Fri./a.m./T)

Chairman: David W. Borst, International Rectifier Co.

15/1 Problems in Designing a dc Power Transmission System—*Stuart P. Jackson, Solid-State Controls, Inc.*

15/2 Current Regulators for Electrochemical Rectifier Systems—*R. P. DePuy and J. W. Luoma, General Electric Co.*

15/3 Application & Design Aspects of a 2.5-kVA Solid-State Frequency Converter for An Airborne Installation—*S. G. Campbell and T. H. Ussher, The de Havilland Aircraft Co. of Canada, Ltd.*

15/4 Static Stand-by Power Systems—*Chris F. Seyer, Fansteel Metallurgical Corp.*

15/5 Redundancy and Switching in Stand-by Systems—*Stuart P. Jackson and Dennis M. Swing, Solid-State Controls, Inc.*

16

The Computer as a System Component

(Fri./a.m./De)

Chairman: Pete England, Scientific Data Systems.

16/1 The Impact of Third-Generation Computers on System Design—*David L. Stein and Joe Glasier, Scientific Data Systems.*

16/2 A Third-Generation Computer in a Nuclear Physics Laboratory—*Richard F. Au, John V. Kane, and William E. Merritt, Michigan State University.*

16/3 Software as a Component in Computerized Systems—*Bob L. Ryle, Planning Research Corp.*

16/4 On-Line Computers and Patient Care—*Shannon Brunjes and Robert F. Maronde, University of Southern California; Stanley Seibert, Los Angeles County Hospital; John C. Soutter, IBM.*

D Special Session

Systems Approach to Natural Resources Control

(Fri./p.m./E)

Chairman: R. J. Pafford, Jr., Bureau of Reclamation, Sacramento, Calif.

D/1 Integrating Hydro and Thermal Generation—*E. F. Kaprielian, Pacific Gas and Electric Co.*

D/2 Systems Analysis Applications for the Future—*John Eichelman, Stanford Research Institute.*

D/3 Missouri Basin Flood Control and Water Conservation—*Tim Waara, Missouri River Div., U.S. Corps of Engineers.*

D/4 Bonneville Power Administration System Control—*Marvin Harris, Bonneville Power Administration.*

THE PACKAGING SYMPOSIUM

Here's a guide to the Electronic Packaging Symposium to be held Aug. 21 and 22 at the San Francisco Hilton.

1
Considerations for Joining Techniques

(Mon./a.m.)

Moderators: D. A. Beck, Bendix Research Labs., and E. C. Neidel, Sandia Corp.

1/1 Influence of Surface Structure on the Quality of Gold Electrodeposits—*J. B. P. Williamson and Morton Antier, Burndy Corp.*

1/2 Ultrasonic Soldering and Bonding Techniques—*Paul J. Bud, Electrovert, Inc.*

1/3 Nondestructive In-Process Weld Evaluation—*Forest C. Deal, Martin-Marietta Corp.*

1/4 Electromechanical Design of a Matched Impedance Connector—*H. H. Blonder and R. T. Evans, IBM.*

1/5 System Packaging At The Chip Level—*W. L. Doelp, Jr., Philco-Ford Corp.*

2
Advances in Packaging Techniques

(Mon./p.m.)

Moderators: H. J. Scagnelli, Bell Telephone Labs., and T. A. Telfer, General Electric Co.

2/1 A Preliminary Investigation of Plastic Encapsulated Transistors—*Edward B. Hakim and R. Canepa, U. S. Army Electronics Command.*

2/2 Development of Thin-Film Circuits with Thick-Film Conductor Networks and Crossovers—*Halle Abrams, Western Electric.*

2/3 Thick-Film Techniques and Design Criteria for Space-Vehicle Application—*A. Ottaviano and J. Thomas, General Electric.*

2/4 The Application of Thick-Film Technology in Multilayered Circuitry—*W. O. Giesfeldt, Centralab.*

3
Linking the Electronics

(Mon./p.m.)

Moderators: W. J. Prise, Lockheed Missiles & Space Co., and G. E. Gless, University of Colorado.

3/1 Fabricating Reliable Multilayer Boards—*D. H. Rossi, Conductron-Missouri.*

3/2 A Flat-Pack Module Intraconnected by Molded Printed Circuits—*L. Eugene Jayden and Cornelius D. Flynn, Westinghouse Electric Corp.*

3/3 Equipment Design for Integrated-Circuit Packaging—*J. P. Focarlie and C. D. Irish, Bell Telephone Labs.*

3/4 Flexible Circuit Connections—*F. R. Sullivan, Lockheed Missiles & Space Co.*

4
The Computer and Electronic Packaging

(Tues./a.m.)

Moderators: E. J. Lorenz, IBM Corp., and T. G. Boe, *EDN* Magazine.

4/1 Packaging Aspects of Computer-Designed Multilayer-Interconnection Printed-Wiring—*Gerald L. Ginsberg, Philco-Ford.*

4/2 Large-Scale Integration—Computer Aids and Systems Aspects—*Thomas F. Prosser, Philco-Ford Corp., Microelectronics Div.*

4/3 Computer-Automated Design and Thermal Analysis of Printed Circuits—*B. Hyman and M. J. Merges, Bell Telephone Labs.*

4/4 Packaging Flat-Pack Integrated Circuits for Earth Satellites—*Robert C. Moore, Johns Hopkins University.*

5
Some Aspects of Thermal Design

(Tues./a.m.)

Moderators: R. C. Mayne, JPL, and J. R. Goodykoontz, TRW.

5/1 Thermal Design Considerations of a Very High-Speed Computer—*Kenji Taniguchi and Yuichiro Oya, Central Research Laboratory.*

5/2 Thermal Design for IBM System/360 Model 91—*V. W. Antonetti, R. C. Chu and J. H. Seely, IBM.*

5/3 Thermal Problems Encountered in the Design of the Electronics Packages of the LMS-Band Steerable Antenna and the Apollo High-Gain Antenna—*Allen L. Schmidt, Dalmo Victor.*

5/4 Temperature Predictions Within an Electronics Section of an Externally Mounted Aircraft Missile During Mach-4.0 Carry Flight—*S. A. Casazza, Raytheon Co.*

5/5 Simplified Transmitter Cooling System—*L. R. Paradis, Raytheon Co.*

6
Meeting the Challenge in Electronic Packaging

(Tues./p.m.)

Moderators: J. C. Rubin, Eastman Kodak Co., and S. Shuey, Sprague Electric.

6/1 Packaging Design of a Solenoid Array Correlator—*John G. Simon, Sylvania Electronic Systems.*

6/2 The Integration of Microelectronics and the Product—*J. F. Hinchey, Friden, Inc.*

6/3 Packaging Design of the Apollo-Lunar-Module Abort Computer—*Thomas B. Hibler, TRW, Inc.*

6/4 Packaging a Capacitor Read-Only Memory—*C. P. del Cano and H. E. Mayles, IBM.*

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ELECTRONICS

Technical Program

"MICROELECTRONICS COMES OF AGE"

Here's a guide to a special technical symposium to be held Aug. 23 and 24 at the San Francisco Hilton.

1

An Introduction to Microelectronics

(Wed./a.m.)

Keynote Address: Microelectronics in Perspective—*E. Keonjian, Grumman Aircraft Engineering Corp.*

1/1 Terminology and Classifications —*S. M. Stuhlbarg, Raytheon.*

2

The Hybrid Approach

(Wed./a.m.)

Session Organizer: Wayne Martin—RCA.

2/1 Thin-Film Networks—*M. Penberg, Aerojet General Corp.*

2/2 Thick-Film Networks—*R. C. Early, General Electric Co.*

2/3 Microcomponent Parts and Assembly—*M. Ohanian, Raytheon Co.*

2/4 Microbonding—*R. Eggleston, Kulicke & Soffa, Inc.*

2/5 Microassembly Production Techniques Using Thin Films—*W. D. Moyers, Lockheed Electronics.*

2/6 Microassembly Production Techniques Using Multichips—*J. Welty, Amelco Co.*

2/7 Microassembly Production Techniques Using Thick Films—*R. Lia, IBM.*

3

The Monolithic Approach

(Wed./p.m.)

Session Organizer: Carl H. Worembrand, Adage, Inc.

3/1 Basic Theory—*H. C. Lin, Westinghouse Molecular Electronics.*

3/2 Processing—*C. Awad, Raytheon Semiconductor Operation.*

3/3 Design Parameters—*R. E. Bohn, Sylvania Semiconductor.*

3/4 Bipolar Digital Circuit Applications—*W. R. Rhoades, Hughes Aircraft Co.*

3/5 MOSFET Circuit Applications—*M. Sussman, General Instruments Corp.*

3/6 Linear Circuit Applications—*J. Gifford, Fairchild Semiconductor.*

3/7 Microwave Circuit Applications —*V. Gelnovatch, U. S. Army Electronics Command.*

4

Interconnection and Packaging Technology

(Thurs./a.m.)

Session Organizer: Donald Sherman—Raytheon Co.

4/1 Current and Future Packaging Methods—*J. J. Staller, Sylvania Electric Co.*

4/2 Large-Scale Integration—*J. Lathrop, Texas Instruments.*

4/3 Mechanical Wiring Technology —*L. Katzin, Jet Propulsion Laboratory.*

4/4 Multilayer Wiring Technology—*A. Levy, RCA.*

4/5 Thermal Management—*J. R. Baum, Motorola Inc., Government Products Div.*

4/6 Future Manufacturing Methods—*Maurice Nelles, University of Virginia.*

5

Reliability and Cost Effectiveness

(Thurs./p.m.)

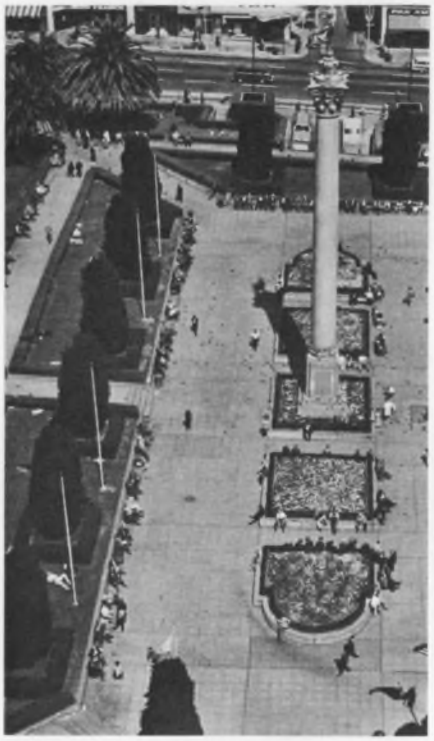
Session Organizer: Jules A. Rothman—Ikor Inc.

5/1 Microelectronics Reliabillity—*Eldon Hall, MIT Instrumentation Laboratories.*

5/2 Reliability Characteristics of Integrated Circuits—*D. I. Troxel, RCA.*

5/3 Cost Effectiveness—*H. Gunther Rudenberg, A. D. Little, Inc.*

5/4 The DOD View—*Ernest C. Wood, Department of Defense.*



Union Square, near the Hilton, is the hub of San Francisco's shopping area.

6

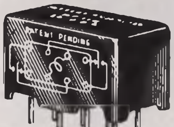
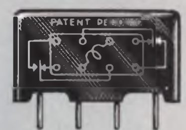
A Look into The Future

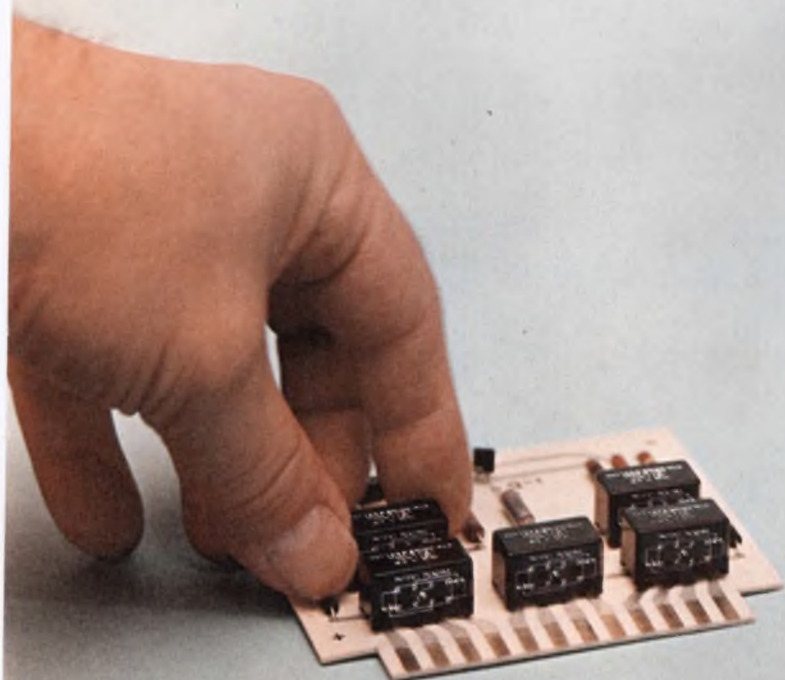
(Thurs./p.m.)

Session Organizer: Jules A. Rothman—Ikor Inc.

6/1 Systems of the Future—*W. W. Gaertner, Gaertner Research, Inc.*

6/2 The Future of Integrated Circuits —*Glen R. Madland, Integrated Circuit Engineering Corp.*

NEW! A commercial relay this  small with 2-ampere dpdt contacts. Printed circuit or socket terminals.  Has Lexan dust cover. This design bonus from our aero/space program is ideal for tape recorders, desk-top computers,  copying machines, television cameras, alarm systems, etc., etc., etc., etc., etc.



High density relay packaging becomes a reality with the low profile HP Series. Only one-fifth of a cubic inch is required for each relay. Seated height in socket or printed circuit board is 0.49". Mechanical life is placed at 10 million operations.

The DPDT contacts are rated from low level to 2 amperes at 30V DC resistive or 0.5 ampere maximum at 120V AC. Coil voltages range from 6V to 48V DC . . . with 12- and 24-volt models available from authorized electronic parts distributors.

These microminiature relays are direct descendants of our military, aero/space designs and have been engineered to perform with singular reliability in modern commercial equipment.

HP SPECIFICATIONS

GENERAL:
- **Temperature Range:** −45°C to +70°C.
- **Dimensions:** 0.49" x 0.88" x 0.48" max.

CONTACTS:
- **Arrangement:** DPDT, 2 Form C.
- **Rating:** Low level to 2 amps @ 30V DC, resistive; 0.5 amps max. @120V AC.
- **Contact Resistance:** 50 milliohms before life measured at maximum rated load.

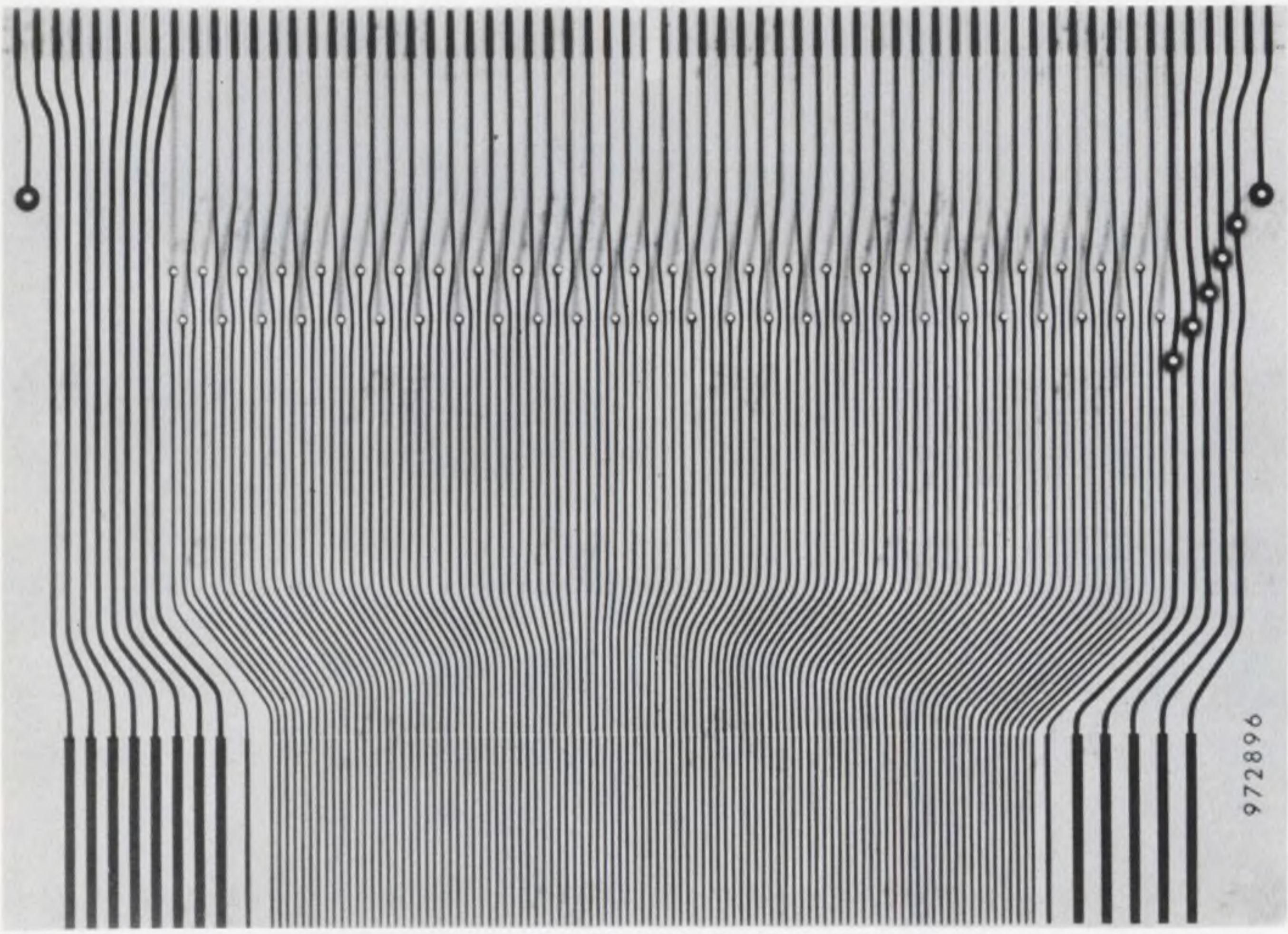
COILS:
- **Power:** Approximately .662 watts nominal @ 25°C. 1.0 watts max. @ 25°C.
- **Duty:** Continuous.
- **Pick-up:** 75% of nominal @ 25°C.
- **Operate Time:** 5 milliseconds max. at nominal coil voltage and 25°C.

Call your electronic parts distributor

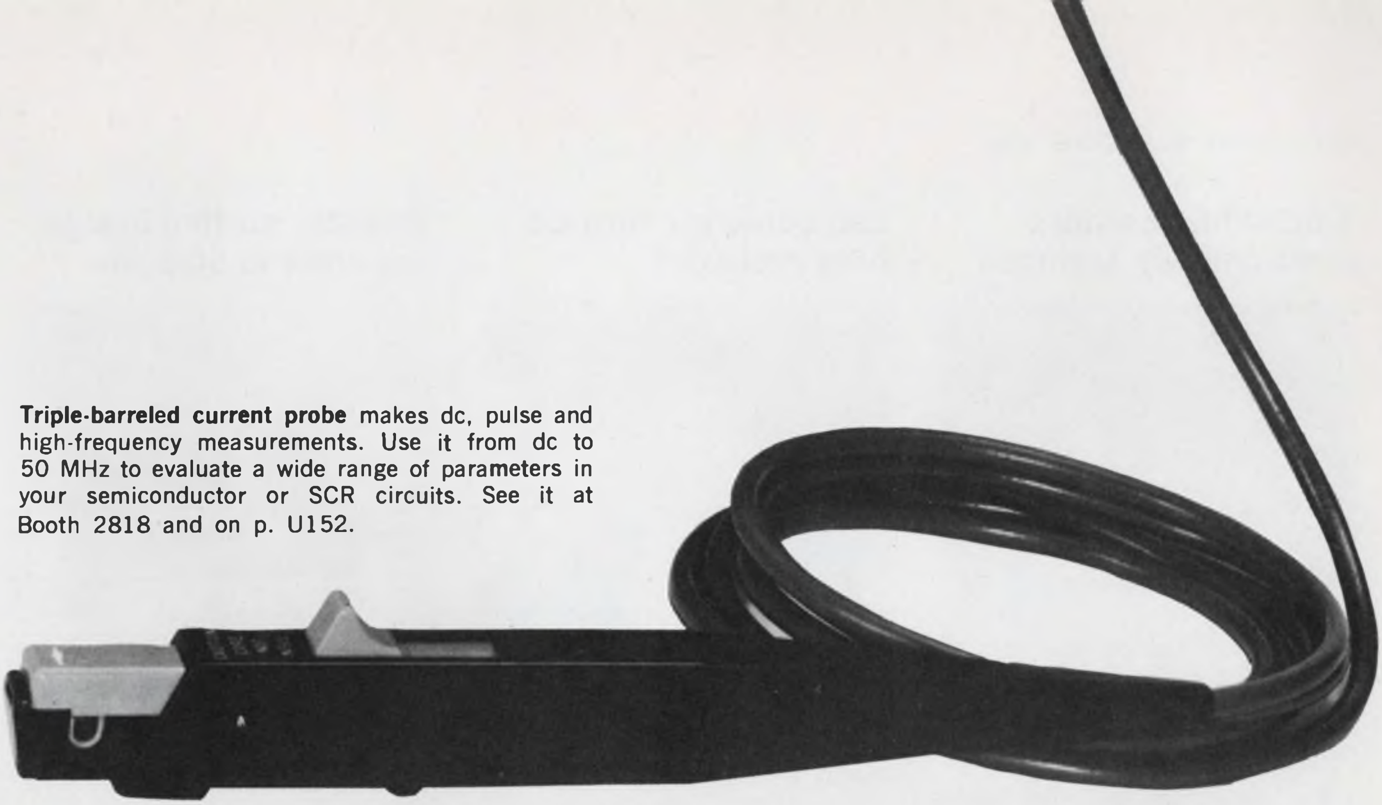
POTTER & BRUMFIELD
Division of American Machine & Foundry Co., Princeton, Ind. 47570
Export: AMF International, 261 Madison Ave., New York, N.Y. 10016

TOURING THE EXHIBIT AREAS

What's new? An electrostatic strip chart recorder, a microwave hybrid and the wares of some 600 exhibitors. Tour the aisles and then "shop the show" using the Reader Service card.

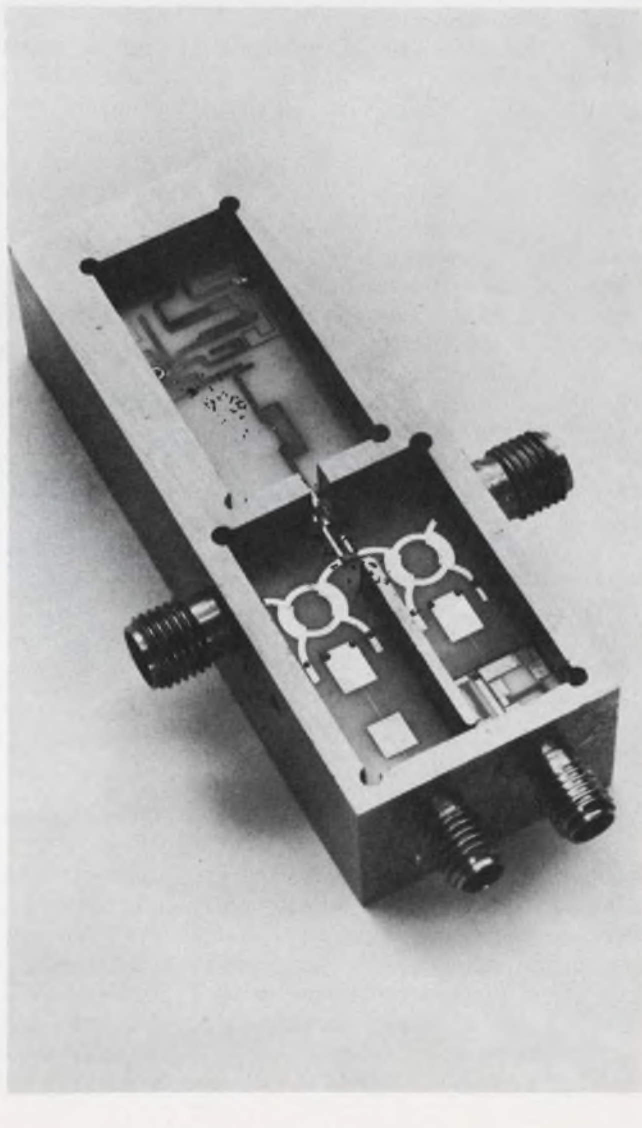


The electrostatic recorder writes as only the paper moves on. Event (left) and time-interval (right) styli flank the 100 fixed data styli in the recording head of Varian's electrostatic strip-chart recorders. With no moving parts other than the transport, the units record dc-to-3-kHz data with a writing speed of better than 20,000 inches per second. Showgoers can see it at Booth 2309, stay-at-homes on p. U148.



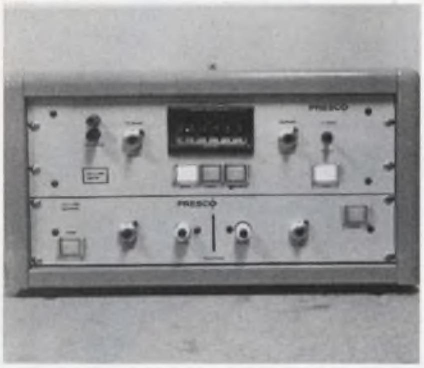
Triple-barreled current probe makes dc, pulse and high-frequency measurements. Use it from dc to 50 MHz to evaluate a wide range of parameters in your semiconductor or SCR circuits. See it at Booth 2818 and on p. U152.

Long-lived ion laser is based on ring-discharge plasma excitation. Its high-power can be used in large-format information displays or to shorten exposure time in holography. At WESCON, it's at Booth 2922; or you can see it on p. U180.



Hybrid integrated mixer and local oscillator assembly performs as well as waveguide and stripline units. Put its size and reliability to work in manpack or airborne pulsed and fm radar receivers. Microwave Associates can tell you about it at Booth 3723, or you can read about it on p. U194.

Thick-film resistors electronically trimmed



Precision Systems Co., Inc., U.S. Highway 22, P. O. Box 148, Somerville, N. J.

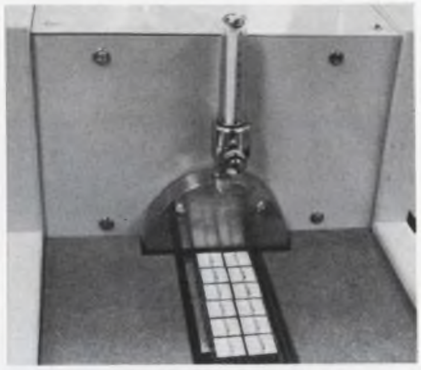
For adjusting thick-film resistors, this equipment uses a high-frequency field operating at high voltage and low current. The complete system consists of a generator and a monitor. The generator, using single or multiple-fixed probes, energizes the fired resistor causing a change in value. The process is clean, rapid, nondestructive, controllable and accurate. Once the unit is set up to adjust a run of resistors, time for each resistor adjustment can be set from a few milliseconds to several seconds. Because of the repeatability of the equipment, it is suited to automatic production applications.

The monitor is an electronic, chopper-stabilized bridge-amplifier circuit. The target resistance is preset into the monitor with two 10-turn pots. Tolerances from a fraction of a per cent to over 5% and target resistances from 1 Ω to 5 MΩ can be selected. The potentiometers may be calibrated externally with any accurate bridge or DVM plugged into calibrating jacks on the monitor panel.

Accessories available include a three-numeral digital ohmmeter to provide resistance readout. A simple, manually switched system is also available using a null-point bridge. This system depends on the operator to shut off the adjustment process. To adjust multiple resistors on the same substrate, the unit may be sequenced or two or more systems can be used, working simultaneously.

Booth No. 1210 Circle No. 341

Lab conveyor furnace fires resistors

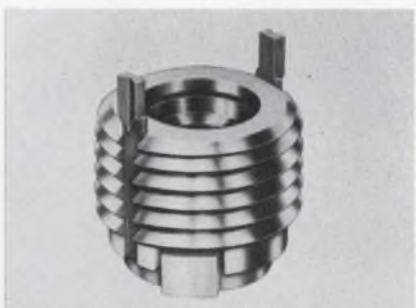


Watkins Johnson Co., Stewart Div., Bean Creek Rd., Santa Cruz, Calif. Phone: (408) 438-2100. P&A: $3975; 6 to 8 wks.

Designed specifically for thick-film firing of resistors, capacitors, and conductors, this lab conveyor furnace has four independently controlled temperature zones available with analog or digital set points and a straight-through quartz muffle. The controlled positive atmosphere flow assures uniform atmosphere quality and gives good binder and solvent removal.

Booth No. 1323 Circle No. 340

Floating insert prevents misalignment



Newton Insert Company, 6500 Avalon Blvd., Los Angeles. Phone: (213) 753-4271.

These inserts simplify the assembly of curved surfaces and permit broader tolerances when using flat head screws. Incorporating "waveform" threads, the units roll their own threads in soft metals and plastics without creating chips. They compensate for misalignments up to 0.04 inches in mating parts.

Booth No. 1817 Circle No. 339

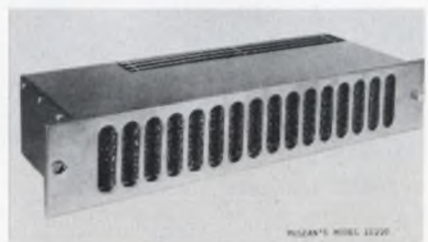
Resistor sorting bridge accurate to 50 ppm

Electro Scientific Industries, Inc., 13900 N.W. Science Park Dr., Portland, Ore. Phone: (503) 646-4141. P&A: $2595; stock to 30 days.

Designed for sorting or measuring resistors at production speeds, this guarded four-terminal Kelvin bridge design permits measurements from well under 1 Ω to more than 100 MΩ in six ranges. The front panel meter allows direct readout of percent deviation on any of the seven calibrated ranges from ±0.01% to ±10% end scale. Panel lights indicate go-no-go sorting.

Booth No. 2717 Circle No. 281

Low-noise blower delivers 150 cfm



McLean Engineering Laboratories, Princeton Junction, N. J. Phone: (609) 799-0100.

This unit fits into a 3-1/2 inch slot in the front panel of an enclosure and forces a slot of air 12-1/2 inches wide to cool the equipment. Air is delivered in one long continuous discharge. The velocity and pressure ensure cooling of densely packed electronics. Each blower is equipped with an aluminum dust filter. The motor is a two-pole operating on 115-volt, 50/60-Hz single-phase power.

Booth No. 3107 Circle No. 316

For a clear picture of Centralab...

...keep an eye on our ripples

In our years of manufacturing miniature and subminiature components, we've made many ripples, and a few splashes, in the electronics industry:

Centralab designed and produced the world's first carbon composition potentiometer and for more than 40 years has been an industry leader. In 1936 we introduced the first temperature-compensating ceramic capacitor in America. We were first to offer dual controls and to add integral line switches to variable resistors. Our exclusive ⟨PEC⟩ integrated circuits have been key elements in the miniaturization of electronic equipment. During World War II days Centralab developed the ceramic disc capacitor design for military requirements. And our Ultra-Kap® ceramic disc capacitor has replaced millions of larger, more costly devices.

Centralab sales have increased substantially every year and our services have grown proportionately. Our products are sold, by separate sales groups and from separate warehouses, to original equipment and distributor markets.

Centralab's tested and proven products include capacitors, packaged circuits, rotary switches, potentiometers and technical ceramics. In October, 1966, we erected a push button switch manufacturing plant and in May, 1967, we acquired solar devices and semiconductor facilities.

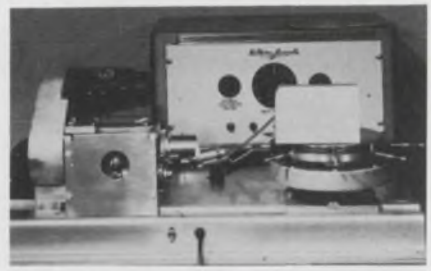
Innovation, growth and stirring the waters are nothing new at Centralab; and we don't intend to stop. As technology advances and components become smaller, more complex and more sophisticated, we'll keep our feet wet.

To help keep abreast of Centralab developments, we'll be happy to send you our periodical "This Is Centralab." Write for future issues.

CENTRALAB
Electronics Division
GLOBE-UNION INC
5757 NORTH GREEN BAY AVENUE
MILWAUKEE, WISCONSIN 53201

ON READER-SERVICE CARD CIRCLE 68

Coil winding unit has many applications



Coil Winding Equipment Co., Railroad Plaza, Oyster Bay, N. Y. Phone: (516) 922-5660

Lattice-wound, pi-wound and progressive universal windings are produced by this equipment. In addition, patterns that cannot be wound on conventional machines are possible. The wire is rapidly distributed across the face of the coil without the use of cams and reciprocating parts. The high winding speeds and free flow of the wire through the winding head is mated with a transfer mechanism so that both winding and transfer time are held down.

Booth No. 1802 Circle No. 344

Arc illuminator puts out 6500 W

Christie Electric Corp., Box 43187, 3410 W. 67th St., Los Angeles. Phone: (213) 750-1151.

High-intensity xenon arc illuminators have applications in photochemistry, semiconductor photoresist processes, high-speed photography and general research. The system includes the lamp, power supply, and lamp housing with optics and igniter. Systems are available in lamp ratings from 200 to 6500 watts with various types of optics and three performance classes of power supplies.

Booth No. 2523 Circle No. 321

"New I/C Dual Op Amp (Op Amp 2) Provides 36-Million Voltage Gain!"

Naturally, you would have no need to use that much gain (right now) . . . yet, the fact remains that with a typical open-loop voltage gain of 6,000 in *each* of the two amplifier sections of the MC1535 (Op Amp²) — the total theoretical voltage gain of the pair in cascade *is* 36,000,000! Now, for a really large number from the industry's first I/C dual op amp, consider the power gain — where you square the above number . . .

Even more importantly, you can *use* whatever gain you need in practical applications without having to cascade. Since two operational amplifiers are constructed on a single monolithic chip and contained within the same package — you can save on component costs — and, on assembly time, too! In addition, you save even more on the low initial cost of the MC1535 Op Amp² — priced at only $8.50 (100-up) in the TO-100 package.

In addition to excellent gain characteristics, the MC1535 Op Amp² also offers excellent stability, with a minimum of external components; so, it functions well in summing amplifiers, integrators or other amplifiers where operating characteristics are a function of feedback. Some of the specifications that help to make possible the versatile and unusual performance of the MC1535 Op Amp² are:

CHARACTERISTIC	SYMBOL	TYPICAL RATING	UNIT
Temperature Drift	$T_{C_{V_{io}}}$	10.0	μV/°C
Output Voltage Swing	V_{out}	±3.6	V
Input Offset Voltage	V_{io}	1.0	mV
Output Impedance	Z_{out}	1.7	kΩ
Input Impedance	Z_{in}	45.0	kΩ
Input Offset Current	I_{io}	0.05	μA
DC Power Dissipation	P_D	100.00	mW

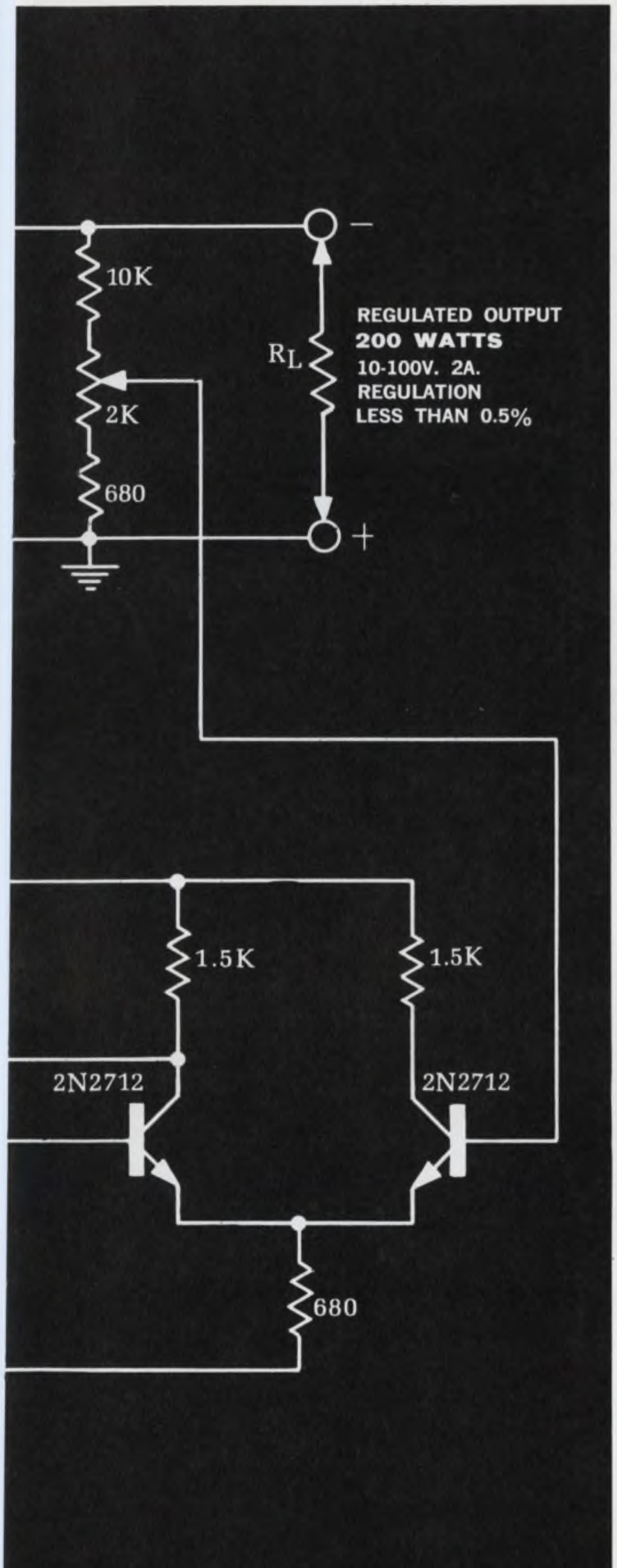
The MC1535 Op Amp² is currently available, from stock, in both the 10-pin metal can and 14-pin ceramic flat pack. For complete details about this exciting, new integrated circuit, write for our data sheet.

where the priceless ingredient is care!

MOTOROLA Semiconductors

MOTOROLA SEMICONDUCTOR PRODUCTS INC. / P.O. BOX 955 / PHOENIX, ARIZONA 85001 / (602) 273-6900 / TWX 910-951-1334

ON READER-SERVICE CARD CIRCLE 63



the switching regulator.

Start with circuit designs using Delco high voltage silicon power.

The simple switching regulator in the diagram at left turns out 200 watts (2 amps) output at efficiencies exceeding 85%. And it does it with just one series element working directly from rectified line voltage: the new Delco DTS-410 transistor at *just $1.95 each**.

Or if you need regulation of 250 volts DC and 400 watts output, the DTS-411 may be your answer. Cost? Just $3.15 each*. And for extra-high voltage applications, there's the DTS-423, now priced at $4.95 each*.

Now combine our new low prices with these other cost-cutting advantages of Delco high voltage silicon power transistors: you can reduce the number and complexity of input, output and filtering components. This means more compact circuitry, greater reliability and lower assembly costs.

These NPN silicon transistors are packaged in a rugged TO-3 case for low thermal resistance. Inside, they are mounted to withstand mechanical and thermal shock because of special bonding of the emitter to base contacts.

There's no need to be concerned about delivery. They are available right now in production quantities. Call us. Or order samples from your Delco distributor.

For details on the switching regulator circuit ask for application note number 39.

*Prices shown are for quantities of 1,000 or more.

TYPE	V_{CEO}	V_{CEO} (sus)	I_C Max	h_{FE} Min @ I_C $V_{CE}=5V$	Power Diss Max
DTS-410	200V	200V (min)	3.5A	10 @ 2.5A	80W
DTS-411	300V	300V (min)	3.5A	10 @ 2.5A	100W
DTS-423	400V	325V (min)	3.5A	10 @ 2.5A	100W

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**Office includes field lab and resident engineer for applications assistance.

DELCO RADIO

Division of General Motors, Kokomo, Indiana

GM

MARK OF EXCELLENCE

ON READER-SERVICE CARD CIRCLE 64

Portable tape preservers available in 2 sizes

Magnetic Shield Division, Perfection Mica Co., 1322 N. Elston Ave., Chicago. Phone: (312) 384-2122. P&A: $50 to $80, 2 to 4 wks.

Portable magnetic tape preservers measure 7-3/4 x 12 x 12 inches and hold 5 magnetic tapes 1 inch wide and 11-1/2 inches in diameter. The Model holds 3 similar magnetic tapes. The unit can be equipped with locks for additional security.

Booth No. 1602 *Circle No. 372*

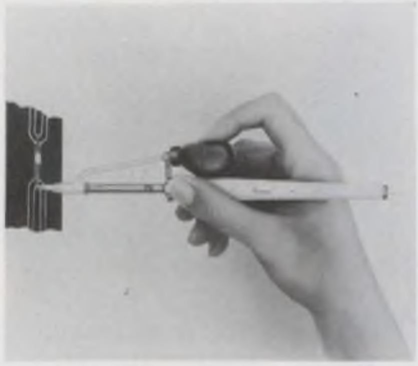
Acid-gold solutions plate pure

Engelhard Industries, Inc., Chemical Div, 113 Astor St., Newark, N. J. Phone: (201) 242-2700.

Engelhard is offering a pair of new gold-plating solutions. Acid-gold electroplating process E 71 produces high-purity, relatively low-stressed, bright gold deposits of 140 to 200 Knoop hardness. Abrasion and wear resistance meets MIL-G-4520A, type II. Solution E-56 gives an ultra-pure deposit (99.99%) and meets all requirements of MIL-G-45204A, type I, and shows good resistance to heat and discoloration at high temperatures.

Booth No. 1617 *Circle No. 343*

Desolder components with hand-held tool



Ungar Electric Tools, 2701 El Segundo Blvd., Hawthorne, Calif. Phone: (213) 757-2151.

Nonclogging and nonsticking features are incorporated in this desoldering tool. Held in one hand, the operator has the other hand free for removal of IC chips and discrete devices during rework and repair. Clogging in the tip is eliminated by the stainless steel lining. The replaceable tip has an 0.033-inch aperture.

Booth No. 1604 *Circle No. 361*

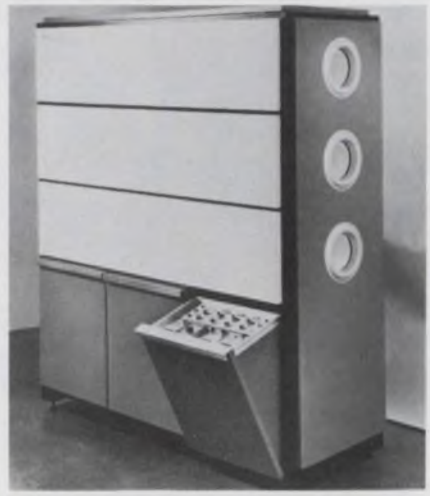
Wire laying machine uses 2-axis control

Hughes Aircraft Co., 5261 W. Imperial Hwy., Los Angeles. Phone: (213) 391-1711. P&A: $45,000; 4 to 5 mos.

For jumper-wire connections, single-terminal connection and wire harness laying, this 2-axis machine uses solid-state logic. The table operates at a traverse speed of 400 inches per minute, with a resolution of 0.001 inches. Positioning accuracy per axis is ±0.003 inches. The photoelectric tape reader reads 60 lines per second.

Booth No. 1704 *Circle No. 381*

Diffusion furnace for wafer makers



Electroglas, Inc., 150 Constitution Drive, Menlo Park, Calif. Phone: (415) 325-1536.

An all-solid-state controller, matched to the equipment, gives this furnace fast response and stability. The controller's high-gain amplifiers provide for narrow operating proportional bandwidths; as low as 1.5°C. All amplifier stages and thermocouple cold junctions are temperature-controlled within the controller to 65°C. Neither electrical nor mechanical choppers are required.

Booth No. 1915 *Circle No. 338*

1000-W power meter monitors cw lasers

Coherent Radiation Laboratories, 932 E. Meadow Dr., Palo Alto, Calif. Phone: (415) 328-1840.

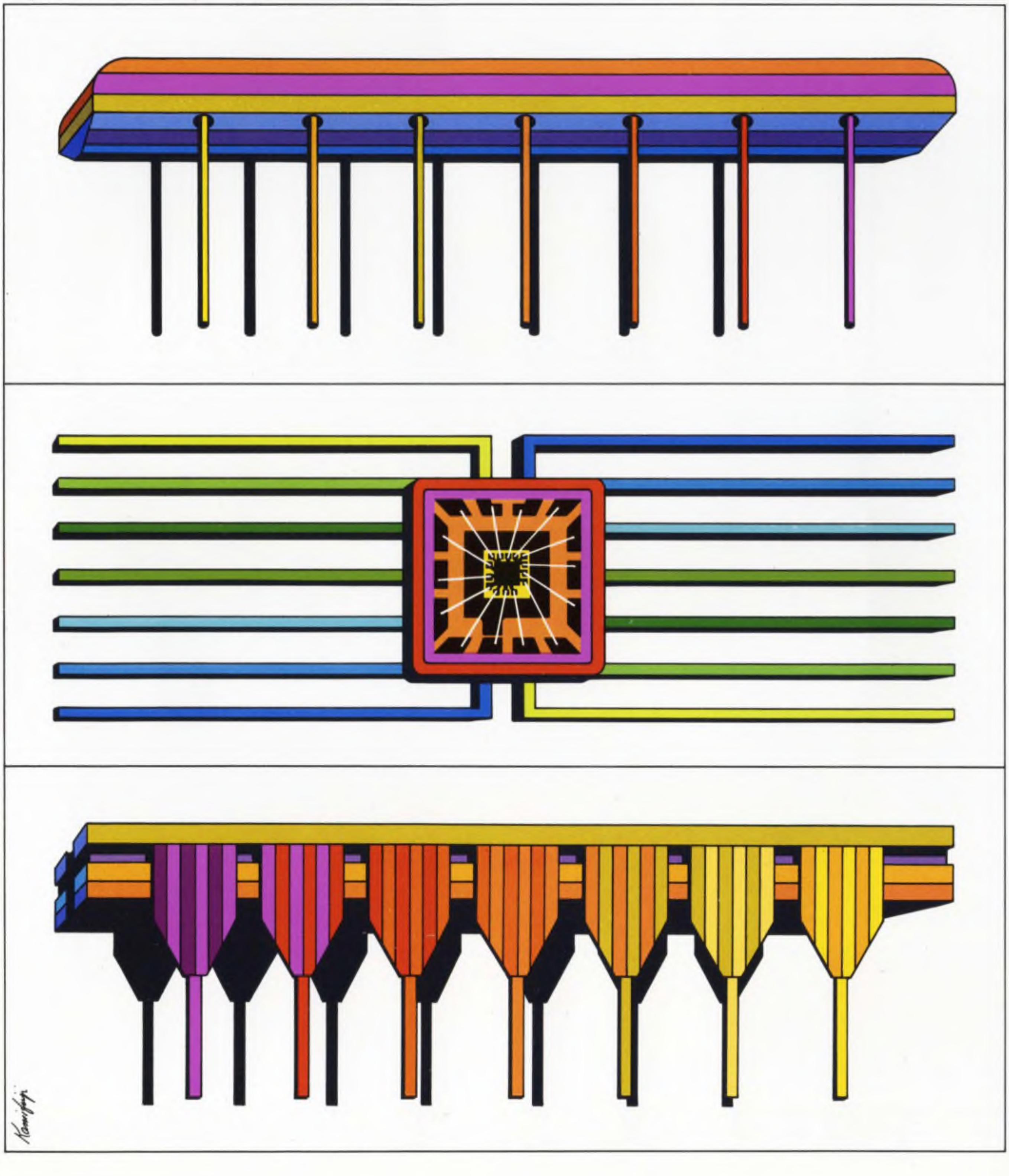
This meter is capable of measurement and direct indication of intense cw laser radiation at the 10.6-micron wavelength. Model 203 consists of a direct-absorption watercooled head with adjustable tabletop stand and a control and indicator unit. The head is capable of dissipating up to 1.5 kilowatts on a continuous basis. The rear of the assembly is in intimate thermal contact with the water-cooled heat sink and the resultant longitudinal heat flow is sensed by an intermeshed system of thermocouples. The voltage thus generated by the thermopile is amplified in the control unit and indicated on the calibrated meter.

Booth No. 3214 *Circle No. 313*

PHILCO Ford

The Innovator: Philco-Ford.

The Product: A 5-way better digital IC family. 1. Only our 9930 Series DTL is available in these three packages: E-line epoxy dual inline, ceramic flat packs, and ceramic dual inline packages. 2. For absolute minimum power dissipation, we've developed a unique MEL (Micro Energy Logic) family of medium-speed TTL integrated circuits (gate, buffer, and register flip flop elements). These circuits have a typical power dissipation of 440 μW per gate function — lowest in the industry. 3. Super RTL is also available: high speed, medium power NAND/NOR log (8ns with 5.3 mW per function). 4. To date, our digital IC's have logged over 65 million device-hours; reliability data available on request. 5. Immediate delivery. Philco-Ford Corporation, Microelectronics Division, Santa Clara, California 95051.



Marker plates for wire harnesses

Panduit Corp., 17301 Ridgeland Ave., Tinley Park, Ill. Phone: (312) 532-1800.

For identifying bundles up to 4-inch diameter, these markers are 3/4-inch wide and available in lengths of 1-1/2, 1-3/4, 2, 2-1/2 and 3-1/2 inches. They are nylon and can be hot-stamped or marked with a pen. All five sizes are easily secured to bundles using standard harness ties. The plates are available in packages of 100, bulk packages of 1000 and continuous rolls of 1000.
Booth No. 1902   Circle No. 347

Low-noise ion generator neutralizes charges

Controlled Environment Equipment Corp., 344 South Ave., Whitman, Mass. Phone: (617) 447-4436.

Laminar flow equipment is available with an air-ionizing unit to eliminate all electrostatic charges from the work area. Since statics are random, it is important to generate both positive and negative ions directly in the air stream. Thus, static charges of either polarity are neutralized. The ion generating unit does not generate ozone, nor is there radiation or shock hazard.
Booth No. 1917   Circle No. 355

For a complete listing of the technical papers at the show, see page U 112. For reprints of most of the papers, fill out the order form on page U 115.

Teflon cable covering zips closed

Zippertubing Co., 13000 S. Broadway, Los Angeles. Phone: (213) 321-3901.

Zippertubing, using Teflon flourocarbon material, withstands environmental extremes of temperature and abrasion. Operable at temperatures to +500° and −425°F, the product comes with the zip-on, zip-off closure which permits easy jacketing application. The material is chemically inert, resistant to outdoor exposure, and has moisture absorption of less than 0.01%.
Booth No. 1505   Circle No. 353

Gas sputtering system modularly constructed

Consolidated Vacuum Corporation, 1775 Mt. Read Blvd., Rochester, N. Y. Phone: (716) 458-2550.

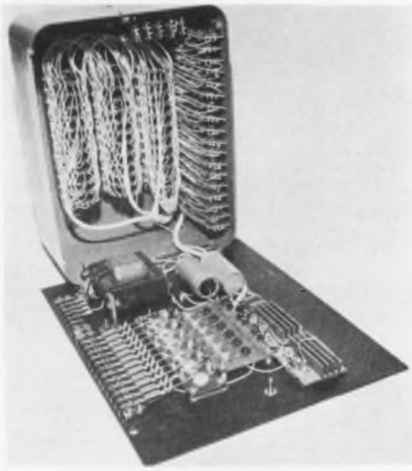
Each chamber of this system is a bolt-on module which can be fastened end-to-end to other chambers. Or, they can be joined to another chamber by means of a transport valve so that the two chambers can be operated at different pressures for multiple sequential processing of the same substrate. All materials now being sputtered in microelectronic circuit fabrication can be deposited in this system.
Booth No. 5228   Circle No. 354

PHILCO Ford

The Innovator: Philco-Ford.

The Product: A 9-way better epoxy transistor. 1. PET TO-18's ambient power dissipation is typically greater than 400 mW (chip dependent). θ_{JC} is typically 105°C/W. 2. PET TO-5's ambient power dissipation is typically greater than 450 mW. θ_{JC} is typically 100°C/W. 3. PET packages have reliability factors equal to or exceeding that of metal cans. 4. PET's are immediately available in large volume production quantities. 5. PET's have a special deep-well interlock construction that insures hermeticity and reliability. 6. PET packages are permanently and legibly marked—lettered black on white. 7. PET's are packaged in our low-cost Taiwan production facility—to keep your cost low. 8. PET amplifiers operate on currents ranging from 10 μA to 1 A; PET switches to speeds 8 ns turn on and 11 ns turn off. 9. PET's cover frequencies from 40 MHz to 1400 MHz. Philco-Ford Corporation, Microelectronics Division, Santa Clara, California 95051.

Solid-state programmer recovers in 1 ms



Leach Corp., Relay Div., 5915 Avalon Blvd., Los Angeles. Phone: (213) 232-8221.

This programmer uses ICs to perform logic and counting functions to control, in a selectable time sequence, the operation of semiautomatic machines, process control equipment, recording and tracking systems. The programmer initiates and terminates timing cycles, with durations as low as hundredths of a second and up to 29.9 seconds. The input power required is 1 A at 115 V ac, 60 Hz. The unit operates over a temperature range of 15° to 55°C.

Booth No. 3005 Circle No. 322

PC connector has wire-wrap terminals

Continental Connector Corp., 34-63 56th St., Woodside, N. Y. Phone: (212) 899-4422.

Printed circuit card-edge connectors feature terminations designed for wire-wrapping. They are available with 28 dual contacts providing 56 wiring terminals on 0.125-inch center-to-center spacing. Contact terminals are 0.025-inch square to permit wire-wrapping for up to three #26 AWG wires on each. Body material is glass-reinforced diallyl phthalate and contacts are gold-plated phosphor bronze.

Booth No. 3805 Circle No. 254

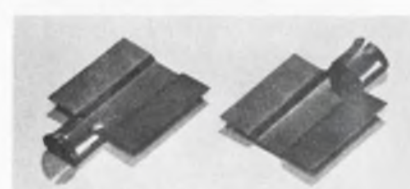
Circular connector mates simply

Viking Industries, Inc., 21001 Nordhoff St., Chatsworth, Calif. Phone: (213) 341-4330.

Miniature circular connectors for nonmilitary applications have crimp, removable high-density contacts. The entire plug/receptacle housing and insulators are molded in one unit eliminating costly separate metal housings and coupling devices. To mate, the user inserts the plug until it snaps to a locked position. By squeezing the finger grips on the plug housing, the plug releases and can be removed from the receptacle by pulling the plug.

Booth No. 4001 Circle No. 251

Heat transfer devices cool off TO-92s



Wakefield Engineering, Inc., Wakefield, Mass. Phone: (617) 245-5900.

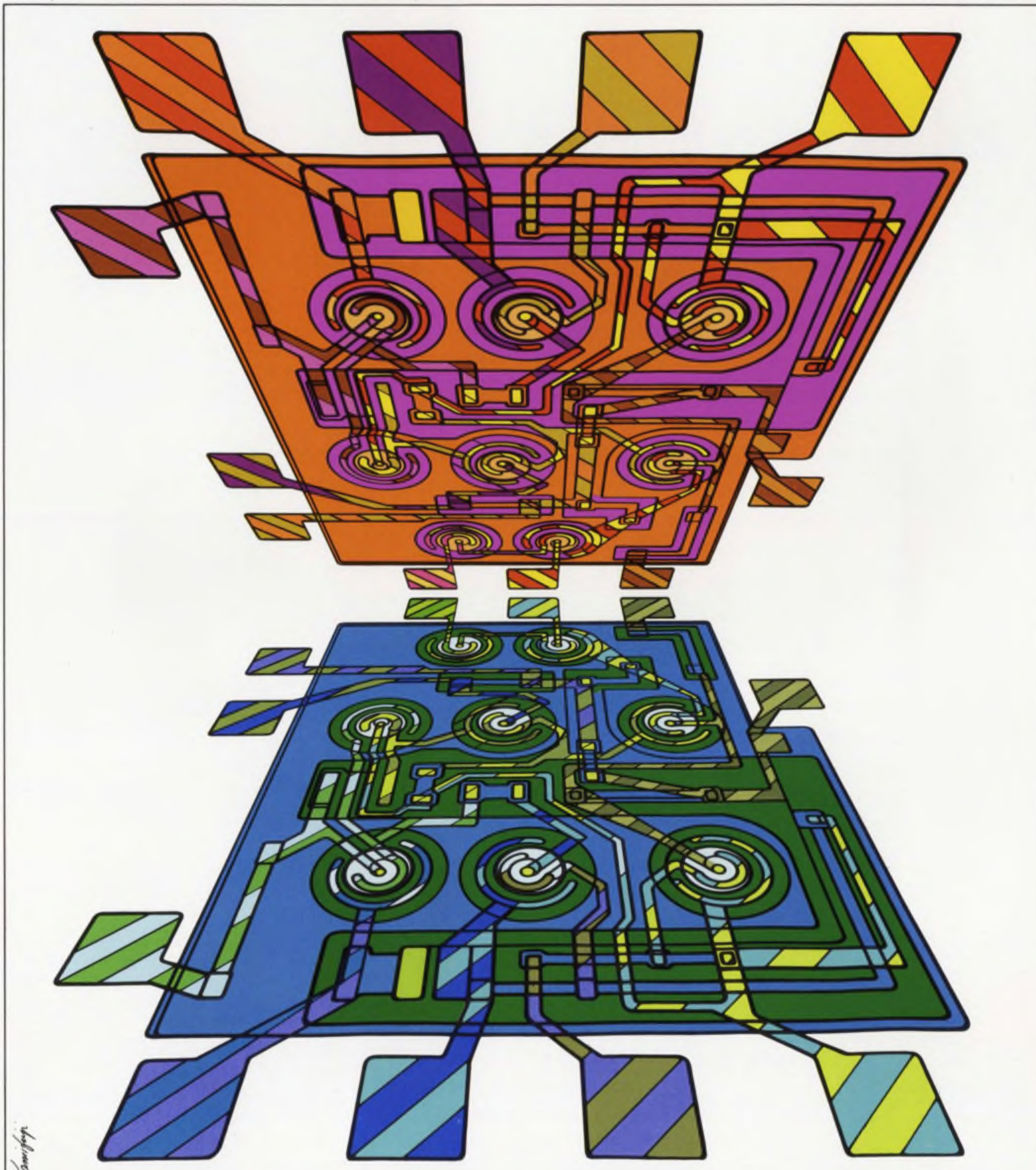
Two cooling devices are designed for TO-92 packages. The heat sink accommodates one TO-92 plastic transistor. It is made of aluminum with black immersion or irridite finish. For power dissipation of 0.2 watts, collector lead temperature rise above ambient is 18°C with black immersion or 20°C with irridite finish. The temperature equalizer for dual TO-92 units has three sizes to accept all different case size TO-92s. Material is aluminum or beryllium copper.

Booth No. 5332 Circle No. 264

PHILCO Ford

The Innovator: Philco-Ford.

The Product: A 5-way better linear IC line. 1. Only linear line that covers the entire frequency spectrum from DC through VHF. 2. Our PA 7600 RF/IF video amplifier offers the highest gain bandwidth available in the industry (passband to 9000 MHz). 3. PA 7601 RF/IF bandpass amplifier offers extreme linearity with AGC. 4. PA 7713 RF/IF video amplifier: a special linear circuit featuring high gain bandwidth at low power (500 MHz at 18 mW). 5. Immediate delivery. Philco-Ford Corporation, Microelectronics Division, Santa Clara, California 95051.



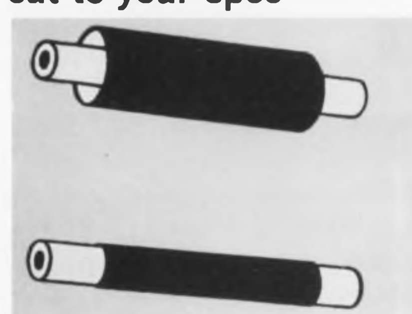
IC sealing system seams cold

Solid State Equipment Corp., 4343 E. River Dr., Philadelphia. Phone: (215) 844-3501. Price: $8250.

Designed to seal all types of hybrid and monolithic integrated circuits, from 1/8 to 3 inches, this system will accomplish sealing either by welding or reflow brazing. Only a small temperature rise occurs within packages being sealed, minimizing resistance shifts of thin- or thick-film resistors during sealing. Sealing may be accomplished in a wide variety of inert atmospheres such as nitrogen, helium or argon.

Booth No. 1014 *Circle No. 337*

Kynar sleeving cut to your spec



Westline Products, 220 S. Rose St., P. O. Box 2980 Terminal Annex, Los Angeles. Phone: (213) 627-2641.

Permanently printed tubular markers in heat-shrinkable Kynar can be used for identification of wires, cables, terminals, leads, connectors and component parts. Kynar is a clear, tough polyvinylidene fluoride which shrinks to 50% of its supplied diameter. Kynar will not cold-flow, does not burn, never melts and will not split over sharp or irregular surfaces. It has a continuous operating temperature from −55° to +175°C.

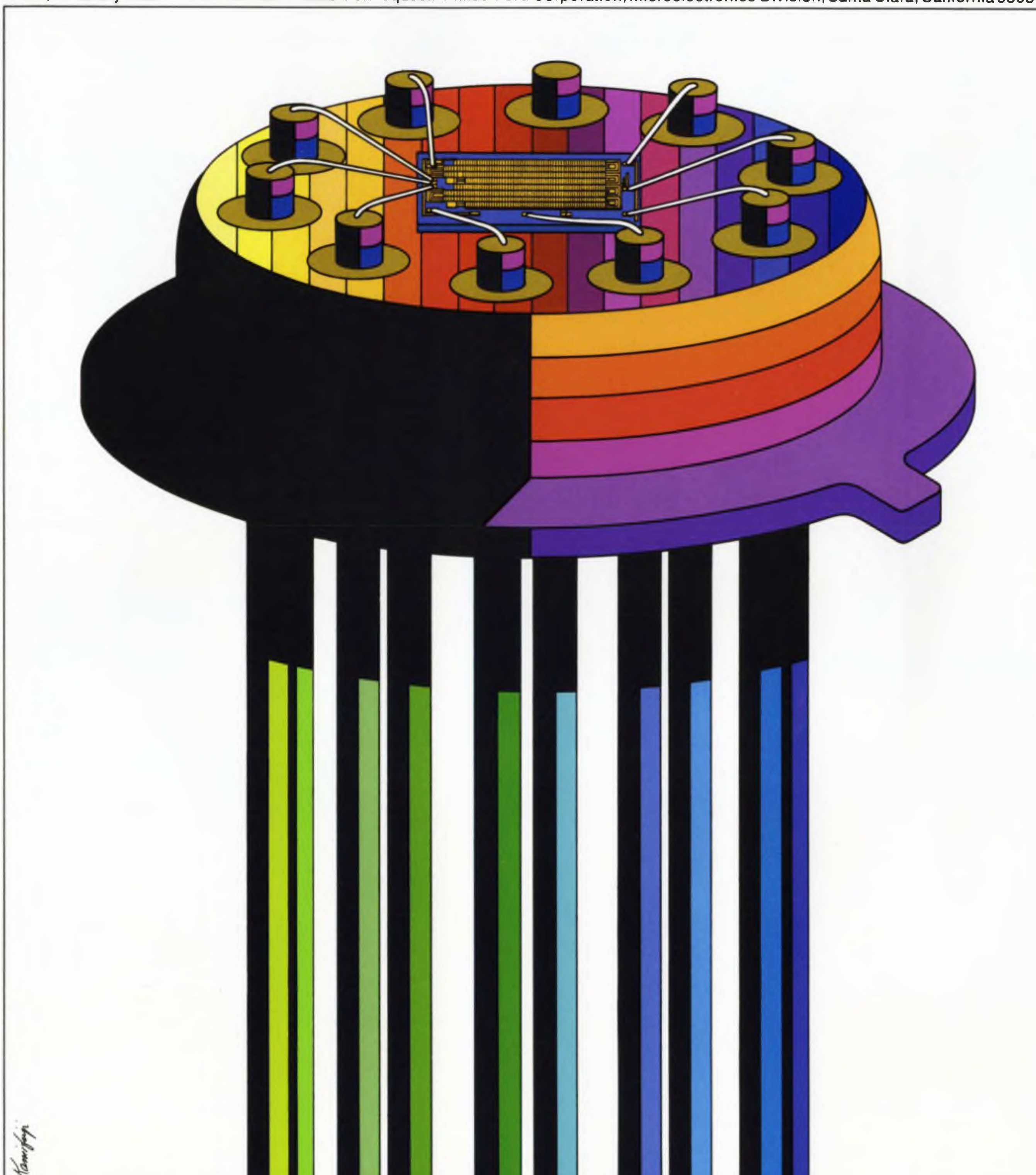
Booth No. 1823 *Circle No. 345*

ON READER-SERVICE CARD CIRCLE 224 ➤

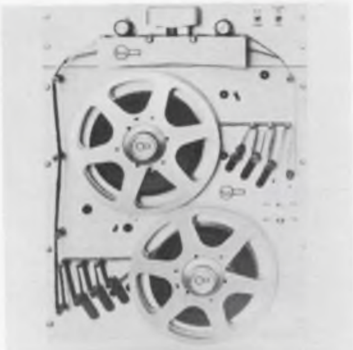
PHILCO Ford

The Innovator: Philco-Ford.

The Product: MOS. 1. The first major manufacturer to take MOS from the theoretical to the practical. 2. Finest MOS manufacturing technique in the industry. 3. Most experienced MOS team in the industry: R&D, engineering, and systems know-how people. 4. Proven systems capability in MOS and large scale integration (LSI). 5. One of our Philco-Ford MOS circuit types has logged over 2.5 million device-hours; reliability data on MOS circuits available on request. Philco-Ford Corporation, Microelectronics Division, Santa Clara, California 95051.



Tape spooler feeds 1000 characters/second

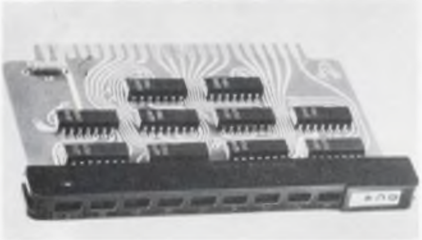


Remex Electronics, 5250 W. El Segundo Blvd., Hawthorne, Calif. Phone: (213) 772-5321. Price: $2195.

This all-solid-state spooling machine's speed is 1000 characters per second with a full 2000 feet of tape on 10-1/2-inch reels. Rewind speed is 2000 characters per second in either direction. Any input line frequency from 50 to 400 Hz at 115 volts can power the unit with 230-volt optionally available.

Booth No. 2011 Circle No. 336

Micrologic cards accept dc-to-10-MHz input



Control Logic, Inc., 3 Strathmore Rd., Natick, Mass. Phone: (617) 655-1170. Price: $150 (4-stage card).

Four to 8 decade dividers connected in groups of 2 dividers each are provided on this card. The CDC-114 base card features two groups of 2 dividers, each providing two independent stages, or one 4-digit divider. Additional dividers, up to a maximum of eight, may be added to order. Each divider group has a separate count input. Each divider employs ripple carry with gated transfer and operates with dc-to-10-MHz inputs with less than 100-ns over-all delay.

Booth No. 2005 Circle No. 334

Stepped-up torque from small motor

IMC Magnetics Corp., 570 Main St., Westbury, N. Y. Phone: (516) 334-7195. Price: $50 (over 500).

A 1.095-inch long, 50-gram permanent magnet step-servo motor, offers bidirectional operation with power consumption of 1.74 watts. Responding at rates of up to $10 pps in 90° steps, the unit meets a variety of X-Y plotter, switch positioning, computer, remote control actuator and digital integrating requirements.

Booth No. 2118 Circle No. 342

High-speed reader operates bidirectionally

Remex Electronics, 5250 W. El Segundo Blvd., Hawthorne, Calif. Phone: (213) 772-5321. Price: $3580.

This photocell punched-tape reader and spooler offers a 500-characters-per-second reader and a 50-inch-per-second spooler equipped with 10-1/2-inch diameter reels. Total height is 21 inches. It is all-solid-state with a choice of output signals. The spooler portion includes an independent high-speed, bidirectional rewind and soft take-up feature that precludes the possibility of breaking tapes.

Booth No. 2011 Circle No. 324

Digital calendar/clock advances automatically

Durant Manufacturing Co., Milwaukee. Phone: (414) 271-9300.

Continuous visual readout and remote electrical readout on command are provided by this clock for date/time information in six-figure form. It is designed for use in data reduction systems, to control batching, to aid in computing piece rates in all production processes, and in all types of data or material handling where a date/time base is required. Manual set-up switches on the front panel are provided to establish initial date and time.

Booth No. 2124 Circle No. 335

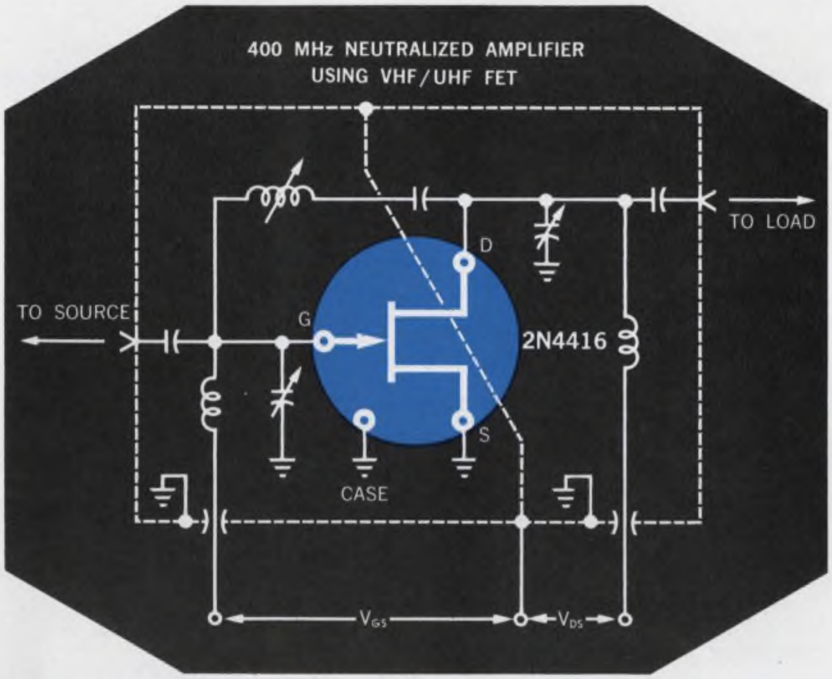
Digital printer totals 10 columns

Victor Comptometer Corp., 3900 N. Rockwell St., Chicago. Phone: (312) 539-8210.

Standard features of this device include 0 to 10 digits and print command, a choice of 24 V dc at 0.98 A or 48 V dc at 0.63-A solenoid voltage and choice of punctuation. Also on accumulators is a print command total and minus, all with signal-sector symbol printing. Nonadd and subtotal solenoid operation is optional.

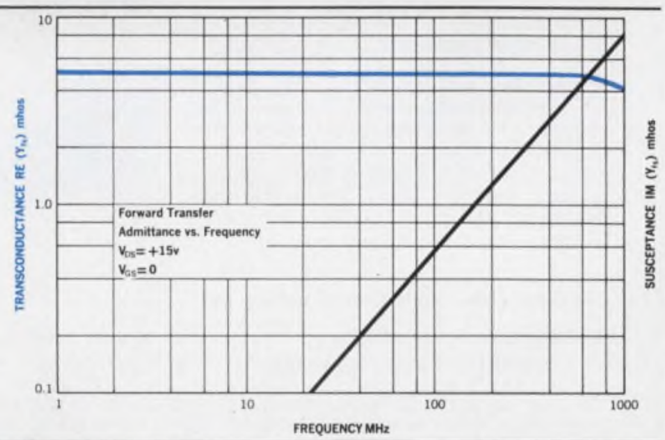
Booth No. 2015 Circle No. 333

Replace 80% of all FET types with one!



Here's how: Buy the Union Carbide 2N4416 universal FET in quantity, and you can select transistors over the entire frequency range covered by 80% of all field effect types. The 2N4416 is specified below as a VHF/UHF amplifier. However, from any class lot of this device you can select (1) general purpose, low noise, high gain amplifiers from D.C. to 900 MHz, or (2) ultra low noise devices for low frequency applications. This device is also available in a ribbon lead ceramic package (.138″ dia.) as the low capacitance 2N4417. Use for TV tuners, FM sets, IF strips, mixers, oscillators, or even switches. Write for complete specifications.

CHARACTERISTICS Small Signal, Common Source @ 25°C	**2N4416 TO-72**	**Frequency**
Forward Transconductance RE (Y_{fs}) (min.)	4000 μmhos	400 MHz
Input Capacitance, C_{iss} (max.)	4.0 pf	1.0 MHz
Output Capacitance, C_{oss} (max.)	2.0 pf	1.0 MHz
Reverse Transfer Capacitance, C_{rss} (max.)	0.8 pf	1.0 MHz
Spot Noise Figure (Neutralized), NF (max.)	4.0 dB	400 MHz
Spot Noise Figure, NF (max.) (Neutralized)	2.0 dB	100 MHz
Power Gain, G_{ps} (min.) (Neutralized)	10.0 dB	400 MHz



UNION CARBIDE

ELECTRONICS

Semiconductor Department / 365 Middlefield Road, Mountain View, California 94040 / Telephone: (415) 961-3300 / TWX: 910-379-6942

ON READER-SERVICE CARD CIRCLE 70

Impulse counters stack up small

Landis & Gyr, Inc., 45 W. 45th St., N. Y. Phone: (212) 586-4644.

A compact, low-wattage impulse counter is suited for multiple-counter installations where panel space is at a premium. Plug-in design provides for both surface and flush panel mounting. The counters are available with manual or electric reset or with no reset. Available counting speeds are 10, 25 or 60 Hz. Dimensions are 1.89 by 0.94 by 2.83 inches.

Booth No. 5340 *Circle No. 258*

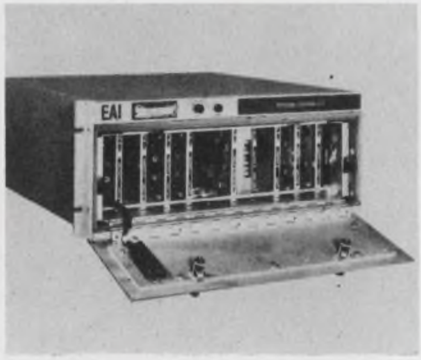
Digital display easy to read

Litton Industries, Aero Service Div., 4219 Van Kirk St., Philadelphia. Phone: (215) 533-3900.

Consisting of two optical shaft transducers (one for X axis, one for Y axis), a power supply and a remote dual-axis, bidirectional display, this unit gives a 5-digit readout with polarity sign to the nearest 0.001 inch. On-off switch and reset controls are mounted on the coordinatograph together with all cabling. The system eliminates the necessity of scale dials and tapes by permitting the operator to view the coordinate data directly on the remote display. It is available in three working area sizes and eight individual configurations.

Booth No. 4207 *Circle No. 376*

Analog data processor plugs in functions



Electronic Associates, Inc., West Long Branch, N. J. Phone: (201) 229-1100. P&A: $3000 to $5000; 3 months.

A selection of plug-in components provides this analog data processor with a high degree of function flexibility. Depending on modular configuration, it can be used for operator guides, closed-loop control, signal conditioning and instrumentation. Modules now available include eight which have dual-function capability and one which can perform four functions. Each slot in the unit may be modified to dual function to provide up to 20 circuits per processor.

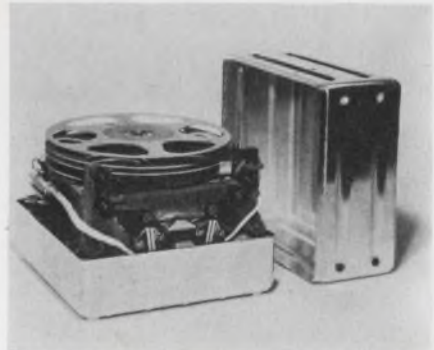
The module selection consists of three dual voltage-to-current and three dual current-to-voltage converters, a low-level wide-bandwidth diff amp, a dual amplifier resistor network which requires either one or two plug-in amplifiers and is the universal amplifier module, a time division multiplier, a variable diode function generator, a relay comparator, a dual integrator network which requires one or two FET high-input-impedance amplifiers and a quad coefficient network.

Power circuitry is built into each module. Test points and trimming potentiometers can be reached without removing the module from the housing. Modules may be cut out of the circuit for trimming purposes by turning a switch on the amplifier card.

Booth No. 2727 Circle No. 378

For a complete listing of the technical papers at the show, see page U 112. For reprints of most of the papers, fill out the order form on page U 115.

Satellite recorder operates unattended

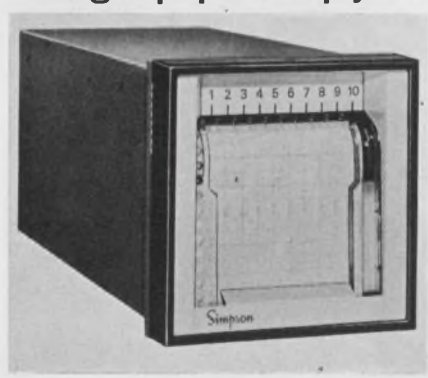


Leach Corp., 717 N. Coney Ave., Azusa, Calif. Phone: (213) 682-3506.

Capable of recording analog data over 1 kHz to 1 MHz, this unit is capable of providing a minimum of 1000 hours unattended operation in orbit. Measuring 7.1 x 8.1 x 5.25 inches, the recorder accommodates 280 feet of 1/2-mil tape using a packing density of 10 kHz per inch. Data can be recorded at 25, 50 or 100 inches per second.

Booth No. 3005 Circle No. 382

Ten-channel recorder changes paper simply



Simpson Electric Co., 5200 W. Kinzie St., Chicago. Phone: (312) 279-1121. Price: $175.

The chart paper of this 10-channel event recorder can be quickly changed just by removing the front cover. If rack-mounted, this means that it is not necessary to remove the unit or go behind the panel. The unit is supplied with two chart speeds (20 or 120 mm per hour), which are switch-selected. Recording is on pressure-sensitive paper.

Booth No. 2501 Circle No. 363

No trace of overload problems

When you use RCA nuvistors

If you find it necessary to include overload protection in your solid-state circuit designs, look to RCA nuvistors. Nuvistors can withstand severe signal and power surges without catastrophic failure.

Nuvistors eliminate many other problems, too, through the benefits of their unique construction: demonstrated reliability of 99.901% per 1,000 hours out to 30,000 hours of operation; temperature stability, Δ gm $\cong$ 4 μmho per degree C over the range −55°C to +250°C; dependable performance in the presence of both pulse and steady state nuclear radiation; low RF and sub-audio noise; 1,000 g shock rating, and exceptional uniformity of electrical characteristics from tube to tube and throughout life.

For complete data on the entire RCA line of nuvistors for industrial and military applications, call your nearest RCA District Office or write RCA Commercial Engineering, Section H-18-DE, Harrison, N.J. 07029.

On Reader Service Card Circle 109

RCA DISTRICT OFFICES—OEM SALES: EAST, 2075 Millburn Ave., Maplewood, N.J. 07040, (201) 485-3900 • MID-ATLANTIC: 605 Marlton Pike, Haddonfield, N.J. 08034, (609) 428-4802 • MID-CENTRAL: 1600 Keith Bldg., 1621 Euclid Ave., Cleveland, Ohio 44115, (216) 241-3450; 2511 East 46th St., Bldg. Q2, Atkinson Sq., Indianapolis, Ind. 46205, (317) 546-4001 • CENTRAL: 446 East Howard Ave., Des Plaines, Illinois 60018, (312) 827-0033 • WEST: 6363 Sunset Blvd., Hollywood, Cal. 90028, (213) 461-9171 • INTERNATIONAL OPERATIONS, RCA International Division: Central and Terminal Aves., Clark, N.J. 07066, (201) 485-3900 • 118 Rue du Rhone, Geneva, Switzerland, 35 75 00

RCA Electronic Components and Devices, Harrison, N.J. 07029

RCA ®

The Most Trusted Name in Electronics

See RCA Nuvistors in Booths 3701/3705

These 14 New Devices Make RCA

the Triac Leader of the Industry

Now, RCA offers you the industry's broadest line of Triacs, with an unmatched choice of ratings and triggering characteristics in space-saving packages ...all at truly economical prices! Triacs are today's most modern, effective component for ac phase-control and load switching. Because they can perform the functions of two SCR's, Triacs make possible new economies in full-wave power circuit design and cost for industrial and commercial applications.

So for efficient, inexpensive solid-state control of motors, lighting, and heating, look to RCA, the Triac Leader. Your RCA Sales Representative will be happy to give you more details, including price and delivery. Also, ask him about RCA's complete line of SCR's. For additional technical data, write RCA Commercial Engineering, Section RG8-2, Harrison, N.J. 07029. See your RCA Distributor for his price and delivery.

*Priced in quantities of 1,000 and up.

On Reader Service Card Circle 107

Current Rating I_T(rms)	Low Voltage (100V)	120V Line (200V)	240V Line (400V)	Package
2.5A (I_{GT} = 3 mA max)	40525	40526	40527	modified 3-lead TO-5
2.5A (I_{GT} = 10 mA max)	40528	40529	40530	modified 3-lead TO-5
6A		40429	40430	TO-66
6A		40485	40486	modified 2-lead TO-5
6A		40431 (with integral trigger)	40432 (with integral trigger)	modified 2-lead TO-5
15A		TA2834	TA2835	TO-66

RCA Electronic Components and Devices

The Most Trusted Name in Electronics

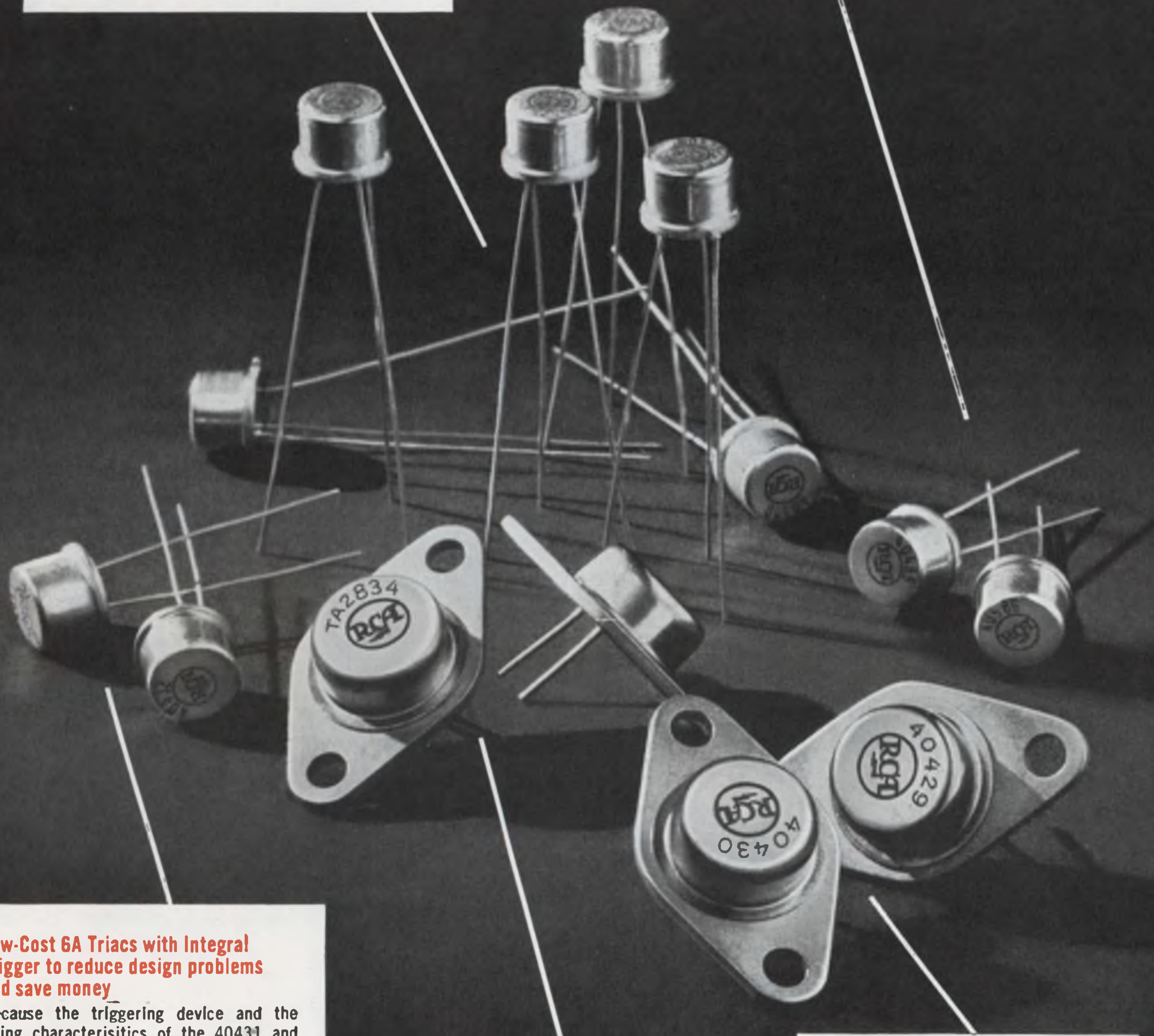
See us at WESCON, Booths 3701-05, 3718-22

Sensitive-Gate Triacs under $1.00*

Extremely high gate sensitivity...rms (on-state) current = 2.5A...and a price level that makes possible a new generation of controls for small appliances, induction motors, and sensing circuits. Maximum gate sensitivities of 3 mA or 10 mA are actually many times greater than that of conventional Triacs! This means simplified triggering circuits and reduced component costs. The 100V versions (40525 and 40528) sell for $0.95*; the 200V types (40526 and 40529) are priced at $0.98*; and the 400V units (40527 and 40530) are available at $1.40*!

6A Triacs in 2-lead TO-5 to Control up to 1440 Watts

With the new 40485 and 40486 6A Triacs, RCA doesn't have to use an expensive press-fit package to control a lot of power. Both types employ the low-cost TO-5 case which can be easily mounted on heat spreaders using mass produced pre-punched parts and batch soldering techniques for improved heat-sinking ability. The 40485 sells for only $1.50* and controls 720 watts. The 40486 can control 1440 watts and sells for $1.98*. And reliability is assured with surge current protection up to 100A!



Low-Cost 6A Triacs with Integral Trigger to reduce design problems and save money

Because the triggering device and the firing characterisitics of the 40431 and 40432 Triacs are coordinated inside a compact TO-5 case, you don't have to worry about designing in additional triggering components. You benefit further from reduced circuit and assembly costs, plus improved packaging densities! So if your ac-load control circuits require a trigger, why not have it built-in for you? The 40431 controls 720 watts at 120V and costs $1.80*; the 40432 controls 1440 watts at 240V and costs only $2.48*.

15A Triacs for Load Control up to 3600W

RCA developmental types TA2834 and TA2835 Triacs extend solid-state control way up into the kilowatt range. These powerful TO-66 units have surge current protection up to 100A, plus all of the other design benefits of RCA's lower current Triacs. Possible applications include power supplies, heating controls, motor drivers, and many other industrial and commercial usages.

6A Triacs in Popular TO-66 Package

Need full-wave control of up to 1440 watts in a TO-66 package? RCA 40429 and 40430 Triacs are your answer... they feature high gate sensitivity, symmetrical triggering characteristics (I_{GT} = 25 mA max), and surge current protection up to 80A. The 200V 40429 costs $1.50*, the 400V 40430 only $1.98*.

NEW DIFFERENTIAL MULTIMETER. Model 853A uses differential techniques to measure voltage, resistance and current to high accuracies. Range is 0 to 1100 volts AC/DC, 0 to 10 amps AC/DC, and 0 to 100 meghoms. Price is a low, low $445.

FOR WESCON '67, FLUKE EXPRESSES SEVEN GREAT IDEAS ABOUT MEASUREMENT IN SEVEN NEW PIECES OF HARDWARE.

7

NEW RMS DIGITAL VOLTMETER. Model 9500A offers true RMS response with fully automatic operation. Measures from 0-1100 volts RMS within ±(0.05% + 0.015% of range) digit and has options for remote control, printer output, and low capacity probe input. Price $2,395.

NEW DC DIFFERENTIAL VOLTMETER. Model 891A features infinite input resistance at null over entire 1100 volt range. Accuracy is ±0.02% Light weight and small, the new unit is priced at $595. Battery option $100.

NEW POWER SUPPLY. Model 415A precision high voltage power supply offers up to 3 kv and 20 mils output in a 3½″ panel. Price is modest $495.

NEW DC CALIBRATOR. Model 335A combines a DC voltage standard with a high impedance voltmeter/null detector for ultimate versatility. The instrument performs as a 0-1100 volt ±0.003% voltage calibrator or infinite input resistance differential voltmeter; a 10 microvolt to 1100 volt voltmeter/null detector with 10 megohm and 100 megohm input resistance, or as a precision 50 ma source to drive a calibration system while separately detecting nulls. Price $2,485.

NEW COMPARATOR. Fluke/Monotronics Model 103A performs short term stability measurements with no peripheral equipment. Priced at a low $1,995. The Model 103A costs 40% less than competitive equipment.

NEW METER CALIBRATOR. Model 760A does the work of five separate instruments for about half the cost and much more conveniently too. Use it to calibrate AC and DC voltmeters, ammeters and ohmmeters. Accuracy ranges from 0.1% to 0.25%. Price is $2,485.

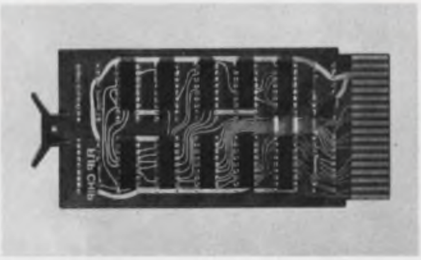
See them all at the Fluke show, Wescon '67, Booths 3209, 3210, and 3211. Perchance you're one of the nine out of ten not going to the show, don't get shook! We'll be happy to send you full data and, if you like, arrange a visit from your full service Fluke sales engineer. Simply write or call us.

Fluke, Box 7428, Seattle, Washington 98133. Phone (206) 774-2211, TWX: (910) 449-2850. In Europe, address Fluke International Corporation, P.O. Box 5053, Ledeboerstraat 27, Tilburg Holland. Telex: 844-50237.

FLUKE

COMPUTERS & DATA PROCESSING

IC logic modules quiet to 10 MHz



Digital Equipment Corp., 146 Main St., Maynard, Mass. Phone: (617) 897-8821.

High-speed, high-power TTL logic models are offered on 36-pin cards. In the logic 0 state (0 to 0.4 V), the driver sinks a maximum 1.6 mA from the driven load. In the logic 1 state (2.4 to 3.6 V), only the leakage current of the driven load must be supplied. Dc noise is 1 volt at either the logic 1 or logic 0 level. Absolute worst-case noise margin is 400 mV at either level.

Booth No. 2102 *Circle No. 364*

Core memory system cycles in microseconds

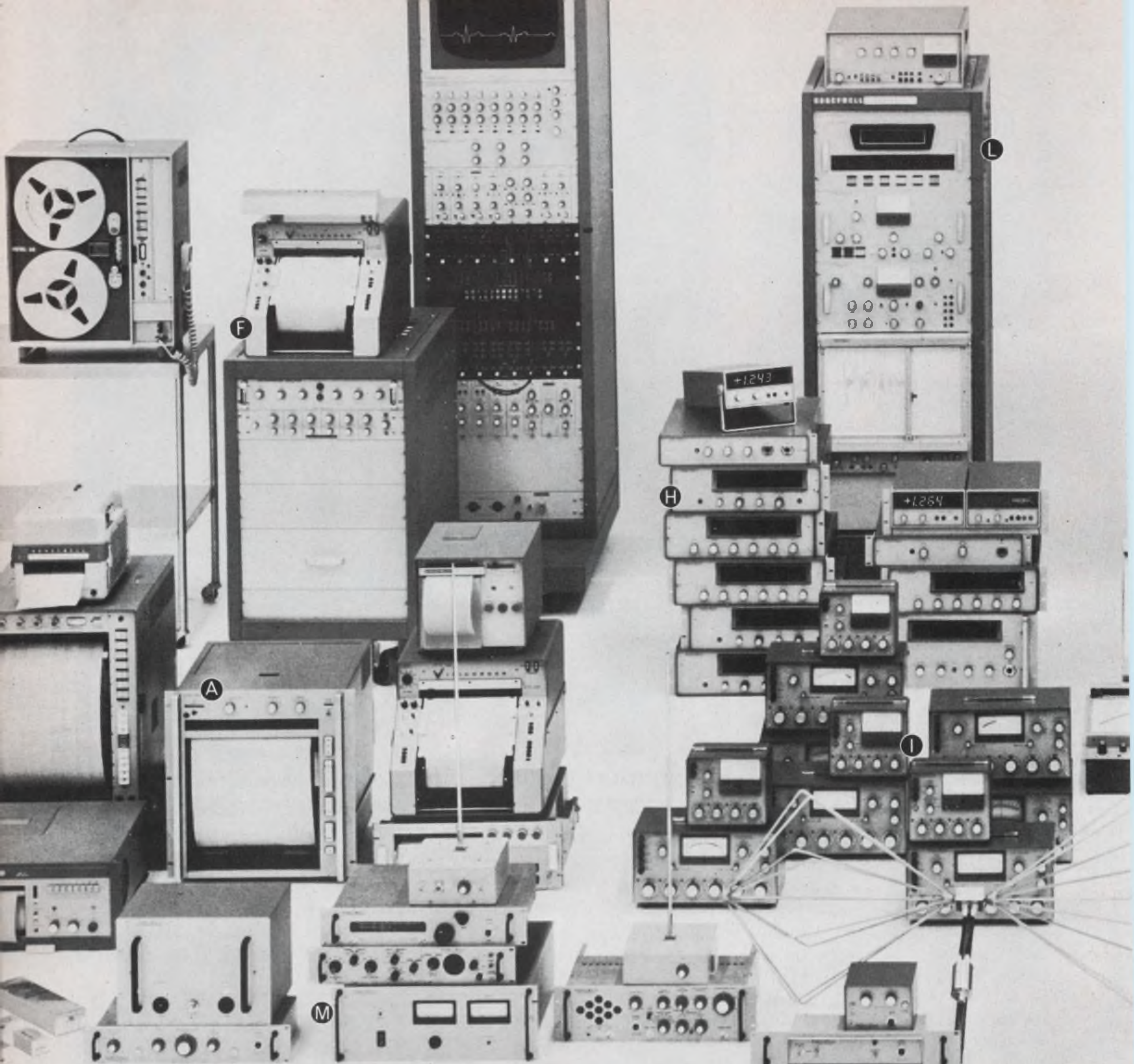
Information Control Corp., 1320 E. Franklin Ave., El Segundo, Calif. Phone: (213) 322-6930.

For small data processing and data collection systems, these memory systems are available in two models. The ComRac 100 exhibits a cycle time of 1 μs, an access time of 0.45 μs, and is available in capacities up to 4096 words by 24 bits. The 150 exhibits a cycle time of 1.5 μs, an access time of 0.7 μs and is available in capacities up to 8192 words by 24 bits.

Both are organized as four-wire current systems and employ 20-mil lithium ferrite cores. They can be operated in standard modes of read/restore, clear/write, buffer read and buffer write. The entire memory, including power supply, is packaged in a 5-1/4-inch rack-mounted chassis.

Booth No. 2006 *Circle No. 362*

For a complete listing of the technical papers at the show, see page U 112. For reprints of most of the papers, fill out the order form on page U 115.



Here's just part of the full Honeywell line, which includes: Ⓐ 117 Visicorder direct-recording oscillographs in 6", 8", and 12" models; Ⓑ 2 Model 1806 fiber-optics CRT Visicorder oscillographs; Ⓒ 26 magnetic tape systems, including the 7600 Series in 10½" and 15" reel versions; Ⓓ 84 amplifiers and other signal-condi-

We build 847 instruments to be sure we have the exact 1 you need.

The static recorder writes, only the paper moves on

Varian Associates, 611 Hansen Way, Palo Alto, Calif. Phone: (415) 326-4000. P&A: $7100, late fall (Statos I); $4700, early 1968 (Statos II).

An entirely new method of strip-chart recording combines electrostatic recording with integrated digital electronics. The result?

- A three-channel dc-to-3-kHz direct-writing strip-chart recorder with no moving parts, ink, arcing or heat elements in the writing.
- A writing speed of 20,000 in./s with less than 1% overshoot.
- Direct interface for computer readout or computer processing.
- Integral grid-chart imprinting with interchangeable grid patterns.
- Continuously variable chart speeds with correlated time-base logging.

Called the Statos I (high-frequency data recorder) and Statos II (50-channel event recorder), respectively, both units make analog records with digital accuracy.

Statos I has a fixed recording-head assembly which will simultaneously record two analog signals and one digital signal across 100 millimeters full-scale. With no moving pens, galvanometers, mirrors or other mechanical writing components, Statos I records three simultaneous signals, at either dc to 1.5 kHz (full-scale, 100-mm resolution) with 1% accuracy, or dc to 3 kHz (50-mm resolution) with 2% accuracy. The recorder also has 8 event-marker channels.

On/off, go/no-go or other binary events may be recorded by external contact closures or a 5-V dc change. Another function of the recorder head assembly is to imprint timing lines across the full width of the chart paper in exact relationship with the data signals. Five time-line intervals from 0.1 second to 10 minutes can be selected.

The chart grid-lines themselves are electrostatically printed on the paper. The Statos I system is supplied with two different chart grids selected by a switch. Any desired grid patterns can be supplied. The paper transport system has a 6000-to-1 speed range with 14 calibrated chart speeds from 0.2 cm/min to 20 cm/s electronically selectable and continuously variable.

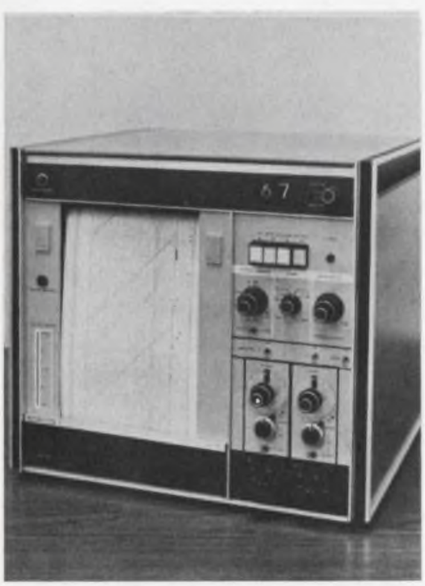
Basically, the technique involves using a fixed recording head to place electrostatic charges on dielectrically coated paper. The paper then passes through a toner and a permanent black image is formed immediately.

The 250-foot paper rolls are inexpensive (up to 50% less than light-sensitive or direct-write papers), insensitive to light and have excellent archival qualities. Continuous monitoring of any one of three data signals is provided by digital readout tubes, which indicate signal amplitude as a percentage of full scale.

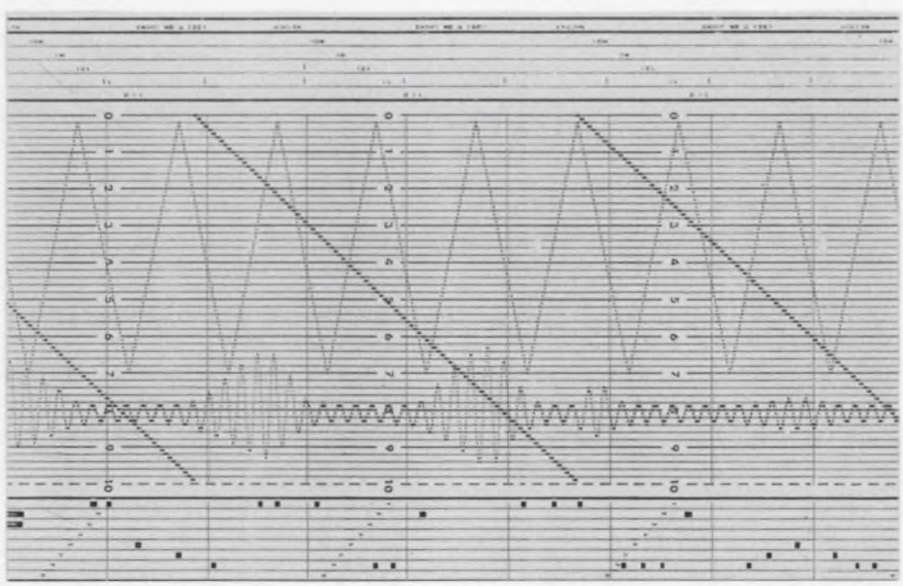
Statos I has two plug-in differential analog preamplifiers with a sensitivity of 100 μV and 13 ranges, from 1 mV/cm to 10 V/cm. In addition to the two analog input signals, a third signal in BCD format may be simultaneously recorded.

The companion product, Statos II, records up to 50 channels of two-level events by the same fixed-recording-head, electrostatic recording technique. The chart paper channels are preprinted in 250-foot-long rolls 7 inches wide. Events with a duration of 2 μs or longer can be recorded. The time relationship betwen events can be resolved to 1-ms accuracy at a chart speed of 20 cm/s using the full-scale timing lines.

Booth No. 2903 *Circle No. 318*



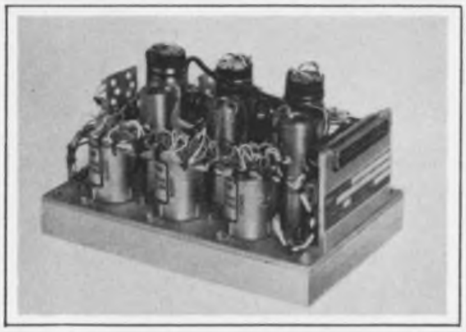
One hundred times faster than direct-writing processes, the electrostatic recorder writes at 20,000 inches per second, prints dc to 3 kHz data.



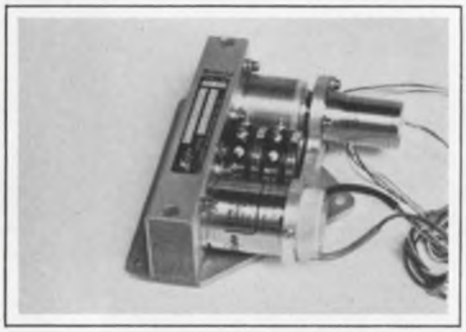
An analog presentation with digital accuracy, this 3-channel recording shows good clarity and resolution of both the grid pattern and the printed data. Note full-width time lines with time code at the top and event marks at the bottom of the 7-inch-wide paper.

ON READER-SERVICE CARD CIRCLE 82 ➤

SERVO PACKAGE PROBLEMS?



Three-Axis Coordinate Transformation Servo for airborne instrument landing system. Electrical inputs to CT's represent position in roll, pitch and yaw. Electrical outputs are a coordinate transformation of the aircraft's coordinates with respect to ILS coordinates.



Inertial Navigation System Coupler for side-looking radar used in RF4B and RA4C aircraft. Vibration snubbers overcome 500 cps, 30 g vibration.

When it comes to servo packages, we've got the technical considerations licked. That goes for both components and packaging design.

We can give you the "tightest" job at the lowest price and meet your delivery requirements, too.

We have literally thousands of different servo components. Motors: stepper, synchronous, braked, viscous-damped and inertial-damped. Motor generators: rate, damping, integrating and high-signal-to-noise. Synchros and resolvers of all descriptions. Clutches, brakes and gearheads.

We design and build all the associated electronics: servo and buffer amplifiers, stepper-motor logic packages, phase-shifting capacitors, quadrature rejection circuits, electronic choppers and summing, isolation and switching networks.

Shown here are servo assemblies we've designed and produced to customer requirements using not-so-standard Kearfott elements and experience.

All you have to do to solve similar problems is call one single source—Kearfott. Write for our new brochure "Kearfott Servos." Address: Kearfott Products Division, General Precision, Inc., Aerospace Group, Dept. 1450, 1150 McBride Ave., Little Falls, N.J. 07424.

KEARFOTT PRODUCTS DIVISION

GENERAL PRECISION INC.

AEROSPACE GROUP

Little Falls, New Jersey 07424.

General Precision, Inc. is a subsidiary of General Precision Equipment Corporation.

ANSWER: KEARFOTT'S "ALL-UNDER-ONE-ROOF" SERVICES.

ON READER-SERVICE CARD CIRCLE 83

ON READER-SERVICE CARD CIRCLE 84 ➤

THE NEW GENERATION

SILVERLINE T.M.*

a new, superior line of Clifton Synchros

• Higher Accuracy. 5′ standard • Outstanding Repeatability of Calibration Pattern • Stability of Calibration over Temp. • 150°C Standard Operating Temp.

Keeping pace with the developing aerospace field, Clifton announces SILVERLINE, a new, superior line of standard synchros. □ These units, a natural evolution from our present line of quality synchros, embody certain new manufacturing techniques and space age materials. The result is a standard synchro which outperforms present synchros in four distinct ways shown above. □ SILVERLINE synchros are in the field now. Call your local Clifton Sales Office for price, delivery and further information.

cppc CLIFTON
DIVISION OF LITTON INDUSTRIES

*Trademark of Clifton Division of Litton Industries

Triple-barrelled probe spans dc to 50 MHz

Tektronix, Inc., P. O. Box 500, Beaverton, Ore. Phone: (503) 644-0161. Price: $600.

This probe is useful for evaluating the performance of semiconductor and SCR circuits where a wide range of parameters exist. Fast switching transients, low-frequency response, and dc current level will be displayed simultaneously. Type P6042 has dc, pulse and high-frequency capability. Calibrated deflection factor ranges from 1 mA/div to 1 A/div in a 1-2-5 sequence (oscilloscope set at 50 mV/div). It has a bandwidth of dc-to-50 MHz and risetime of 7 ns. The output impedance is 50 Ω and is terminated into 50 Ω at the input of conventional oscilloscopes. When the probe is clipped around two wires carrying current in the same direction, the sum is displayed; when one of the wires is reversed, their difference is displayed. For increased sensitivity, several loops of one wire may be placed through the probe, increasing the sensitivity by the number of the loops.

Booth No. 2818 Circle No. 317

Get nanovolt sensitivity in dc testing

Keithley Instruments, Inc., 28775 Aurora Rd., Cleveland. Phone: (216) 248-0400. Price: $1795.

A sensitive nanovolt amplifier extends the range of accurate dc voltage measuring systems. It can be used to obtain nanovolt sensitivity with digital voltmeters, differential voltmeters, A-to-D converters and any digital data handling systems. Model 140 has selectable gains from 10^2 to 10^5, allowing a choice of sensitivity. Its maximum output of 10 volts is more than sufficient to be accurately measured with a DVM. Since only two instruments are used, interface and connection problems within the system are minimized. Accuracy is between ±0.005% and 0.01% depending upon measurement conditions. A choice of three rise times is available: 5 seconds for low-noise measurements, and 0.5 or 0.05 seconds for fast measurements with little aditional noise. To minimize circuit loading errors in the recording instrument, output resistance is less than 0.2 Ω. Battery operation permits maximum isolation from power lines and ground. The battery will be charged automatically when the model 140 is connected to the line, whether it is turned on or off. When battery operated, the line is internally disconnected.

Booth No. 3008 Circle No. 325

Amplifier finds signals 51 dB below noise

Princeton Applied Research Corp., P.O. Box 565, Princeton, N. J. Phone: (609) 924-6835 P&A: $765; 60 days.

The lock-in amplifier operates as an amplifier, detector and filter combination with an equivalent noise bandwidth of less than 0.0083 Hz. The operating frequency is locked to the input signal, eliminating drift problems encountered when narrow-banding to eliminate noise. With a signal channel input impedance of 10 MΩ shunted by 30 pF and a noise figure of less than 3 dB at 1 kHz, the amplifier has minimum full-scale sensitivity of 100 μV for low level signal detection.

Booth No. 2706 Circle No. 299

Integrating DVM holds its calibration

Cohu Electronics, Inc., Box 623, San Diego, Calif. Phone: (714) 277-6700. P&A: $1495 to $2750; 28 days.

This integrating digital voltmeter has an accuracy of 0.01% of reading ±1 digit in four ranges from 1.5 to 1000 volts dc. Features include five-digit readout with overranging digit, polarity and decimal, manual and automatic range selection and constant 10-MΩ input impedance. No zero adjustment is required between six month calibration periods.

Booth No. 3001 Circle No. 287

Integrating DVM takes 40 readings per second

Hewlett Packard, 1501 Page Mill Rd., Palo Alto, Calif. Phone: (415) 326-7000. P&A: $4800; 2 months.

Five measurement ranges, from ±0.1 V to ±1000 V full scale are featured in this voltmeter. Resolution on the 0.1-V range is 1 μV, enabling the voltmeter to measure millivolt signals accurately without a preamp. The measurement linearity is 0.003%. Accuracy is ±0.01% of reading ±0.005% of full scale. The instrument automatically opens the input circuit when overloaded, and resets itself at the start of the next measurement cycle. Input resistance is 10 MΩ shunted by 200 pF on all ranges.

Booth No. 2909 Circle No. 297

The wrapped tubular explosion!

When you think of wrapped mylar capacitors, you naturally think of Cornell-Dubilier. Over the years, our type WMF has become an industry standard.

But our wrapped mylars are just a small part of the biggest selection of wrapped tubular capacitors made. The CDE line also includes type MFP pressed mylars, military grade type CTM mylars, type MMW metallized mylars and two brand new types. WCR polycarbonates and MCR metallized polycarbonates.

All are SPRINT stock standards. All are available through CDE's Authorized Industrial Distributors.

CDE CORNELL-DUBILIER

— STOCK STANDARDS — WRAPPED TUBULAR CAPACITORS —

WMF — GENERAL PURPOSE MINIATURE

STANDARD STOCK RATINGS

‡ Tolerance ±20% or ±10%

Cap. Mfd.	100V DCW		200V DCW		400V DCW		600V DCW	
	†Type WMF -	Size DxL (In.)	†Type WMF -	Size DxL (In.)	†Type WMF -	Size DxL (In.)	†Type WMF -	Size DxL (In.)
.001	1D1	.156 x 1/2	2D1	.156 x 1/2	4D1	.156 x 5/8	6D1	.170 x 3/4
.0012	1D12	.156 x 1/2	—	—	—	—	—	—
.0015	1D15	.156 x 1/2	2D15	.156 x 1/2	4D15	.156 x 5/8	6D15	.170 x 3/4
.0018	1D18	.156 x 1/2	—	—	—	—	—	—
.0022	1D22	.156 x 1/2	2D22	.156 x 1/2	4D22	.156 x 5/8	6D22	.187 x 3/4
.0027	1D27	.156 x 1/2	—	—	—	—	—	—
.0033	1D33	.156 x 1/2	2D33	.160 x 1/2	4D33	.190 x 5/8	6D33	.203 x 3/4
.0039	1039	.156 x 1/2	—	—	—	—	—	—
.0047	1D47	.156 x 1/2	2D47	.170 x 1/2	4D47	.200 x 5/8	6047	.234 x 3/4
.0050	1D5	.156 x 1/2	—	—	—	—	—	—
.0056	1D56	.156 x 1/2	—	—	—	—	—	—
.0068	1D68	.175 x 1/2	2D68	.200 x 1/2	4068	.250 x 5/8	6D68	.265 x 3/4
.0082	1D82	.175 x 1/2	—	—	—	—	—	—
.01	1S1	.200 x 1/2	2S1	.230 x 1/2	4S1	.300 x 5/8	6S1	.290 x 3/4
.012	1S12	.215 x 1/2	—	—	—	—	—	—
.015	1S15	.235 x 1/2	2S15	.290 x 1/2	4S15	.360 x 5/8	6S15	.312 x 7/8
.018	1S18	.255 x 1/2	—	—	—	—	—	—
.022	1S22	.275 x 5/8	2S22	.260 x 5/8	4S22	.320 x 3/4	6S22	.335 x 7/8
.027	1S27	.300 x 5/8	—	—	—	—	—	—
.033	1S33	.300 x 5/8	2S33	.270 x 3/4	4S33	350 x 7/8	6S33	.350 x 1
.039	1S39	.245 x 3/4	—	—	—	—	—	—
.047	1S47	.265 x 3/4	2S47	.320 x 3/4	4S47	.400 x 7/8	6S47	.415 x 1
.050	1S5	.265 x 3/4	—	—	—	—	—	—

Cap. Mfd.	100V DCW		200V DCW		400V DCW		600V DCW	
	†Type WMF -	Size DxL (In.)	†Type WMF -	Size DxL (In.)	†Type WMF -	Size DxL (In.)	†Type WMF -	Size DxL (In.
.056	1S56	.265 x 3/4	—	—	—	—	—	—
.068	1S68	.280 x 3/4	2S68	.350 x 3/4	4S68	.390 x 1	6S68	.500 x 1
.082	1S82	.270 x 3/4	—	—	—	—	—	—
.1	1P1	.290 x 7/8	2P1	.410 x 7/8	4P1	.465 x 1	6P1	.520 x 1 3/
.12	1P12	.315 x 7/8	—	—	—	—	—	—
.15	1P15	.335 x 7/8	2P15	.500 x 7/8	4P15	.515 x 1 1/4	6P15	.625 x 1 3/
.18	1P18	.350 x 1	—	—	—	—	—	—
.22	1P22	.385 x 1	2P22	.500 x 1 1/8	4P22	.565 x 1 3/8	6P22	.660 x 1 5/
.27	1P27	.380 x 1 1/8	—	—	—	—	—	—
.33	1P33	.415 x 1 1/8	2P33	.550 x 1 1/8	4P33	.600 x 1 5/8	6P33	.687 x 2
.39	1P39	.460 x 1 1/8	—	—	—	—	—	—
.47	1P47	.475 x 1 1/4	2P47	.600 x 1 1/4	4P47	.700 x 1 5/8	6P47	.855 x 2
.50	1P5	.500 x 1 1/4	—	—	—	—	—	—
.56	1P56	.525 x 1 1/4	—	—	—	—	—	—
.68	1P68	.570 x 1 1/4	2P68	.650 x 1 5/8	4P68	.790 x 1 3/4	6P68	.970 x 2
.82	1P82	.585 x 1 3/8	—	—	—	—	—	—
1.0	1W1	.625 x 1 1/2	2W1	.750 x 1 3/4	4W1	.875 x 2	6W1	1.165 x 2 1/
1.25	1W1P25	.690 x 1 1/2	2W1P25	.825 x 1 3/4	4W1P25	.950 x 2	6W1P25	1.340 x 2 1/
1.5	1W1P5	.770 x 1 3/4	2W1P5	.900 x 1 3/4	4W1P5	.975 x 2 1/4	6W1P5	1.275 x 3
2.0	1W2	.955 x 1 3/4	2W2	.980 x 1 7/8	4W2	1.250 x 2 1/4	6W2	1.460 x 3
3.0	1W3	1.100 x 2 5/16						
4.0	1W4	1.250 x 2.500						

† Order by complete type no.; e.g., WMF1D68 Type numbers listed are ±10%; Available to 1.0 mfd in ±20% tolerance. To specify ±20% add —20

MFP — FLAT MYLAR* WRAP

STANDARD STOCK RATINGS

‡ Tolerance ±20% or ±10%

Cap. Mfd.	100V DCW		200V DCW		400V DCW		600V DCW	
	†Type MFP—	L x W x T (Inches)	†Type MFP—	L x W x T (Inches)	†Type MFP—	L x W x T (Inches)	†Type MFP—	L x W x T (Inches)
.01	★		★		★		6S1	.750 x .343 x .218
.015	★		2S15	.500 x .312 x .187	4S15	.625 x .437 x .312	6S15	.875 x .343 x .218
.022	1S22	.625 x .343 x .218	2S22	.625 x .343 x .218	4S22	.750 x .375 x .250	6S22	.875 x .406 x .281
.033	1S33	.625 x .312 x .187	2S33	.750 x .343 x .218	4S33	.875 x .406 x .281	6S33	1.000 x .406 x .281
.047	1S47	.750 x .312 x .187	2S47	.750 x .375 x .250	4S47	.875 x .500 x .343	6S47	1.000 x .468 x .343
.068	1S68	.750 x .343 x .218	2S68	.750 x .437 x .250	4S68	1.000 x .437 x .312	6S68	1.000 x .562 x .406
.1	1P1	.875 x .343 x .218	2P1	.875 x .500 x .312	4P1	1.000 x .531 x .375	6P1	1.375 x .593 x .406
.15	1P15	.875 x .406 x .250	2P15	.875 x .562 x .375	4P15	1.250 x .562 x .406	6P15	1.375 x .687 x .531
.22	1P22	1.000 x .468 x .281	2P22	1.125 x .562 x .406	4P22	1.375 x .625 x .500	6P22	1.625 x .750 x .531
.33	1P33	1.125 x .500 x .312	2P33	1.125 x .625 x .500	4P33	1.625 x .656 x .500	6P33	2.000 x .781 x .562
.47	1P47	1.250 x .531 x .375	2P47	1.250 x .656 x .500	4P47	1.625 x .781 x .593	6P47	2.000 x .937 x .718
.68	1P68	1.250 x .687 x .468	2P68	1.625 x .718 x .531	4P68	1.750 x .875 x .687	6P68	2.000 x 1.062 x .843
1.0	1W1	1.500 x .718 x .500	2W1	1.750 x .812 x .625	4W1	2.000 x .937 x .750	6W1	2.500 x 1.250 x 1.062
1.25	1W1P25	1.500 x .718 x .562	2W1P25	1.750 x .960 x .687	4W1P25	2.000 x 1.062 x .843	6W1-P25	2.500 x 1.437 x 1.218
1.50	1W1P5	1.750 x .843 x .656	2W1P5	1.750 x 1.000 x .781	4W1P5	2.250 x 1.062 x .843	6W1P5	3.000 x 1.406 x 1.093
2.0	1W2	1.750 x 1.062 x .843	2W2	1.875 x 1.062 x .843	4W2	2.250 x 1.312 x 1.125	6W2	3.000 x 1.593 x 1.281

★ Covered by Parent Case size. Use next higher voltage for same case size. † Order by complete type no.; e.g., MFP1S22. ‡ Type numbers listed are ±20%; to specify ±10% add —10 to type no.

MMW — MINIATURE MYLAR WRAP — METALLIZED

STANDARD STOCK RATINGS

Tolerance ±20%

Cap. Mfd.	200V DCW		400V DCW		600V DCW		Cap. Mfd.	200V DCW		400V DCW		600V DCW	
	Type† MMW—	D x L (Inches)	Type† MMW—	D x L (Inches)	Type† MMW—	D x L (Inches)		Type† MMW—	D x L (Inches)	Type† MMW—	D x L (Inches)	Type† MMW—	D x L (Inches)
.01	★		4S1	.180 x 9/16	6S1	.200 x 3/4	.22	2P22	.340 x 11/16	4P22	.400 x 1 1/4	6P22	.575 x 1 1/4
.015	★		4S15	.180 x 11/16	6S15	.250 x 3/4	.33	2P33	.390 x 11/16	4P33	.450 x 1 1/2	6P33	.560 x 1 3/4
.022	★		4S22	.210 x 11/16	6S22	.300 x 3/4	.47	2P47	.370 x 1	4P47	.520 x 1 1/2	6P47	.675 x 1 3/4
.033	2S33	.180 x 5/16	4S33	.250 x 11/16	6S33	.370 x 3/4	.68	2P68	.420 x 1	4P68	.625 x 1 1/2	6P68	.800 x 1 3/4
.047	2S47	.200 x 5/16	4S47	.300 x 11/16	6S47	.325 x 1 1/16	1.0	2W1	.500 x 1	4W1	.675 x 1 3/4	6W1	.950 x 1 3/4
.068	2S68	.200 x 11/16	4S68	.350 x 11/16	6S68	.400 x 1 1/16	1.5	2W1P5	.540 x 1 1/4	4W1P5	.825 x 1 3/4		
.1	2P1	.240 x 11/16	4P1	.325 x 1	6P1	.450 x 1 1/16	2.0	2W2	.620 x 1 1/4	4W2	.950 x 1 3/4		
.15	2P15	.280 x 11/16	4P15	.375 x 1	6P15	.475 x 1 1/4							

★ Use next higher voltage rating. † Order by complete type number; e.g., MMW2S33.

MCR — FILM WRAP METALLIZED POLYCARBONATE

STANDARD STOCK RATINGS

Tolerance ±20%

Cap. Mfd.	200V DCW		Lead Size	400V DCW		Lead Size	600V DCW		Lead Size
	†Type MCR—	Size D x L (In.)		†Type MCR—	Size D x L (In.)		†Type MCR—	Size D x L (In.)	
.01	2S1	.150 x 5/16	24	4S1	.200 x 9/16	24	6S1	.245 x 3/4	24
.015	2S15	.175 x 5/16	24	4S15	.200 x 11/16	24	6S15	.295 x 3/4	24
.022	2S22	.185 x 5/16	24	4S22	.225 x 11/16	24	6S22	.350 x 3/4	24
.033	2S33	.215 x 5/16	24	4S33	.260 x 11/16	24	6S33	.420 x 3/4	22
.047	2S47	.240 x 5/16	24	4S47	.320 x 11/16	22	6S47	.375 x 1 1/16	22
.068	2S68	.215 x 11/16	24	4S68	.375 x 11/16	22	6S68	.435 x 1 1/16	22
.1	2P1	.275 x 11/16	24	4P1	.345 x 1	22	6P1	.525 x 1 1/16	22
.15	2P15	.310 x 11/16	22	4P15	.400 x 1	22	6P15	.565 x 1 1/4	22
.22	2P22	.370 x 11/16	22	4P22	.425 x 1 1/4	22	6P22	.670 x 1 1/4	22
.33	2P33	.430 x 11/16	22	4P33	.465 x 1 1/2	22	6P33	.670 x 1 3/4	22

Cap. Mfd.	200V DCW		Lead Size	400V DCW		Lead Size	600V DCW		Lead Size
	†Type MCR—	Size D x L (In.)		†Type MCR—	Size D x L (In.)		†Type MCR—	Size D x L (In.)	
.47	2P47	.370 x 1	22	4P47	.550 x 1 1/2	20	6P47	.775 x 1 3/4	18
.68	2P68	.450 x 1	22	4P68	.650 x 1 1/2	20	6P68	.925 x 1 3/4	18
1.0	2W1	.530 x 1	22	4W1	.725 x 1 3/4	18	6W1	1.125 x 1 3/4	18
1.5	2W1P5	.575 x 1 1/4	20	4W1P5	.865 x 1 3/4	18	—	—	—
2.0	2W2	.650 x 1 1/4	20	4W2	.990 x 1 3/4	18	—	—	—
3.0	2W3	.700 x 1 1/2	18	4W3	1.062 x 2 1/4	18	—	—	—
4.0	2W4	.745 x 1 3/4	18	—	—	—	—	—	—
5.0	2W5	.825 x 1 3/4	18	—	—	—	—	—	—

† Order by complete type number; e.g., MCR2S22

WCR — FILM WRAP POLYCARBONATE

STANDARD STOCK RATINGS

Tolerance ±10%

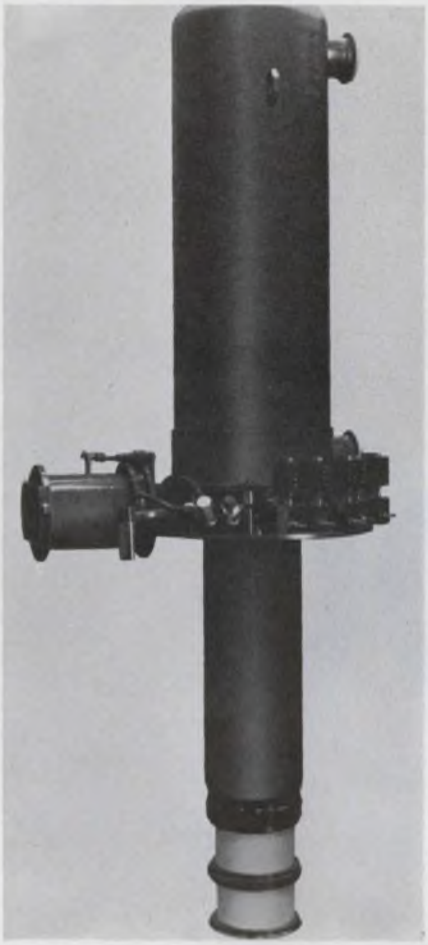
Cap. Mfd.	100V DCW		Lead Size	200V DCW		Lead Size
	†Type WCR—	Size (D x L (Inches)		†Type WCR—	Size (D x L (Inches)	
.001	1D1	.200 x 15/16	24	2D1	.200 x 15/16	24
.0022	1D22	.220 x 15/16	24	2D22	.220 x 15/16	24
.0033	1D33	.260 x 15/16	24	2D33	.260 x 15/16	22
.0047	1D47	.290 x 15/16	24	2D47	.290 x 15/16	22
.0068	1D68	.340 x 15/16	24	2D68	.290 x 15/16	22
.01	1S1	.235 x 3/4	24	2S1	.290 x 15/16	22
.015	1S15	.245 x 3/4	24	2S15	.320 x 15/16	22
.022	1S22	.295 x 3/4	22	2S22	.385 x 15/16	22
.033	1S33	.345 x 3/4	22	2S33	.465 x 15/16	22
.047	1S47	.395 x 3/4	22	2S47	.405 x 1 5/16	22

Cap. Mfd.	100V DCW		Lead Size	200V DCW		Lead Size
	†Type WCR—	Size (D x L (Inches)		†Type WCR—	Size (D x L (Inches)	
.068	1S68	.415 x 7/8	22	2S68	.485 x 1 5/16	22
.1	1P1	.450 x 1	22	2P1	.585 x 1 5/16	20
.15	1P15	.525 x 1 1/8	20	2P15	.700 x 1 5/16	18
.22	1P22	.590 x 1 1/8	20	2P22	.675 x 1 7/8	18
.33	1P33	.645 x 1 3/8	20	2P33	.815 x 1 7/8	18
.47	1P47	.735 x 1 5/8	18	2P47	.950 x 1 7/8	18
.68	1P68	.765 x 1 7/8	18	2P68	1.000 x 2 3/8	18
1.0	1W1	.925 x 1 7/8	18	—	—	—

† Order by complete type number; e.g., WCR1D22

* DuPont T.M.

S-band klystrons give 500 kW cw



EIMAC Division of Varian, 301 Industrial Way, San Carlos, Calif. Phone: (415) 592-1221.

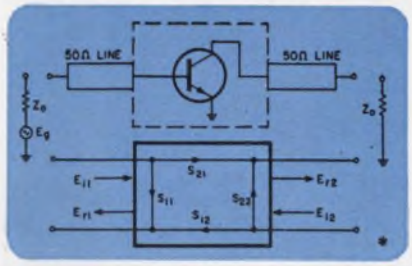
Producing over 500-kW continuous wave power at S-band, this tube is reportedly the highest power klystron yet delivered. The five-cavity klystron features 56% efficiency and 56-dB gain, and has an instantaneous bandwidth of 20 MHz. The tube may be operated in any attitude, including antenna mounting. The collector is rated at a megawatt, allowing amplitude modulation of the drive level or full removal of drive without overheating. Digital counters are provided to facilitate tuning.

Beam voltage may be varied from 45 kV (130-kW output) to 63 kV (500-kW output) without retuning. The output window is a single beryllium oxide structure in a half-wave circular configuration. The magnet requires only a single power supply at a fixed current for all operating conditions and powers.

Booth No. 2309 *Circle No. 285*

Transistor Parameter Measurements
with the hp 8405A Vector Voltmeter

Measurement of transistor h, y or z parameters becomes increasingly difficult above 100 MHz through an inability to obtain consistently good open- and short-circuits. Tedious adjustment of tuning stubs is usually required for each measurement frequency, and unwanted circuit oscillations often occur.



With the 8405A Vector Voltmeter, however, it is easy to measure a slightly different set of parameters—the "s" or scattering parameters. Measurement is simple over a wide frequency range and since the parameters are measured with a Z_0 load, there is little chance for oscillation. The measured s parameters can be plotted directly on a Smith Chart and easily manipulated to establish optimum gain with matching networks. Or the s parameters can be translated into h, y, or z parameters if desired.

Free Application Data

Hewlett-Packard has prepared an application note on s parameter measurements. Write today for your copy of Application Note #77-1, "Transistor Parameter Measurement", to Hewlett-Packard, Palo Alto, California 94304. Europe: 54 Route des Acacias, Geneva.

The hp 8405A Vector Voltmeter is a new, wideband, 2-channel RF millivoltmeter-phasemeter. With the 8405A, measurements that were formerly difficult or impossible can now be made quickly, easily and accurately.

Major Specifications, HP 8405A Vector Voltmeter

Frequency Range is 1 to 1000 MHz in 21 overlapping octave bands; automatic tuning within each band.

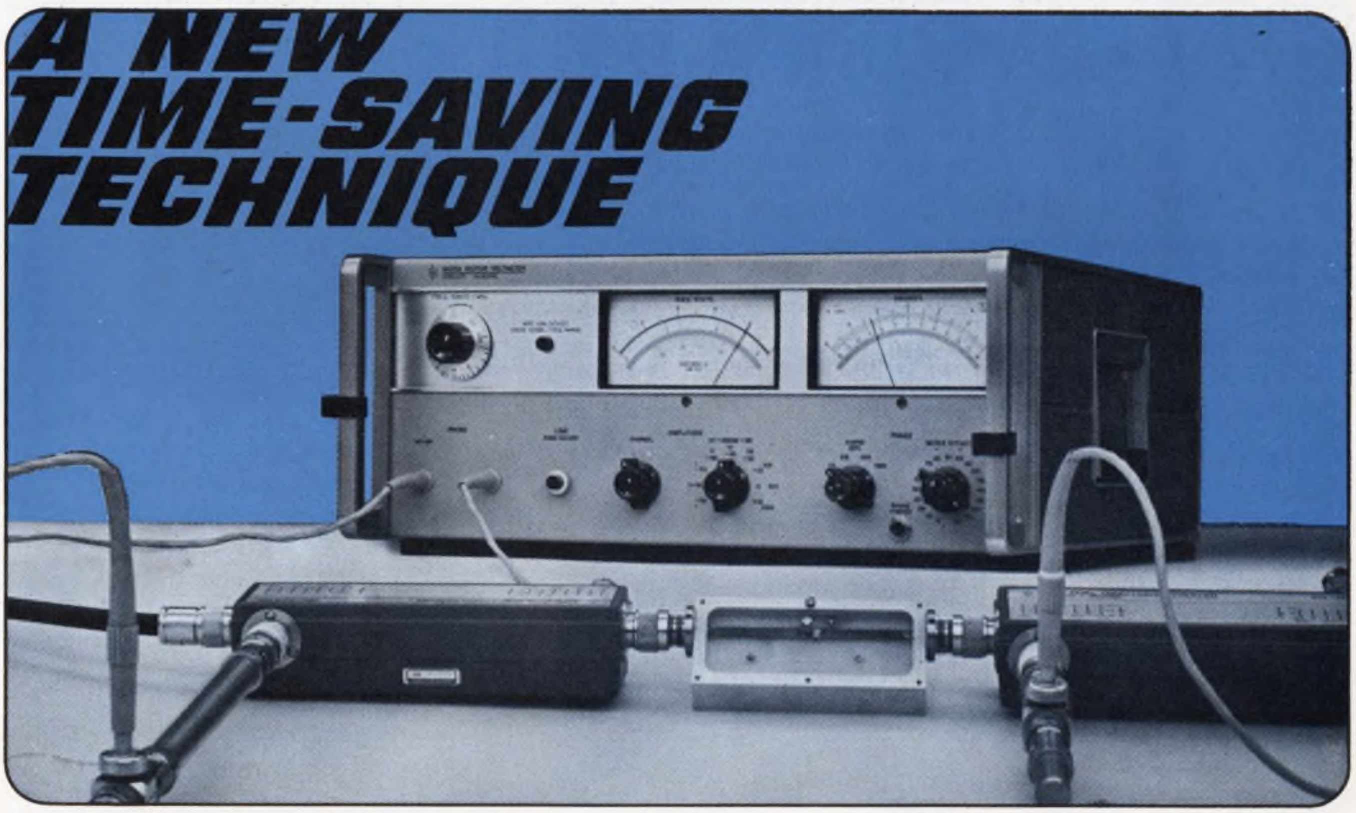
Voltage Range for Channel A (synchronizing channel), 300 μv to 1 v rms (10-500 MHz), 500 μv to 1 v rms (500-1000 MHz), 1.5 mv to 1 v rms (1-10 MHz).

Voltage Range for Channel B (input to Channel A required), 100 μv to 1 v rms, full scale. Full-scale meter ranges from 100 μv to 1 v in 10 db steps. Both channels can be extended to 10 v rms with 11576A 10:1 Divider.

Phase Range of 360° indicated on zero-center meter with end-scale ranges of ±180°, ±60°, ±18°, ±6°. Phase meter OFFSET of ±180° in 10° steps permits use of ±6° range for 0.1° phase resolution at any phase angle.

Price: $2750.

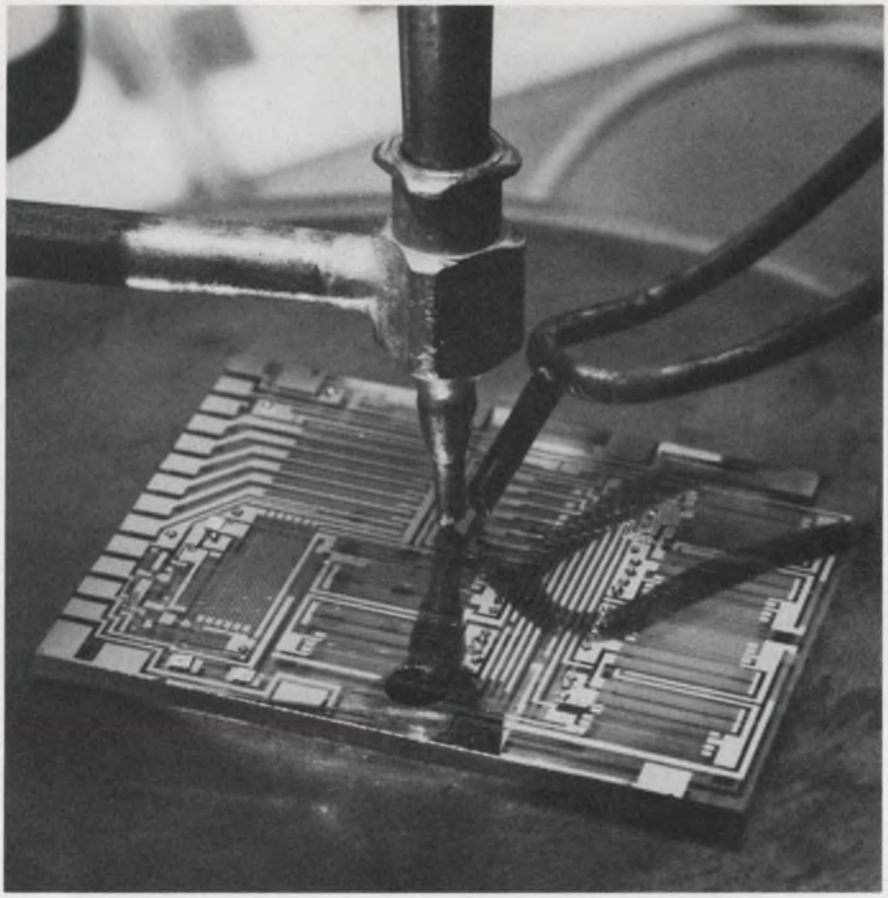
* NPN Transistor in common emitter configuration and its equivalent 2 port scattering diagram.



HEWLETT hp PACKARD

1697R

ON READER-SERVICE CARD CIRCLE 88



Precision phase standard accurate to 0.015°

Ad-Yu Electronics Inc., 249 Terhune St., Passaic, N. J. Phone: (201) 472-5622. Price: $4365.

This device features self-calibration and self-checking by means of fundamental bridge balancing, without the use of an external standard. Its phase shift can be set from 0° to 360° with 7-digit resolution. The instrument accepts a stable sine wave and produces two output signals. Type 209 can be used over the range of 50 Hz to 10 kHz. It does not require interpretation of patterns on a scope, or electrical sampling of many cycles.

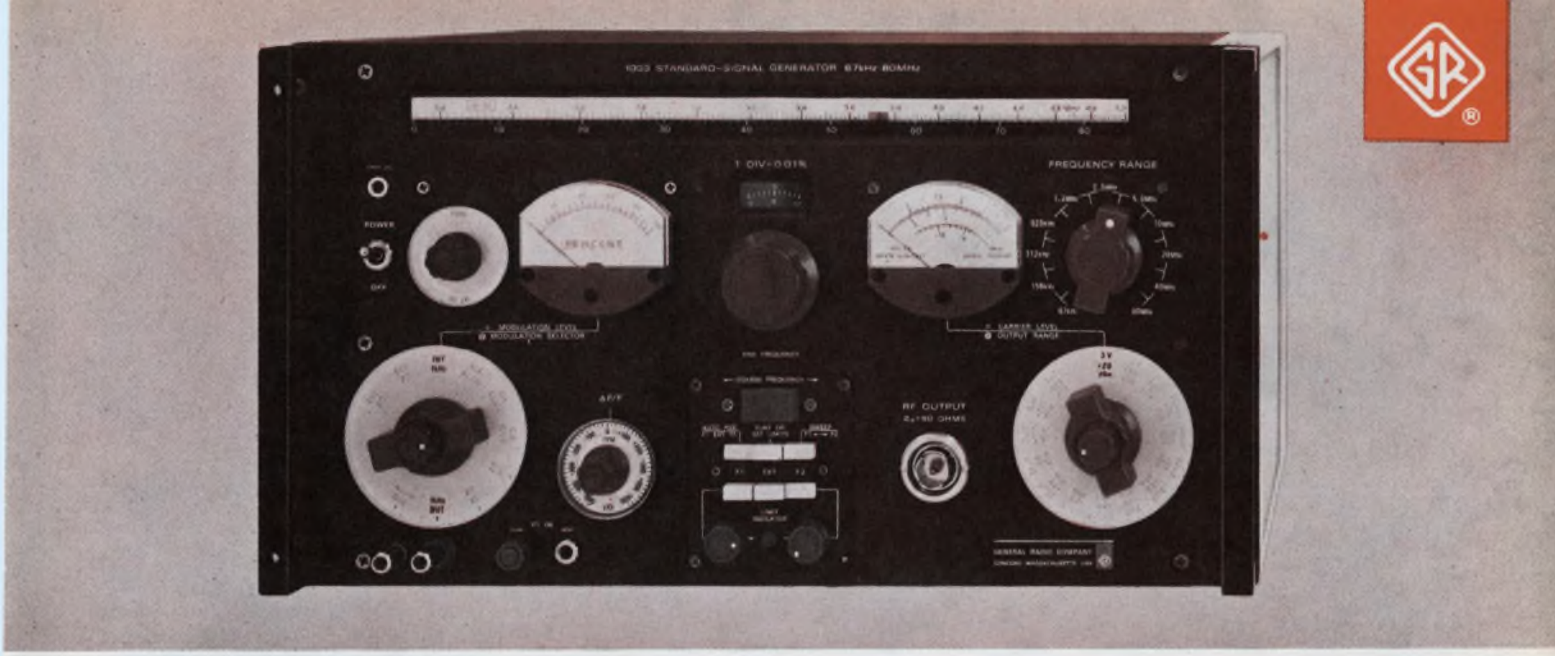
Booth No. 3302 Circle No. 294

Frequency synthesizer spans dc to 100 kHz

Measurements, McGraw Edison Div., Boonton, N. J. Phone: (201) 334-2131. Price: $2850.

This instrument spans dc to 100 kHz with digital selection of 0.01 cycle. A variable oscillator provides continuous frequency selection over the range of any digit except the 10 kHz. The unit operates on the direct synthesis principle, avoiding the problems common to phase-locked oscillators. Frequency generation is under control of a 1-MHz quartz oscillator with short-term stability of one part in 10^8. Digital assemblies may be omitted with a price reduction of $170 per digit.

Booth No. 2803 Circle No. 283



We've Pushed Signal-Generator Performance to the Limits

An innovation in signal-generators brings about 10-to-1 better frequency stability and improved accuracy and resolution, without sacrificing other performance features. The key to this performance is the frequency-generating system — a single-range, optimally designed oscillator followed by frequency dividers to provide the successively lower ranges. Thus, the stability of one range is the stability of all, and range switching is accomplished without transient instability. After warmup, drift is typically less than 1 ppm per ten minutes, at least 10 times better than that of any other generator. Because of all-solid-state circuitry, total warmup drift is less than 150 ppm in three hours. Frequency changes caused by band switching or variations in line voltage, load, or level are virtually nonexistent.

The 1003 covers a 67-kHz-to-80 MHz frequency range, and tuning this instrument is as much fun as it is convenient and fast. You can coarse-tune by motor over the main slide-rule dial to within 0.25% at a rate of about 7% per second, and fine-tune manually with a large control whose dial divisions correspond to 0.01% of the main scale. For greater resolution, a "ΔF" control provides electronic, backlash-free settability to 2 ppm. The motor-driven frequency control is fully utilized in the model containing the auto-control unit, which lets you preset frequencies. The preselected frequencies are useful either as limits for automatic sweeping or for programmed frequency selection (repeatable to 0.1%).

Frequency, incremental frequency, and automatic sweeping can all be programmed, as can output level and modulation-percentage. A crystal calibrator with 1-MHz, 200-kHz, and 50-kHz outputs is also supplied with the model containing the auto-control unit. This calibrator allows you to calibrate to within 0.002 percent.

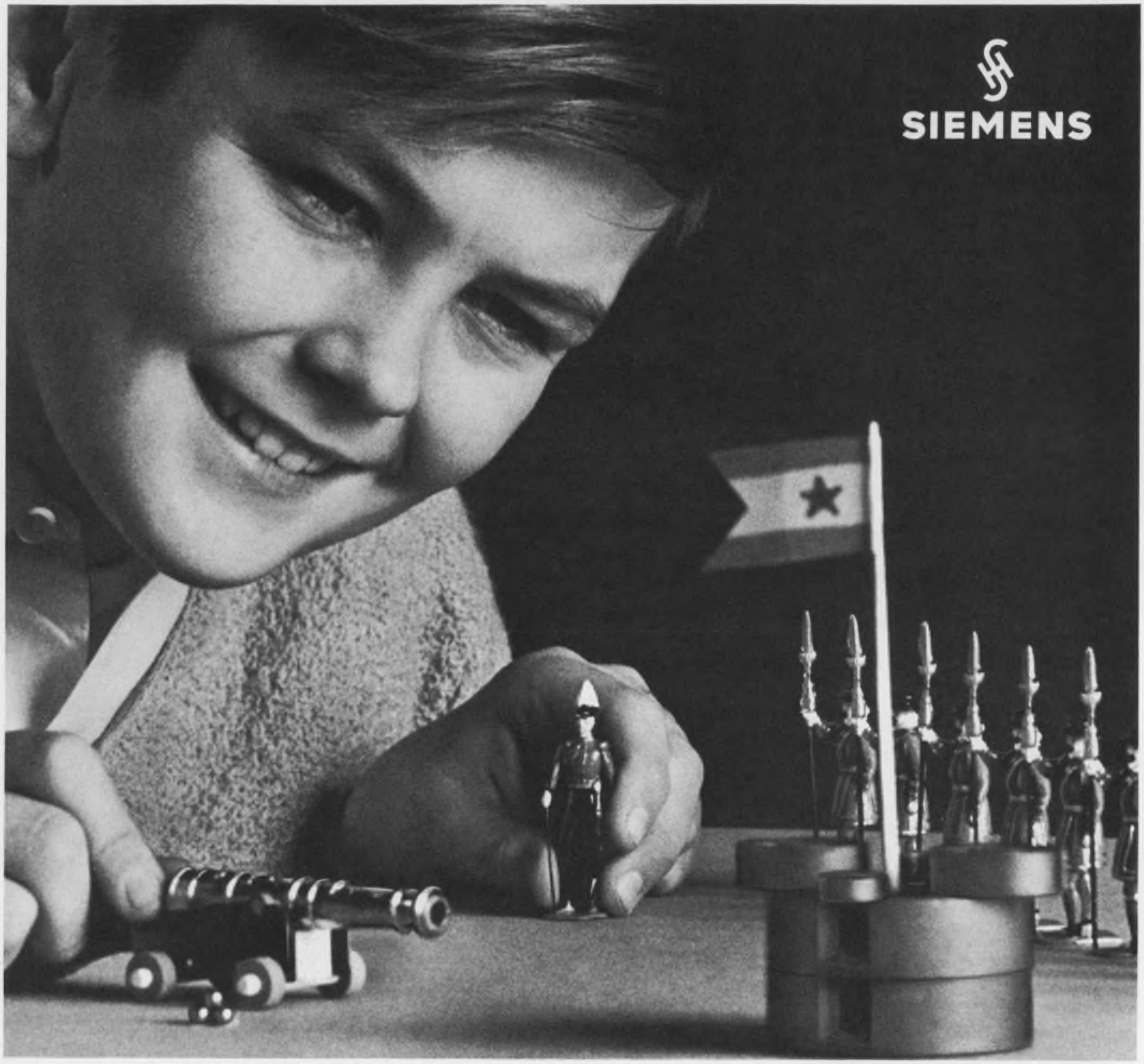
The 1003 requires only 20 watts and delivers 180 milliwatts of leveled CW power into a 50-ohm load (6 volts behind 50 ohms). Envelope distortion is less than 2% at 70% a-m, with the modulating signal of 400 Hz or 1 kHz provided. Incidental phase modulation is less than 0.1 radian with 30% a-m. The highly accurate, 10-dB-per-step attenuator and a continuously adjustable carrier-level control give an over-all 155-dB dynamic range.

This instrument must be seen to be appreciated. A demonstration will show that very-narrow-bandwidth measurements can be made in 10 seconds with a 1003 signal generator and an oscilloscope. Try that with any other signal generator.

Price of the 1003 is $2995 ($2795 without the auto-control unit and crystal calibrator). For complete information, write General Radio Company, 22 Baker Avenue, W. Concord, Massachusetts 01781; telephone (617) 369-4400; TWX (710) 347-1051.

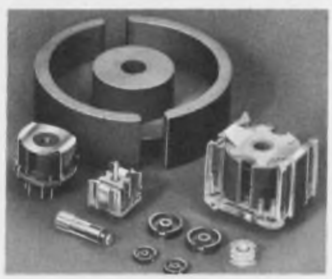
GENERAL RADIO

See the Type 1003 Standard-Signal Generator at WESCON, Booths No. 3015-3018.



uniformity

Month after month, the electrical characteristics of Siemens pot cores are consistent. Precision engineered for adjustable high stability, high-Q coils, they meet the most critical requirements for filters used in multiplex and other carrier-frequency applications. Low distortion and self-shielding are two important plus features. Available out of stock, too. Let a Siemens engineer show you how Siemens pot cores fit into your application. It's child's play.



SIEMENS FERRITE POT CORES

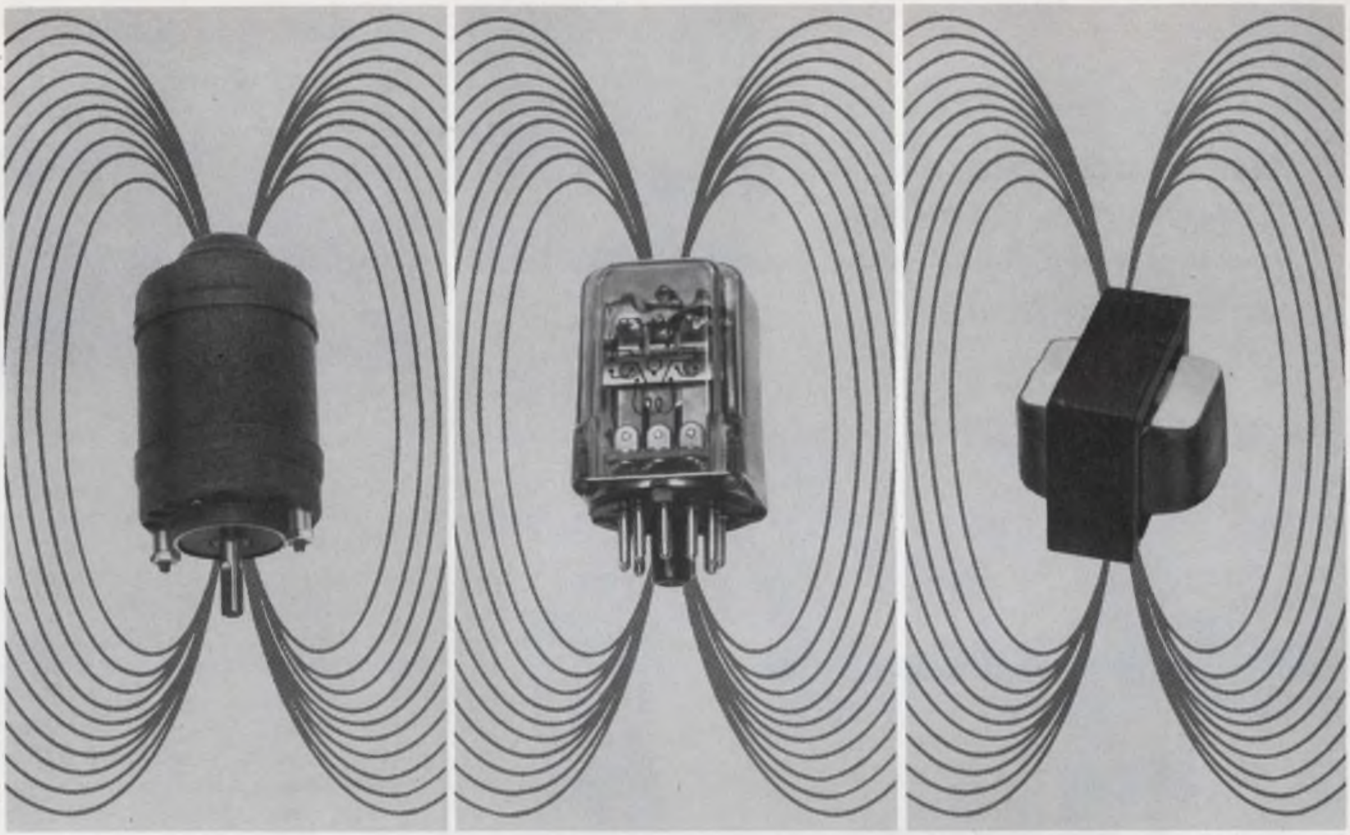
8 different materials, 18 different sizes (.22 to 2.75 inches diameter) and more than 250 standard types afford optimum properties for all filter, oscillator and transformer applications. High Q value with high stability is typical: a 26 x 16 core of N22 or N28 material AL 315 at 100 kc/s shows a Q value of approx. 950. Siemens components include ferrite materials, metallized polyester and polystyrene capacitors, all electronic and microwave tubes, rectifiers and a complete line of semi-conductors.

SIEMENS AMERICA INCORPORATED

VISIT BOOTH 5027/28 WESCON SHOW

Components Division • 230 Ferris Avenue, White Plains, N.Y. 10603

ON READER-SERVICE CARD CIRCLE 121



Now, Get 6 Volts Noise Immunity For Your Digital Control System With New MHTL Integrated Circuits!

You'll get the "right" signal every time in your numerical control, supervisory control and computer peripheral equipment with the new Motorola-developed high threshold integrated circuit logic series. Called MHTL, it's the first family of integrated circuits to offer a noise margin of 6 volts (typ) and a 15 volt (±1V) operating voltage. And, it's priced, packaged, and specified for application in equipment designed for use in high noise industrial environments.

MHTL combines high noise immunity with a voltage swing of 13 volts, broad operating temperature range, large fan-out and a 35 mW power dissipation rating. In short, it offers you discrete circuit characteristics PLUS the price, size, and reliability advantages of integrated circuitry.

Here are some of the MHTL specifications:

CHARACTERISTICS	MHTL
Operating Voltage	15 ± 1 Volts
Noise Immunity	6 Volts (typ)
Fan-out (Gate)	10 (min)
Clock Rate (Flip-Flop)	4 MHz (typ)
Operating Temperature Range	−30°C to +75°C

Offered in the 14-pin dual in-line plastic Unibloc* package, the circuit functions and prices for the MHTL family are as follows:

TYPE	DESCRIPTION	PRICE (1,000 UP)
MC660P	Dual 4-Input Gate	$3.50
MC661P	Dual 4-Input Gate (Passive Pull-Up)	$3.50
MC663P	Dual J-K Flip-Flop	$6.10
MC664P	Master Slave R-S Flip-Flop	$4.05

Other functions planned for the immediate future include a Dual 4-Input Line Driver, Triple Input Interface, Quad Output Interface, Dual Monostable Multivibrator, and Quad 2-Input Gate.

To find out how easily your designs can conquer high-noise-environments with MHTL, write for our data sheets. We'll also send you our latest application note on how MHTL solves your noise problems. For circuits you can try right now — call your nearby franchised Motorola Semiconductor distributor. He has high-noise-immunity MHTL in stock!

*Trademark of Motorola Inc.

– where the priceless ingredient is care!

MOTOROLA Semiconductors

MOTOROLA SEMICONDUCTOR PRODUCTS INC. / P. O. BOX 955 / PHOENIX, ARIZONA 85001 / (602) 273-6900 / TWX 910-931-1334

ON READER-SERVICE CARD CIRCLE 122

INSTRUMENTS & CONTROL

Thin-line counter spans 0.3 to 12.4 GHz

Systron-Donner Corp., 888 Galindo St., Concord, Calif. Phone: (415) 682-6161. Price: $4650.

A new integrated circuit counter has been added to Systron-Donner's "Thin-line" (ED 5, Mar. 1, 1967, p. 114). Featuring automatic measurements from 300 MHz to 12.4 GHz and a direct 100-MHz counting range, the unit combines a built-in Acto (automatic computing transfer oscillator) with a 100-MHz frequency counter for the wide range and automatic operation.

The Acto technique performs phase lock and selection of the proper harmonic automatically. Readout of measurements in the 0.3-to-12.4 GHz range appear instantaneously in 8 digits (9 digits optional) and with a "lok" annunciator that appears only when the Acto has achieved a phase lock with the unknown input. Designed principally of ICs, the unit offers such features as a 1-3/4-inch panel height, slide switches, an optional high-stability oscillator (5 parts in 10^{10} per 24 hrs) and 9-digit readout.

Booth No. 2402 *Circle No. 288*

Audio phase meter ranges 10 Hz to 2 MHz

Wiltron Co., 930 E. Meadow Dr., Palo Alto, Calif. Phone: (415) 321-7428. P&A: $995; 10 wks.

Covering 10 Hz to 2 MHz, this audio phase meter has a dynamic range of 60 dB and a swept frequency capability. A 1-millivolt sensitivity in both channels eliminates the need for external or plug-in preamplifiers which may introduce phase error of their own.

Booth No. 2711 *Circle No. 293*

Adlake Mercury Wetted Relay — Application Data

Measurement of "Dynamic Contact Noise" for Low Level Signal Applications

Adlake AWCS 26000 Series Relay — 2 Switch Form C

In small signal applications, such as computers, telemetric systems, strain gauges, etc. generated emf. within the system's relays must be taken into account.

Dynamic Contact Noise is a "coined" phrase used to indicate an undesired generated emf. upon contact closure. It is the result of mechanical oscillation of the armature—caused by the impact of the armature on the stationary contacts — sweeping the coil flux.

Typical illustrations of this noise are shown in the oscillograms, with the relay being driven at nominal voltage in the test circuit shown below. The frequency and amplitude are integral functions of system bandwidth and coil drive conditions.

The slight ripple seen at the end of each trace is not noise, but due to resolution of test equipment and test circuit.*

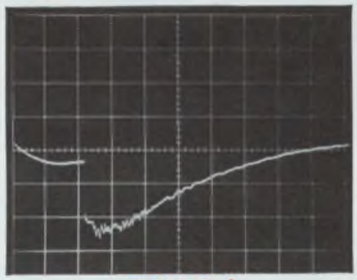


FIGURE 1

Horizontal Deflection	1.0 ms/cm
Vertical Deflection	20 µV/cm
Systems Bandwidth	.06—60 Hz.

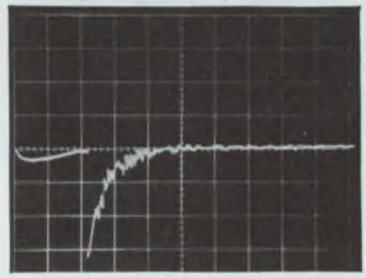


FIGURE 2

Horizontal Deflection	1.0 ms/cm
Vertical Deflection	100 µV/cm
Systems Bandwidth	.06—600 Hz.

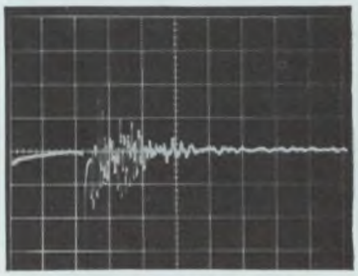


FIGURE 3

Horizontal Deflection	1.0 ms/cm
Vertical Deflection	200 µV/cm
Systems Bandwidth	.06—6K Hz.

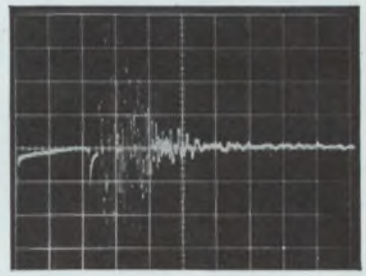
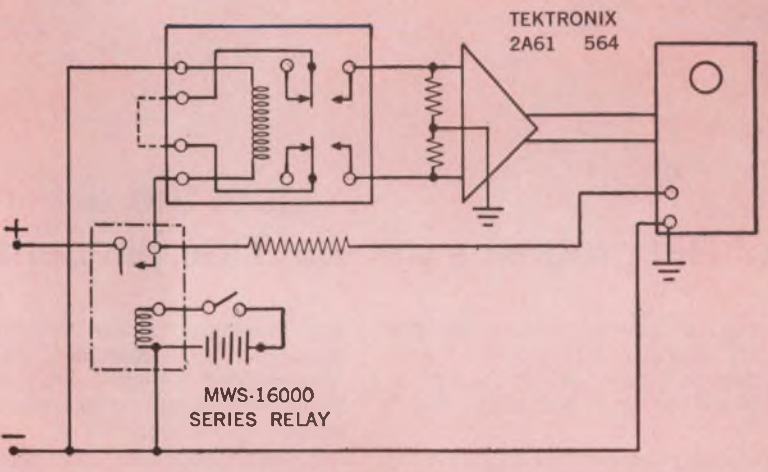


FIGURE 4

Horizontal Deflection	1.0 ms/cm
Vertical Deflection	200 µV/cm
Systems Bandwidth	.06—60K Hz.

TEST CIRCUIT



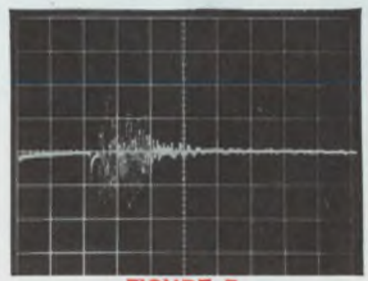


FIGURE 5

Horizontal Deflection	1.0 ms/cm
Vertical Deflection	500 µV/cm
Systems Bandwidth	.06—100K Hz.

*If you have a problem regarding relay applications to a particular system our engineering staff is ready to help you. Contact Mr. Le Roy Carlson, Chief Project Engineer.

Backed by sound research and disciplined engineering, Adlake applies the industry's broadest line of mercury displacement and mercury wetted relays to the creative solution of design circuit problems. However unique or special your application, Adlake can assist you in developing it. For prompt, personal and knowledgeable attention to your relay needs, contact the one source that is the complete source in the mercury relay field. Contact Adlake today for catalog and further information.

Adlake SINCE 1857

THE ADAMS & WESTLAKE *COMPANY*

A SUBSIDIARY OF **ALLIED** *PRODUCTS CORPORATION*

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TRANSPORTATION EQUIPMENT • ARCHITECTURAL PRODUCTS • MERCURY RELAYS • DOORS AND ENTRANCES • CONTRACT MANUFACTURING

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◄ ON READER-SERVICE CARD CIRCLE 125

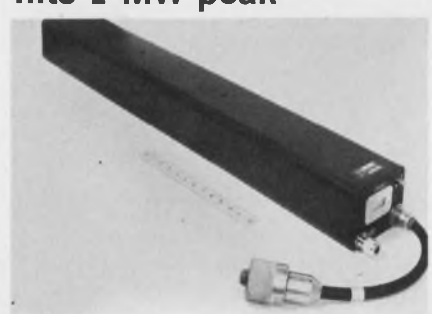
Impedance plots made with pulsed rf

Wiltron Co., 930 E. Meadow Dr., Palo Alto, Calif. Phone: (415) 321-7428. P&A: $3900; 6 wks.

A pulse adapter extends the capabilities of Wiltron's circuit analyzer so it can operate on pulsed signals from 2 MHz to 4 GHz. It is possible to make impedance plots with very short pulses. This is essential in checking mixers whose characteristics change with input level and duty cycle. An important application for this pulse capability is in the testing of the phase shift through microwave tubes where testing can be done with pulses as short as 0.2 μs and phase resolution of better than 1° over the whole range. A dynamic range of 20 dB is automatically handled and can be extended by choice of signal levels.

Booth No. 2711 Circle No. 320

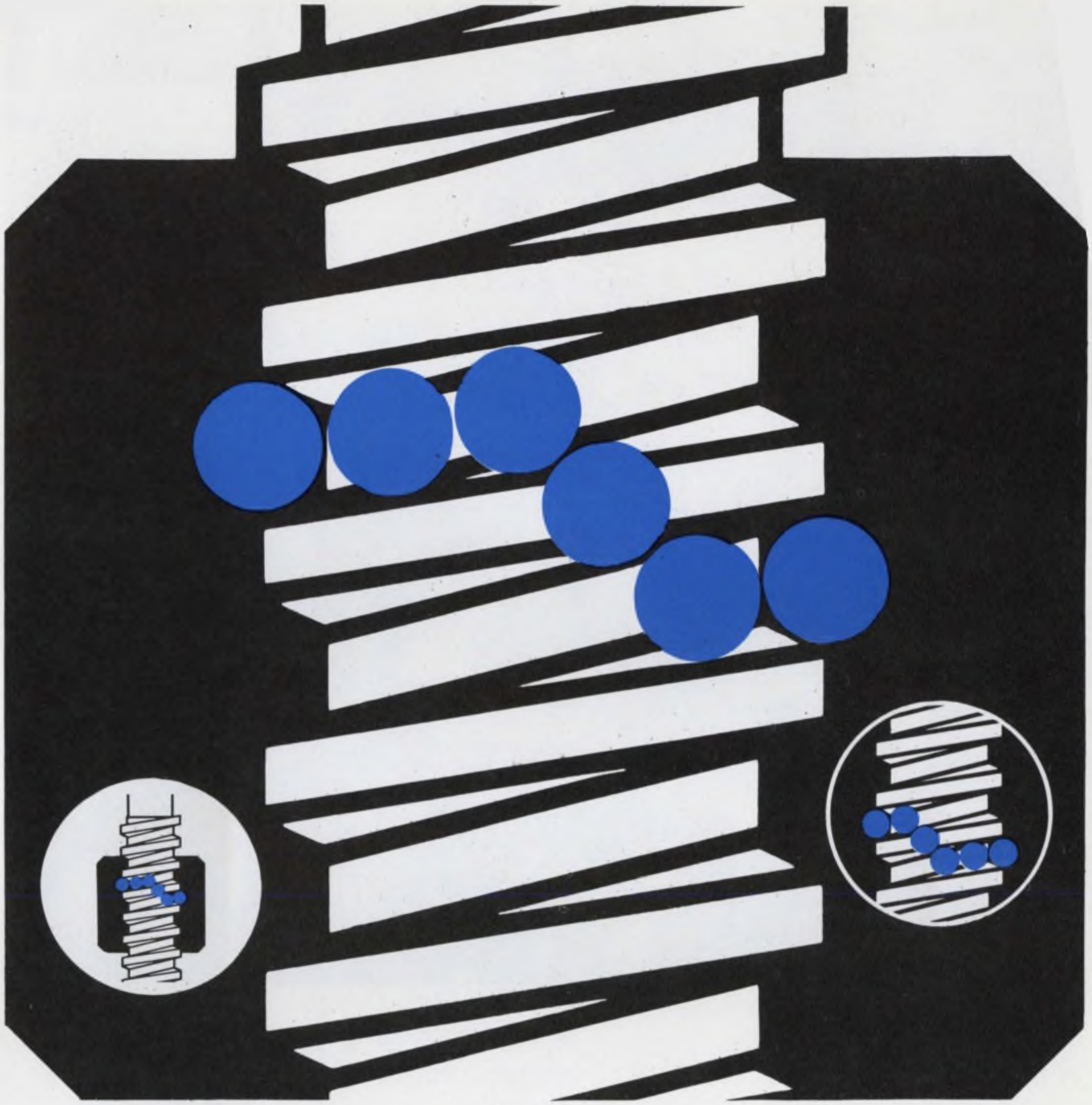
C-band amplifier hits 1 MW peak



Litton Industries, Electron Tube Div., 960 Industrial Rd., San Carlos, Calif. Phone: (415) 591-8411.

With excellent phase and gain characteristics as well as high power outputs over wide bandwidths, this cold-cathode device requires only a dc power supply for operation. At the end of the rf input pulse it automatically ceases operation within a few nanoseconds. Between pulses, there is no current drawn from the supply. No complicated pulse circuitry is required to amplify pulse trains with varying pulse widths and repetition rates.

Booth No. 4207 Circle No. 279



Kidde Ballscrews

SIZE AND WEIGHT PROBLEM SOLVERS

Kidde Ballscrews do more than solve friction problems of prime movers and drives. They can solve size and weight problems, too—and meet the demands for high efficiency transfer of motion and power. Here's why:

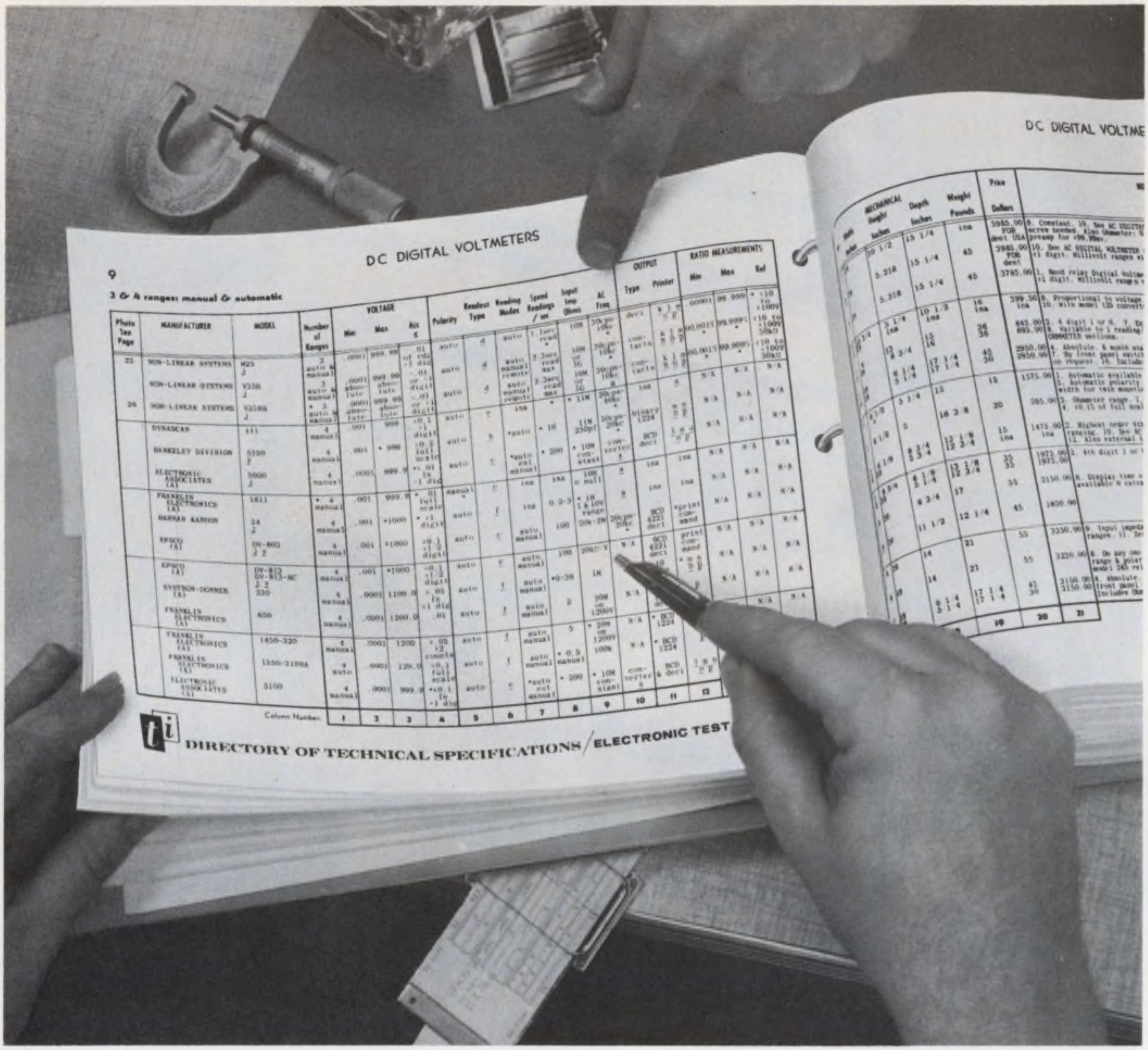
Their compact design results in smaller envelope dimensions. Weight is reduced because external tubes and fittings are eliminated. Kidde designs allow optimum usable power, due to extremely high efficiencies.

To solve these major problems, Kidde has designed a wide range of Ballscrew sizes—from units less than 1″ long to 32 foot custom assemblies. From 6″ diameters down to 1/8″; sizes 3/16″ to 1-1/2″ (with various lead) are stocked.

Learn how Kidde Ballscrews can become your problem solver. Write for your free copy of "Standard and Precision Ballscrews." Walter Kidde & Company Inc., 675 Main Street, Belleville, New Jersey 07109.

Kidde

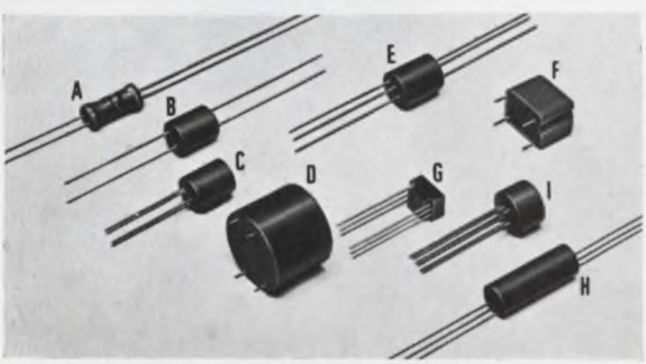
ON READER-SERVICE CARD CIRCLE 128



DC DIGITAL VOLTMETERS
DIRECTORY OF TECHNICAL SPECIFICATIONS/ELECTRONIC TEST
DC DIGITAL VOLTME

fire them this flexible, economical, precise, fail-safe way

. . . with Aladdin pulse transformers . . . allows triggering from a high impedance control circuit . . . provides isolation from the trigger source; permits triggering through the use of fewer components (reducing overall circuit cost). Applicable to both closed and open loop systems; gate isolation permits use of both AC and DC circuits. Precise firing depends on characteristics of the pulse transformer *and* semi conductor elements—the extensive *Aladdin* transformer line affords maximum "trading" of characteristics for optimum results. Readily available—the chart lists some of the most common ratios of 1:1 and 1:1:1.



For other applications, consult our applications engineers. Meanwhile send for bulletin 195 listing other standard SCR transformers and additional performance data.

Part Number	Package Style	OCL (mh)	Turns Ratio (± 10%)	High Potential Test Voltage
307-102	A	.2 min.	1:1	1600
90-2569	B	1.3 min.	1:1	550
306-136	C	1.3 min.	1:1	550
314-162	D	3.5 min.	1:1	550
90-2510	B	5.0 min.	1:1	550
72-2040	F	5.0 ± 20%	1:1	1750
314-141	D	6.6 ± 20%	1:1	1000
02-1864	E	6.0 ± 20%	1:1	700
90-1055	B	6.0 ± 20%	1:1	700
90-2364	B	8.5 ± 20%	1:1	700
90-2555	B	24.0 ± 20%	1:1	700
314-142	D	41.0 ± 20%	1:1	1000
314-143	D	162 ± 20%	1:1	1000
307-101	H	.045 ± 10%	1:1:1	700
78-2028	G	.7 min.	1:1:1	1000
90-2397	B	1.3 min.	1:1:1	550
312-114	I	1.3 min.	1:1:1	550
90-2398	B*	5.0 min.	1:1:1	550
90-2362	B*	6.0 ± 20%	1:1:1	700
02-2062	E*	6.0 ± 20%	1:1:1	1250
314-144	D*	6.6 ± 20%	1:1:1	1000
02-2066	E*	14.0 min.	1:1:1	1000
02-1861	E*	15.0 ± 20%	1:1:1	700
314-139	D*	21.0 ± 20%	1:1:1	700
314-170	D*	28.0 ± 20%	1:1:1	1000
314-145	D*	41.0 ± 20%	1:1:1	1000

Aladdin Electronics can custom design to individual needs for higher interwinding voltage strengths.

*Package configuration are same as shown except for the additional leads required for 1:1:1 transformers.

where the magic of magnetics is a science...™

Aladdin® electronics / Nashville 10, Tennessee

ON READER-SERVICE CARD CIRCLE 130

INSTRUMENTS & CONTROL

Picosecond pulser tests sampling scopes

Tektronix, Inc., P. O. Box 500, Beaverton, Ore. Phone: (503) 644-0161. Price: $525.

Available outputs of this pulser include all the signals required to check the risetime, vertical deflection factors and horizontal sweep rates of sampling systems. The repetition rate of the pulse generator is 50 kHz with a pulse duration of 1 μs and a flatness of ±3% or better. A pre-trigger is available that occurs either 5 ns or 50 ns before the pulse output. Rise time is 50 ps. Squarewave outputs with a period of 10 μs, 1 μs or 100 ns and amplitudes of 1 V, 100 mV or 10 mV into 50 Ω may be selected. Sinewave outputs of 10 ns or 1 ns period are available for checking fast sweep rates.

Booth No. 2818 *Circle No. 315*

Directional rf wattmeter accurate to 100 W

Bird Electronic Corp., 30303 Aurora Rd., Cleveland. Phone: (216) 248-1200. Price: $895.

With all components assembled in an 11 x 9-1/2 x 6-3/8-inch case, this rf wattmeter remains accurate to 100 watts. A section of machined 50-Ω reference line for insertion into the users coax system is connected to a 5-1/2-inch taut-band meter, which permits readings without residual jewel friction. Five 100-watt plug-in elements cover a continuous frequency range from 2 to 1000 MHz.

Booth No. 2601 *Circle No. 320*

It tests all digital integrated circuits & costs only $60,000 per dozen.

1. REDCOR's new IC tester does everything $50,000 testers do. Except cost $50,000. True, it's somewhat slower than expensive units, but as it costs only one-tenth as much, perhaps you could manage with less than overwhelming speed.

2. The 990 IC tester *has* to be the perfect tester for small run production, incoming inspection, and laboratory analysis. It performs both pulse and dc parameter tests as well as functional tests without external equipment. Measurement accuracy is 1%. (For an extra thousand bucks we build in a digital readout that gives an accuracy of 0.1% on all ranges.)

3. The 990 is easy to operate. You can train a bright girl to be a proficient operator in half a day. Test programming is accomplished with thumbwheels and requires less than 60 seconds for most IC's.

4. Power supply accuracy is 0.1% ±1 mv. All supplies have adjustable current or voltage limiting and will both source and sink. Kelvin connections are provided to the device under test.

5. For more information on the 990, flip the page.

An outlined guide to testing IC's

cheap

start here

7

8 1. BRILLIANT PERFORMANCE 6.

The 990 stimulates and measures all dc parameters without additional equipment. In combination with an oscilloscope it measures ac parameters.

FETCHING MODULARITY

The standard complement of modules is three voltage supplies, one current supply, one swept voltage supply, one dual loads module, and one dual output pulse generator. All modules are individually powered from ac line and are floating. Current and voltage are continuously variable with indication when limits are reached.

STUNNING ACCURACY

The 990's metering capability is comparable to that of testers ten times its cost. With the optional DRO, accuracy is 0.1% ±1 mv. Kelvin referencing means that the actual voltage or current at the lead is just what it should be. (Greater accuracy in low-level current measurements.)

RATHER SWIFT PROGRAMMING

Test programming for any available device can be set up in less than sixty seconds. Thumbwheel/pushbutton programming gives instantaneous verification of testing conditions. A complete line of device adaptors is available.

CRASHINGLY SIMPLE OPERATION 5.

From the programming to the actual testing, the model 990 can be operated by nearly anyone (even salesmen). Why don't you call one of ours

2 and see.

9. 4.

12

DELIVERY

Immediate.

11

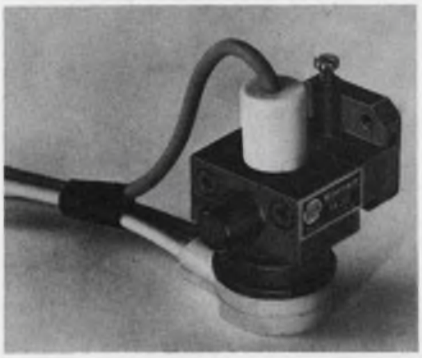
3 FURTHER INFORMATION

Call collect to Dick Barr, our sales manager for this product.

10

Redcor Corporation / 7760 Deering Avenue / P.O. Box 1031 / Canoga Park, California / (213) 348-5892 TWX (213) 348-2573

Ka-band oscillators pump paramps



Varian Associates, 611 Hansen Way, Palo Alto, Calif. Phone: (415) 326-4000.

Reflex klystron oscillators covering the frequency range between 26.5 and 35 GHz are designed for use as pump tubes in parametric amplifiers. Tuning over a 1-GHz range, the tube delivers 150 mW at a beam voltage of 550 V. Mechanical tuning range is 700 MHz and the tube delivers 500 mW at 26 GHz and 250 mW at 35 GHz.

Booth No. 2309 Circle No. 286

Frequency program unit presents slim profile

General Radio Co., West Concord, Mass. Phone: (617) 369-4400.

Designed for use with GR frequency synthesizers with remote digit programing, this frequency program unit can be preset to select up to 40 seven-digit frequencies. A single contact closure is required for complete selection of each frequency. The digit-programing switches are contained in plug-in trays which can be changed quickly if more than one program of 40 frequencies is needed. Manual control of any or all digits of the synthesizer overrides the preset program.

Booth No. 3015 Circle No. 292

ON READER-SERVICE CARD CIRCLE 132 ➤

◀ ON READER-SERVICE CARD CIRCLE 91, 92

Inductor analyzer spans micro to kilohenries

Marconi Instruments, 111 Cedar Lane, Englewood, N. J. Phone: (201) 567-0607. P&A: $1485; stock.

Twenty-seven controls and a CRT provide ease of balance on this inductance bridge. With a range from 0.3 μH to 21,000 H, this true inductor analyzer incorporates a low and medium-current bridge and the nucleus of a complete high-power inductor test assembly. It can be used from 20 Hz to 20 kHz and has internal frequencies of 10 kHz, 1 kHz and 60 Hz line. The display gives a positive indication of direction of inductor balance and tells if the inductor is capacitive at the test frequency.

Booth No. 2619 Circle No. 291

Random data generator weighs 25 pounds

Datapulse, Inc., 10150 W. Jefferson Blvd., Culver City, Calif. Phone: (213) 836-6100.

This 10-stage shift register operates in a closed loop with feedback into the first stage selectable from any two of the stages in the register. It provides a pattern up to 1023 bits long, two units provide over a million bits, three over a billion bits. On pseudo-random operation, the unit may generate the pseudo-random sequence under internal control or synchronize the sequence to a selected sync pattern in external data. Or, it uses the content of preceding bits in external data to generate the proper next bit in the sequence.

Booth No. 2719 Circle No. 282

Digital measuring system fully modular

Hickok Electrical Instrument Co., Cleveland. Phone: (216) 541-8060. Price: $320 (main frame), $175 to $240 (plug-ins).

The main frame of this all-solid-state system (with digital readout) accepts any of five plug-ins. It measures dc voltage, frequency or period, resistance, capacitance, or performs event counting. The flexible system features wide measurement ranges for each plug-in.

Booth No. 3002 Circle No. 328

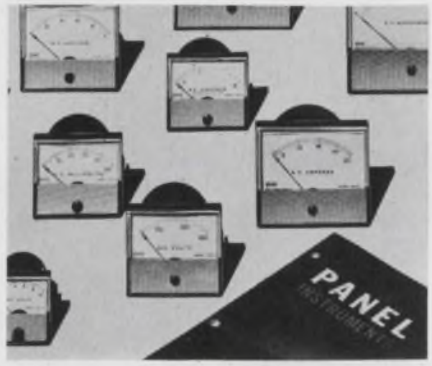
Portable VTVM uses no filters

Industrial Test Equipment Co., 20 Beechwood Ave., Pt. Washington, N. Y. Phone: (516) 767-9190.

The unit measures in-phase voltage, quadrature voltage, true rms voltage and phase angle. It operates over a 50-Hz-to-10-kHz frequency range and rejects noise and harmonics (40-dB down) without the use of filters. For field use where suitable power sources may not be available, D cells may be used.

Booth No. 2304 Circle No. 314

Stock panel meters customized to suit

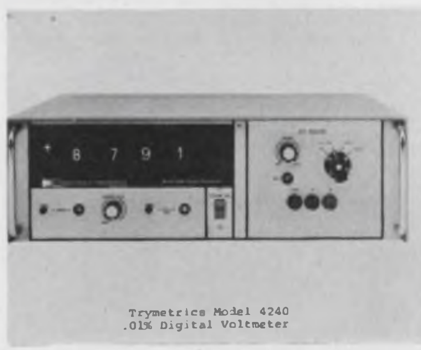


Triplett Electrical Instrument Co., Bluffton, Ohio. Phone: (419) 351-4912.

These panel meters give the user a dial design that provides an area for multiple scales and other special applications. The instruments are available in five sizes from the four ounce 1-1/2-inch to the 2-1/2, 3-1/2, 4-1/2 and 5-1/2 inch units. Accuracy is 2% for all types, 3% for the ac rectifier type.

Booth No. 3013 Circle No. 330

Economy DVM accurate to 0.01%



Trymetrics Corp., 204 Babylon Turnpike, Roosevelt, N. Y. Phone: (516) 378-5020. Price: $595.

Capable of 10 samples per second with a readout accuracy of 0.01% over three dc voltage ranges. this 4-digit DVM operates without display blinking or running numbers. IC counter circuits and a temperature-stabilized pulsed oscillator voltage-to-time conversion system maintain the accuracy and display stability. The unit has ranges of 0.999, 9.999, 99.99 and 999.9 volts full scale.

Booth No. 3112 Circle No. 311

Time interval counter features dc gating

Anadex Instruments, Inc., 7833 Haskell Ave., Van Nuys, Calif. Phone: (213) 782-9527.

Interval measurements such as pulse length, pulse spacing and time between electrical events are provided by this counter. It has start/stop dc levels which are adjustable from +30 to −30 V with slope control. A switch is provided for single line or two line gate inputs. Measurements from 10 μs to 100,000 seconds are possible. Digital readout may be displayed for an adjustable interval or the display may be held indefinitely until reset.

Booth No. 3303 *Circle No. 331*

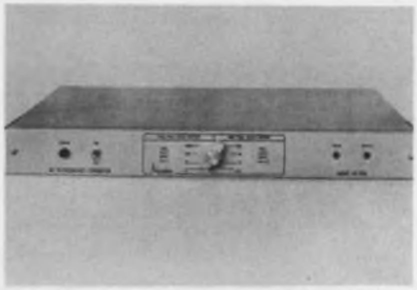
Nanovolt galvo accepts any source impedance

Electro Scientific Industries, Inc., 13900 N.W. Science Park Dr., Portland, Ore. Phone: (503) 646-4141. P&A: $2595; stock to 30 days.

This galvanometer-type null detector operates from any source impedance without changes in response or damping characteristics. The unit has infinite common-mode rejection and multiple calibrated ranges. It measures voltage or current from 10 nV (10 pA) to 3 mV (3 μA). Noise is less than 2 nV or 2 pA p-p.

Booth No. 2717 *Circle No. 280*

Dc-to-freq converter linear to 0.01%



Anadex Instruments, Inc., 7833 Haskell Ave., Van Nuys, Calif. Phone: (213) 782-9527. P&A: $450; 1 month.

An output frequency directly proportional to the input voltage is provided by this converter. By means of a range switch, the user may select any of four input voltage ranges from 10 mV to 10 V full scale with a 10-kHz output, or four input voltage ranges from 100 mV to 100 V with a 100-kHz output. Front-panel controls provides a 0-to-50-kHz output frequency for zero input on any range. The output changes less than ±0.01% for any ±10% change of line voltage.

Booth No. 3303 Circle No. 332

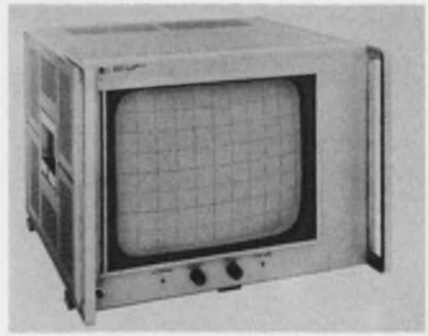
Turret attenuators operable to 12.4 GHz

Narda Microwave Corp., Plainview, N. Y. Phone: (516) 433-9000.

Model 710 turret attenuator provides a 0-to-60-dB attenuation range in 10-dB steps, model 711 ranges 0 to 10 dB in 1-dB steps and model 712 is a dual-turret device combining both attenuation ranges. Turrets are mounted in a cast-aluminum housing, and all units are equipped with type N female connectors. Positive attenuator rf mating is ensured by spring-loaded inner and outer conductors.

Booth No. 2704 Circle No. 319

Solid-state monitor displays X-Y-Z

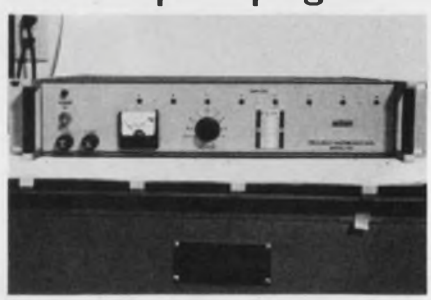


Hewlett Packard, 1501 Page Mill Rd., Palo Alto, Calif. Phone: (415) 326-7000. P&A: $1900; September.

A CRT monitor with an 8 × 10-inch display area has 20-MHz response on all 3 axes. The CRT writing rate is faster than 20 inches/μs. The power consumption is 175 W (the unit has a self-contained power supply). Input sensitivity of the X and Y amplifiers is 0.1 V/inch and a 2.5:1 vernier amplitude control is included on each axis.

Booth No. 2909 Circle No. 312

Frequency distribution unit accepts 8 plug-ins



Tracor, Inc., 6500 Tracor Lane, Austin, Tex. Phone: (512) 926-2800.

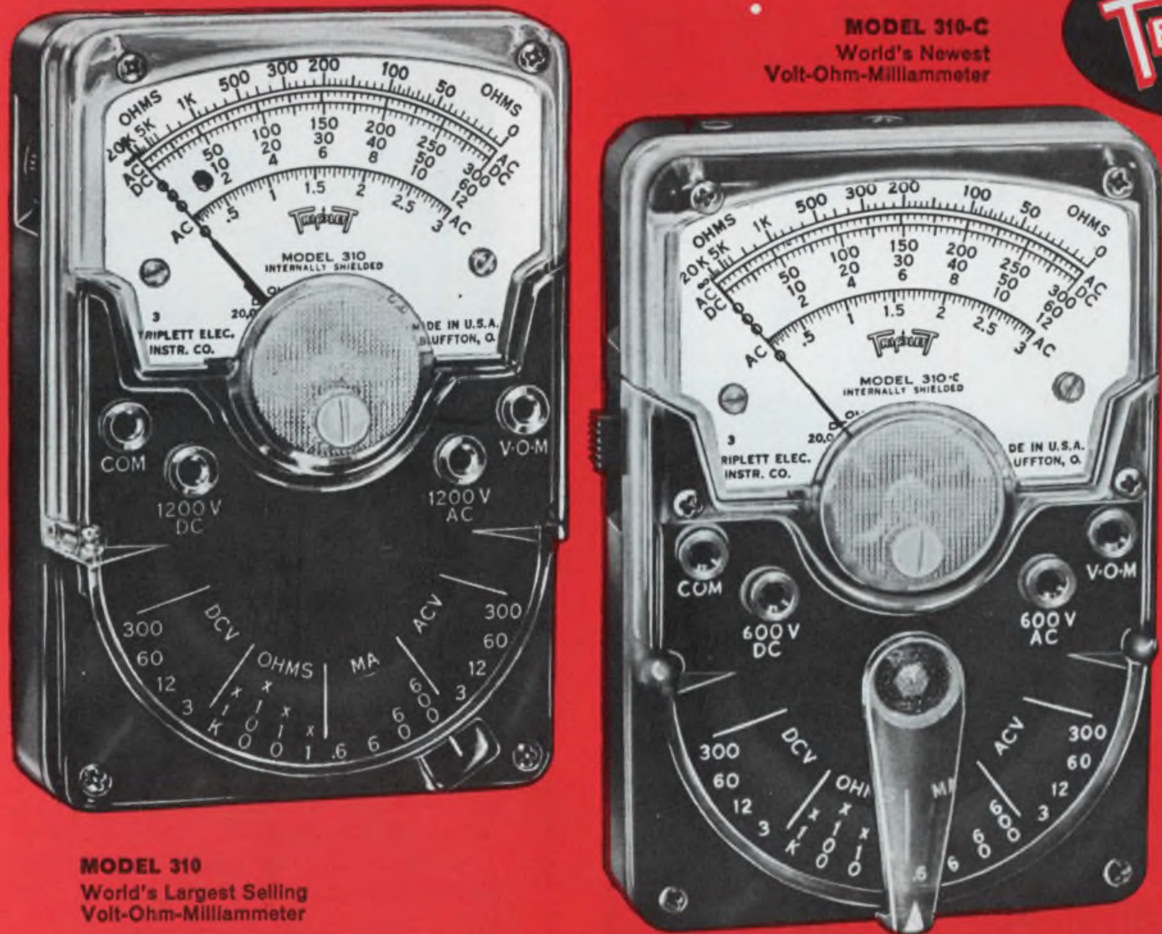
This unit features modular construction, adjustable gain, low distortion, output level monitoring, short-circuit protection and instantaneous switchover to an external dc standby supply should ac power fail. The modules, which plug in from the rear of the unit, are available in frequencies of 5 MHz, 1 MHz and 100 kHz. There are two outputs available from each module, with either output capable of delivering a minimum of one volt rms to a 50-Ω load at the end of a 300-foot length of RG 58/U cable.

Booth No. 2205 Circle No. 296

WORLD'S LARGEST SELLING AND WORLD'S NEWEST Hand Size V-O-M's

TRIPLETT

MODEL 310-C
World's Newest
Volt-Ohm-Milliammeter



MODEL 310
World's Largest Selling
Volt-Ohm-Milliammeter

BOTH TESTERS SHOWN ACTUAL SIZE

1 **HAND SIZE AND LIGHTWEIGHT, but with the features of full-size V-O-M's.**

2 **20,000 OHMS PER VOLT DC; 5,000 AC (310)—15,000 AC (310-C).**

3 **EXCLUSIVE SINGLE SELECTOR SWITCH speeds circuit and range settings. The first miniature V-O-M's with this exclusive feature for quick, fool-proof selection of all ranges.**

SELF-SHIELDED Bar-Ring instrument; permits checking in strong magnetic fields. FITTING INTERCHANGEABLE test prod tip into top of tester makes it the common probe, thereby freeing one hand. UNBREAKABLE plastic meter window. BANANA-TYPE JACKS—positive connection and long life.

Model 310—$42.00 Model 310-C—$53.00 Model 369 Leather Case—$4.00

ALL PRICES ARE SUGGESTED U.S.A. USER NET, SUBJECT TO CHANGE

310-C PLUS FEATURES

1. Fully enclosed lever range switch
2. 15,000 Ohms per volt AC (20,000 O/V DC same as 310)
3. Reversing switch for DC measurements

MODELS 100 AND 100-C

Comprehensive test sets. Model 100 includes: Model 310 V-O-M, Model 10 Clamp-on Ammeter Adapter; Model 101 Line Separator; Model 379 Leather Case; Model 311 leads. ($78.00 Value Separate Unit Purchase Price.)
MODEL 100—U.S.A. User Net..$74.00

MODEL 100-C—Same as above, but with Model 310-C, Net...........$84.00

THE TRIPLETT ELECTRICAL INSTRUMENT COMPANY, BLUFFTON, OHIO

USES UNLIMITED: FIELD ENGINEERS • ELECTRICAL, RADIO, TV, AND APPLIANCE SERVICEMEN • ELECTRICAL CONTRACTORS • FACTORY MAINTENANCE MEN • ELECTRONIC TECHNICIANS • HOME OWNERS, HOBBYISTS

THE WORLD'S MOST COMPLETE LINE OF V-O-M's • AVAILABLE FROM YOUR TRIPLETT DISTRIBUTOR'S STOCK

Narrow marker plug-in triples in brass

Kay Electric Co., Maple Ave., Pine Brook, N. J. Phone: (201) 227-2000.

Essentially a fancy marker plug-in unit using ICs, this device is a complex frequency marking system consisting of:

- a direct reading variable pulse marker a few Hz wide and accurate to ±0.05%.
- a slave pulse marker that can be accurately and simultaneously set a few Hz away.
- a mixer-amplifier providing all marker coupling and 30-dB preamplifier gain.

Designed to operate in Kay's sweep generator, the plug-in covers a frequency range from 100 kHz to 70 MHz, providing pulse markers whose width is approximately 0.5% of total sweep display over a wide range of sweep widths and sweep rates. It is narrow enough to mark filters a few Hz wide. A three-digit, ten-turn dial provides readability of an Hz from 100 kHz to 1 MHz, of 10 Hz from 1 to 10 MHz and of 100 Hz from 10 to 70 MHz. Accuracy increases linearly on each of these ranges from the ±0.05% spec to ±0.005% at the high frequency end.

Incremental dial accuracy (and the accuracy of the spacing between markers) is better than 2%. The 30-dB gain mixer-amplifier provides input impedance of 100 MΩ, variable gain and an output of 4 volts peak to peak into a 500-Ω load.

Booth No. 2804 *Circle No. 284*

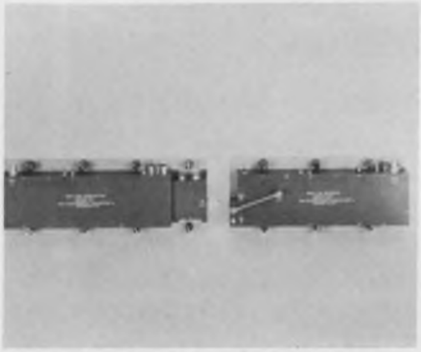
Argon ion laser based on rf induction

Spectra-Physics, 1255 Terra Bella Ave., Mountain View, Calif. Phone: (415) 961-2550.

This unit is based on Spectra-Physics' method of rf induction excitation of ion-laser discharges. In this method, a radio frequency H field is air-coupled to a closed-circuit laser tube so that the plasma forms the equivalent of a one-turn secondary winding of an rf transformer. This ensures a long life time of the plasma tube, far in excess of the dc cathode type of plasma excitation.

Booth No. 2922 Circle No. 295

Transmit-receive pair for fm relay links



RHG Electronics Laboratory, Inc., 94 Milbar Blvd., Farmingdale, N. Y. Phone: (516) 694-3100. P&A: $5900; 8 wks.

Fm transmitter and receiver combinations are intended to be used as basic modules in relay links. They provide a microwave relay capability in a volume of 75 cubic inches each. Standard units are available from 1.4 to 2.3 GHz and offer baseband response to 4.5 MHz. System performance is compatible with EIA and CCIR standards for monochrome TV.

Booth No. 3607 Circle No. 277

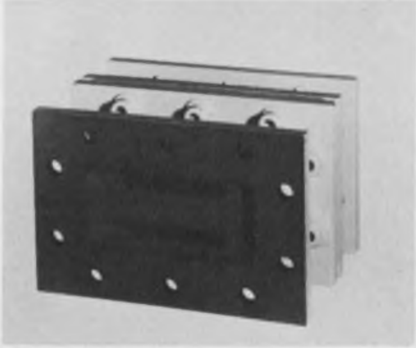
Vhf-uhf varactors break down at 120 V

Alpha Industries, Inc., 381 Elliot St., Newton Upper Fall, Mass. Phone: (617) 969-8480.

A high power varactor suitable for vhf and uhf multipliers has high input and output power levels. The type 1210 of the 1200 series exhibits the following specifications: minimum and maximum junction capacitance of 5 to 10 pF, maximum series resistance of 3.5 Ω, maximum thermal resistance of 15°C/W and breakdown voltage of 120 V minimum.

Booth No. 3615 Circle No. 274

Pre-TR/TR tube protects TWTs

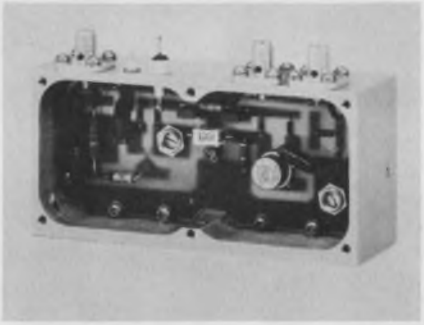


Microwave Associates, Burlington, Mass. Phone: (617) 272-3000.

A dual pre-TR/TR tube provides positive receiver protection for traveling wave tubes. The S-band tube covers a frequency range of 3.35 to 3.65 GHz and operates at a maximum peak power of 750 kW with a maximum recovery time of 30 μs. The compact package provides for an insertion loss of 0.5 dB. It is designed for use in air search radar systems.

Booth No. 3723 Circle No. 269

Solid-state oscillators for fm relay links

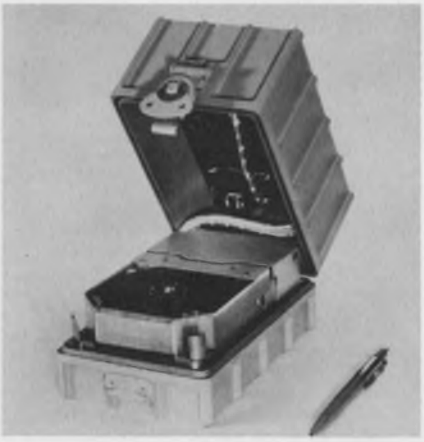


RHG Electronics Laboratory, Inc., 94 Milbar Blvd., Farmingdale, N. Y. Phone: (516) 694-3100. P&A: $995; 30 days.

Capable of being frequency modulated at baseband rates to 12 MHz, this oscillator is used as the basic exciter unit in wideband microwave relay systems. Oscillators are available from 250 to 380 MHz, and can be deviated over 9 MHz with linearity of 2%.

Booth No. 3607 Circle No. 271

Voice, data recorder weighs five pounds



Leach Corp., 717 N. Coney Ave., Azusa, Calif. Phone: (213) 334-8211.

A cartridge-loaded voice and data recorder/reproducer measures only 7 x 4.5 x 4.5 inches and weighs five pounds. The 4-channel cartridge-load unit eliminates complicated tape threading and assures simple tape changes. Each cartridge holds 260 feet of 1/4-inch magnetic tape. The unit will record and reproduce at speeds up to 30 ips.

Booth No. 3005 Circle No. 270

ON READER-SERVICE CARD CIRCLE 144 ➤

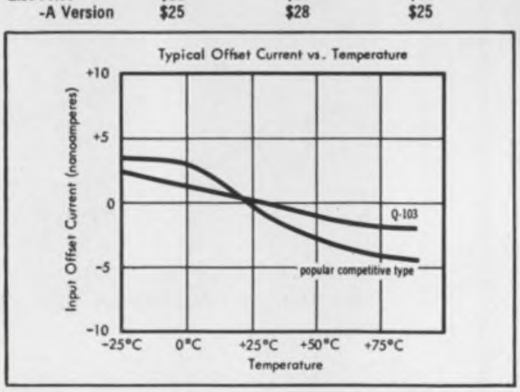
Nexus devises 6 new operational amplifiers...each of which may bring a little happiness into the life of a hard-pressed engineer

3 low-cost, high-performance OP AMPS

These three nifty little modules give better temperature characteristics and lower input bias currents than you would believe possible for the price. Just try to find anything else in the ballpark that comes close to these typical specifications:

TYPICAL PERFORMANCE @ 25°C

	Q-101	Q-102	Q-103
Output	±11V/±5.5mA	±11V/±5.5mA	±11V/±2.5mA
Input Z Diff.	1 Megohm	1 Megohm	5 Megohms
Input Bias Current	±3nA	±3nA	±.5nA
Bias Current Drift	±0.4nA/°C	±0.4nA/°C	±.05nA/°C
Initial Offset Voltage	(Ext Trim)	±0.2mV	(Ext Trim)
Max. Drift vs Temp.	15μV/°C	15μV/°C	15μV/°C
-A Version	5μV/°C	5μV/°C	5μV/°C
List Price	$22	$25	$22
-A Version	$25	$28	$25



1 lowest-cost FET OP AMP

FET prices have gone ffft with the new Nexus QFT-5 which sells for $22 in moderate quantities.

TYPICAL PERFORMANCE @ 25°C

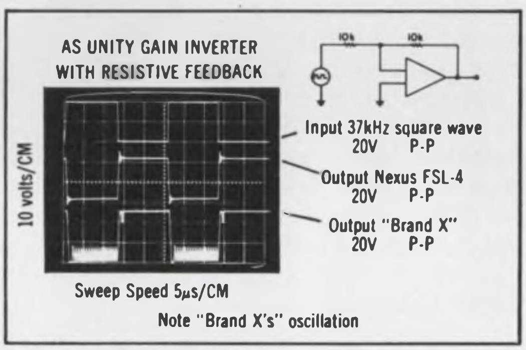
Output	±11V/±5.5mA
Input impedance	10^{10} ohms
Gain	100,000
Drift	50μV/°C
Gain-bandwidth	2MHz
Slewing rate (full output)	5.0V/μs

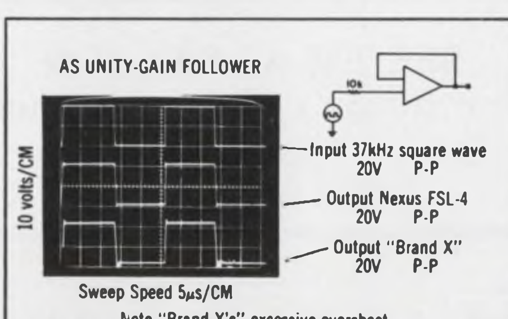
2 ultra-fast differential OP AMPS

Both these new units, the FSL-4 and FSL-5 can handle inverting, non-inverting or differential functions with full output at frequencies up to 1 MHz.

- Smooth Loop Dynamics: 6dB/Octave Rolloff
- 60V/μs Slewing, Either Inverting Or Non-Inverting
- 4μs Settling Time To 0.1% With 20 Volt P-P Square Wave Output
- ±0.2nA/°C Maximum Input Bias Current Drift (FSL-5)
- ±10μV/°C Maximum Offset Voltage Drift (FSL-5)
- ±10 Volt @ ±20mA Output

The following test photos compare FSL-4 performance with a typical competitive (Brand X) unit.





SEE ALL THESE GREAT NEW OP AMPS AT WESCON BOOTH 2420

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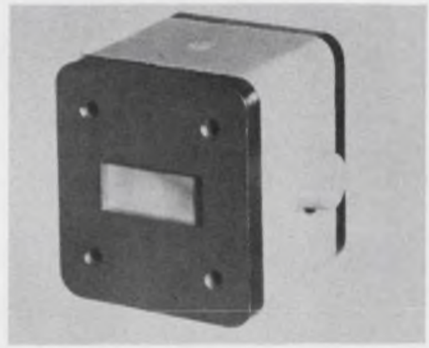
Beacon magnetron compact, powerful



Microwave Associates, Burlington, Mass. Phone: (617) 272-3000.

A compact 7-kW fixed-frequency X-band beacon magnetron weighs 21 ounces. It is designed to operate at a fixed frequency in the 8.5-to-9.6-GHz range with a 0.5 μs pulse width and an 0.005 duty ratio. Input connections are made through flexible leads or solder lugs and the output connector mates with a UG-3/9U cover flange. This unit is designed for beacon and navigation systems, radar detection applications, missile ground support equipment, transponders and airborne radar applications.

Booth No. 3723 *Circle No. 268*

Glass tuning varactors have Q to 1000

American Electronic Laboratories, Inc., Colmar, Pa. Phone: (215) 822-2929.

DO-7 glass tuning varactors are designed for electronic tuning applications in equipment operating at frequencies up to 3 GHz. The units display a Q of 1000. They are suited for hand-solder or stripline insertion. The capacitance ratios, up to 5.2:1, make it possible to design resonant circuits which are tunable over octave bands. The varactors are available in a capacity range from 4 to 27 pF.

Booth No. 5106 *Circle No. 276*

POWER SUPPLIES UNLIMITED

at WESCON Booth 2218.

See 15 NJE power supplies.
Get the lowdown on 216 more.

There's no guessing when you select a power supply from NJE's huge line. No "goofs"! The NJE line covers any conceivable power requirement you may have, so you don't have to underbuy or overbuy. What's more, NJE's slotted supplies narrow the ranges, so you don't have to pay extra for power you can't use. To see just how easy power supply selecting can be, visit us at WESCON Booth 2218.

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See these NJE power supplies at WESCON Booth 2218.

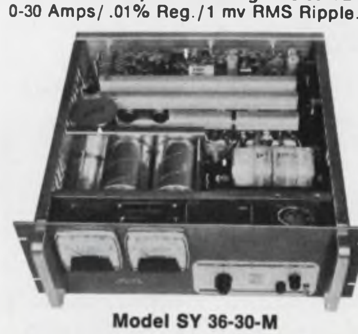
SVC line NJE all-silicon power supplies provide voltage and/or current regulation for lab or system use. Available in Lab-Rak laboratory bench units, rack adaptable, or full rack construction. 0-40 VDC/0-5 Amps/ .01% Reg./1 mv RMS Ripple.

Model SVC 40-5-M

NJE's custom capabilities include design and manufacture of multiple output power supplies for use in systems requiring more than one voltage simultaneously. SIX 20 VDC/0-1.5 Amps/.01% Reg./1 mv RMS Ripple.

Model C6S-20SR1.5

SY "system" NJE power supplies provide the regulation and ripple usually only found in high-cost lab equipment. Unique design provides the maximum power at the lowest dollar-per-watt ratio, but still incorporating "wide slot" adjustment range. 10-36 VDC/ 0-30 Amps/ .01% Reg./1 mv RMS Ripple.



Model SY 36-30-M

312

ON READER-SERVICE CARD CIRCLE 146

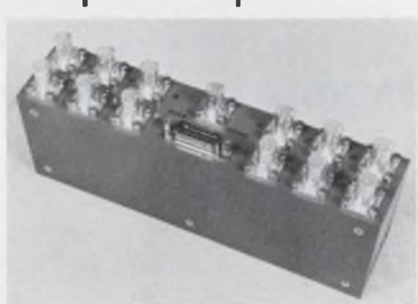
Multiplier varactors cover vhf to Ku band

Microwave Associates, Burlington, Mass. Phone: (617) 272-3000.

High-efficiency multiplier varactors cover vhf to Ku-band. The all-silicon epitaxial diffused junction devices have a multiple junction feature, obtained by the series connection of two diodes. Each diode junction is mounted in its own ceramic package and then welded into a single assembly. A typical unit is useable over 5 to 8 GHz with typical output power of 3.5 W.

Booth No. 3723 Circle No. 266

Vacuum coax relay accepts 12 inputs

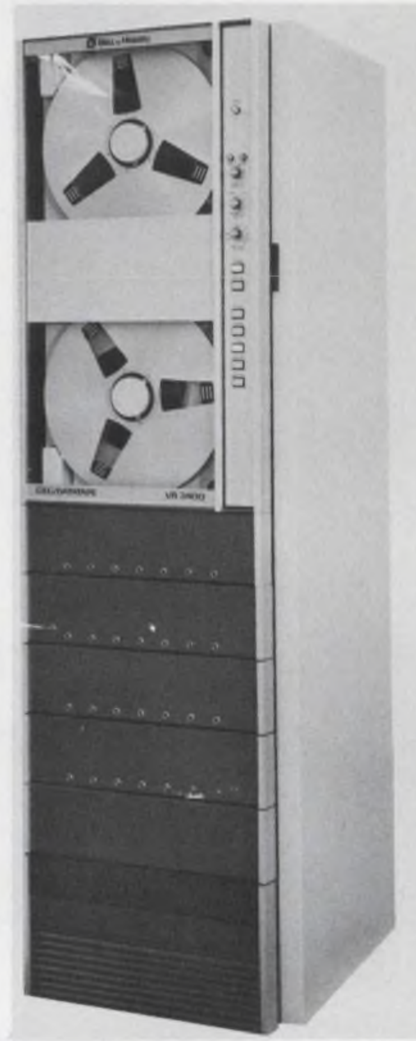


ITT Jennings, P. O. Box 1278, San Jose, Calif. Phone: (408) 292-4025.

A 12-input, common-output vacuum coax relay uses vacuum relays as the interrupting elements. The maximum power switching is limited directly by the BNC type rf connectors. The vacuum construction keeps insertion losses and contact resistance low and isolation of input to input and output to any input high. VSWR at 30 MHz is less than 1.2. In a typical application, a telemetry receiver receives information from 12 separate antennas in any order. Switching speed is 10 ms.

Booth No. 5807 Circle No. 257

Recorder features 8-speed transport



Consolidated Electrodynamics Corp., 1500 Shamrock, Monrovia, Calif. Phone: (213) 796-9381.

A 15-inch reel capacity and recording rates convertible from 100 kHz to 1.5 MHz give this recorder large capacity. All eight bidirectional speeds are automatically selected by one rotary switch, and no adjustments are required throughout the speed range. The electronic capstan control features automatic fail safe operation, assuring continuous recording even in the event of signal loss or minor component failure. The VR-3400 offers direct response to 600 kHz at 120 ips and a low end response of 50 Hz at 1-7/8 ips. Fm electronics permit operation with standard fm (20 kHz at 60 ips) or wideband fm (80 kHz at 120 ips) interchangeably.

Booth No. 3113 Circle No. 323

Now
AE gives you complete PC Correed logic modules

The Automatic Electric PC Correed (dry reed switch) is now available as an integral part of a complete printed circuit board assembly. It's made up of type G10 epoxy-glass laminate, 1/16 inch thick, with the necessary PC Correeds and associated components mounted and soldered. The assembly is a complete circuit package—ready for direct insertion into an edge-type connector.

The high-reliability epoxy-glass cards feature copper-nickel-gold circuit paths and standard 0.800 inch card spacing. They're rigidly inspected and tested before shipment.

You give us your circuit—and we'll take it from there! We do the entire packaging to your specifications—including circuitry and artwork.

You get a completely wired circuit module, which eliminates the need to design, assemble and wire discrete components.

AE's type PC logic modules give the system designer flexibility, reliability and economy. They provide isolation between input and output, and high immunity to electrical noise. Packaged logic circuits are particularly suited for supervisory and telemetering equipment, process controls, checkout and ground support equipment, test equipment and engineering models.

There's a lot of helpful, detailed information in our new 8-page brochure. To get your copy, just write for Circular 1113 to the Director, Electronic Control Equipment Sales, Automatic Electric, Northlake, Illinois 60164.

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GENERAL TELEPHONE & ELECTRONICS GT&E

ON READER-SERVICE CARD CIRCLE 148

C-band magnetron yields 0.5 to 3 MW

Raytheon Co., Waltham, Mass., Phone: (617) 862-6600.

Model QKS1343 is an integral magnet tube with waveguide input and output. It covers 5.4 to 5.9 GHz without electrical or mechanical adjustment when used with a modulator having proper load-line characteristics. In typical operation, peak power is 0.5 MW with 15-kW average power output. At 0.03 duty, pulse duration is 200 μs.

Booth No. 4418 *Circle No. 385*

Line terminations withstand 10 kW cw

Bird Electronics Corporation, 30303 Aurora Rd., Cleveland. Phone: (216) 248-1200.

Line terminations weighing 6.5 lbs can be bolted to the end of a line in any postiion. Model 8736 with a 1.625-inch flange and model 8732 with a 3.125-inch flange have cw power ratings of 10 kW with 4 gal/min water cooling. Fifty-Ω units have 1.1 VSWR to 1 GHz and 1.14 VSWR to 1.4 GHz.

Booth No. 2601 *Circle No. 386*

Circulator tunes 400 MHz to 1.2 GHz

Scientific-Atlanta, P. O. Box 13654, Atlanta. Phone: (404) 938-2930. P&A: $1000; 1 month.

Electrically tunable from 400 MHz to 1.2 GHz, this circulator has an instantaneous bandwidth of greater than 30 MHz. VSWR is below 1.35. The circulator is furnished with a variable-voltage dc power supply and tuning control with linear, direct readout of frequency from 500 MHz to 1 GHz. Tuning from 400 to 500 MHz and 1 to 1.2 GHz is by calibration chart. An external voltage source permits the circulator to be tuned or swept at rates to 60 Hz.

Booth No. 2305 *Circle No. 387*

DCL*

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Signetics puts IC systems design decisions back in the hands of the systems designer.

Some IC families put severe limits on the decisions the systems designer can make. He's often held back by the speed, power, and noise immunity trade-offs built into the family by the IC manufacturer. Now Signetics Designer's Choice Logic changes all that. Signetics DCL* Series 8000 includes high speed TTL circuits, slower low power TTL circuits that offer high AC noise immunity, and low power DTL circuits that provide high DC noise margins. The series also includes large functional arrays for counting and storage applications. All elements in the 8000-Series are specified compatibly. And we've got a 46-page data handbook — the most complete one of its kind ever offered — to guide you in using these flexible circuits. In designing with DCL* you can optimize your system performance without drawn-out calculations, expensive and time-consuming ground-plane designs, or extensive use of outboard discrete components. The handbook provides special sections directed to systems, evaluation and design engineers. Find out fast what can be done with our DCL* series, and how to loosen constraints on your designs. Write Signetics for your DCL* handbook: 811 East Arques, Sunnyvale, California 94086.

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DISTRIBUTORS: Compar at all locations listed below. Semiconductor Specialists, Inc. (312) 279-1000; Terminal Hudson Electronics (212) 243-5200; Wesco Electronics (213) 684-0880; Wesco Electronics (405) 968-3475; Hammond Electronics (305) 241-6601; Avnet Electronics Corp. of Massachusetts (617) 272-3060.

DOMESTIC REPRESENTATIVES: Jack Pyle Company (415) 349-1266. Compar Corporation at the following locations: Alabama (205) 539-8476; Arizona (602) 947-4336; California (203) 245-1172; California (415) 697-6244; Colorado (303) 781-0912; Connecticut (203) 288-9276; Florida (305) 855-3964; Illinois (312) 775-5300; Maryland (301) 484-5400; Massachusetts (617) 969-7140; Michigan (313) 476-5758; Minnesota (612) 922-7011; Missouri (314) 428-5313; New Jersey (609) 429-1526; New Mexico (505) 265-1020; New York (518) 436-8536; New York (607) 723-8743; New York (716) 684-5731; New York (201) 471-6090; North Carolina (919) 724-0750; Ohio (216) 333-4120; Ohio (513) 878-2631; Texas (214) EM 3-1526; Texas (713) 649-5756; Washington (206) 725-7800.

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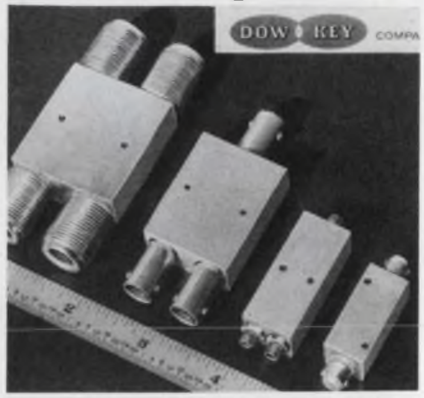
ON READER-SERVICE CARD CIRCLE 151

Four-arm connectors combine rf signals



Dow Key Co., 2260 Industrial Lane, Broomfield, Colo. Phone: (303)466-7303.

Matched or standard connectors are used to connect 3 or 4 coax transmission lines. They are commonly used to divide or combine rf signals with any connector used as input or output. They are offered in two basic types: parallel wired similar to standard tee adapters, and resistive match power dividers, where each arm is matched when the other arms are terminated. They are useful up to 1 GHz with VSWR at 1.1 up to 500 MHz and 1.2 to 1 GHz. Power rating is 0.5 W cw, 5 kW peak.

Booth No. 4917 Circle No. 272

Tapped delay line has 5-ns rise time

Bel Fuse, Inc., 198 Van Vorst St., Jersey City, N. J. Phone: (201) 432-0463.

This unit has a total delay of 15 ns with taps every nanosecond and a rise time of less than 5 ns. Designed for printed circuit mounting, the line is available in impedance values of 93, 200 and 500 Ω. The delay line is suitable for many computer applications.

Booth No. 4910 Circle No. 273

For a complete listing of the technical papers at the show, see page U 112. For reprints of most of the papers, fill out the order form on page U 115.

Compact unit converts digital to synchro

Astrosystems, Inc., 6 Nevada Dr., New Hyde Park, N. Y. Phone: (516) 328-1600. P&A: $1000 to $2500; 6 to 8 wks.

This unit accepts a parallel 10-bit binary angle and provides a synchro output equivalent to the digital input. Inputs are compatible with microelectronic logic levels at updating speeds to 10,000 words per second. The conversion technique uses toroidal transformers and solid state ac switches to drive a load without the use of amplifiers. The unit provides a standard 3-wire synchro output signal of 11.8 volts at 400 Hz completely isolated from ground and input. Serial and parallel interfaces can be accommodated. Accuracy from no load to full load is 0.5°. The unit mounts in a RETMA rock.

Booth No. 4522 Circle No. 275

Switching modules drop into coax line

Hewlett-Packard, 1501 Page Mill Rd., Palo Alto, Calif. Phone: (415) 326-7000. P&A: $100 to $175; stock.

Hermetically sealed switching modules in HP's 3600 series are packaged as coax sections that can be inserted as part of a coax line. The units have a dc-to-18-GHz bandwidth, 0.5-to-2.2-dB loss and 1.5-to-2.3 VSWR. They can be brazed, clamped or pressed into place and match semirigid lines with 0.141- and 0.188-inch ODs. They can be adapted to 0.276-inch OD lines. Switching speed runs 10 to 50 ns.

Booth No. 2909 Circle No. 384

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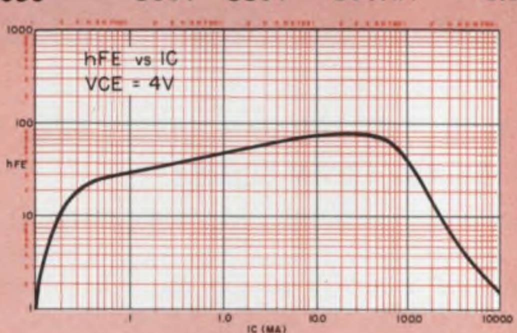
...Attention Designers! Satisfy Your Most Demanding High Voltage Requirements with the Following Premium Devices From... it

NPN

TO-5 OUTLINE	V_{CER} V_{CBO}	V_{CEO}	I_{CBO}	V_{CE} (SAT)
2N5092	400V	350V	500NA	0.5V
2N5095 2N5101*	500V	400V	500NA	0.5V
2N5097	600V	450V	500NA	0.5V
2N5098	700V	500V	500NA	0.5V
2N5099	800V	550V	500NA	0.5V

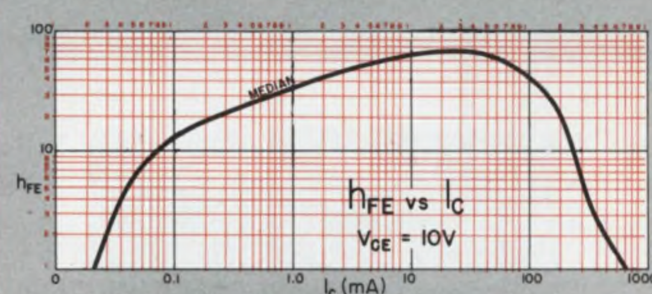


$h_{FE} > 25$ from $I_C = 1.0$ MA to I_C 100 MA

***MD-14 OUTLINE**

PNP

TO-5 OUTLINE	V_{CER} V_{CBO}	V_{CEO}	I_{CBO}	V_{CE} (SAT)
2N5091	350V	300V	500NA	3.0V
2N5093	400V	350V	500NA	3.0V
2N5094 2N1510*	450V	400V	500NA	3.0V
2N5096	500V	450V	500NA	3.0V



$h_{FE} > 20$ from $I_C = 1.0$ MA to I_C 100 MA

***MD-14 OUTLINE**

it CORP.

INDUSTRO TRANSISTOR CORP.
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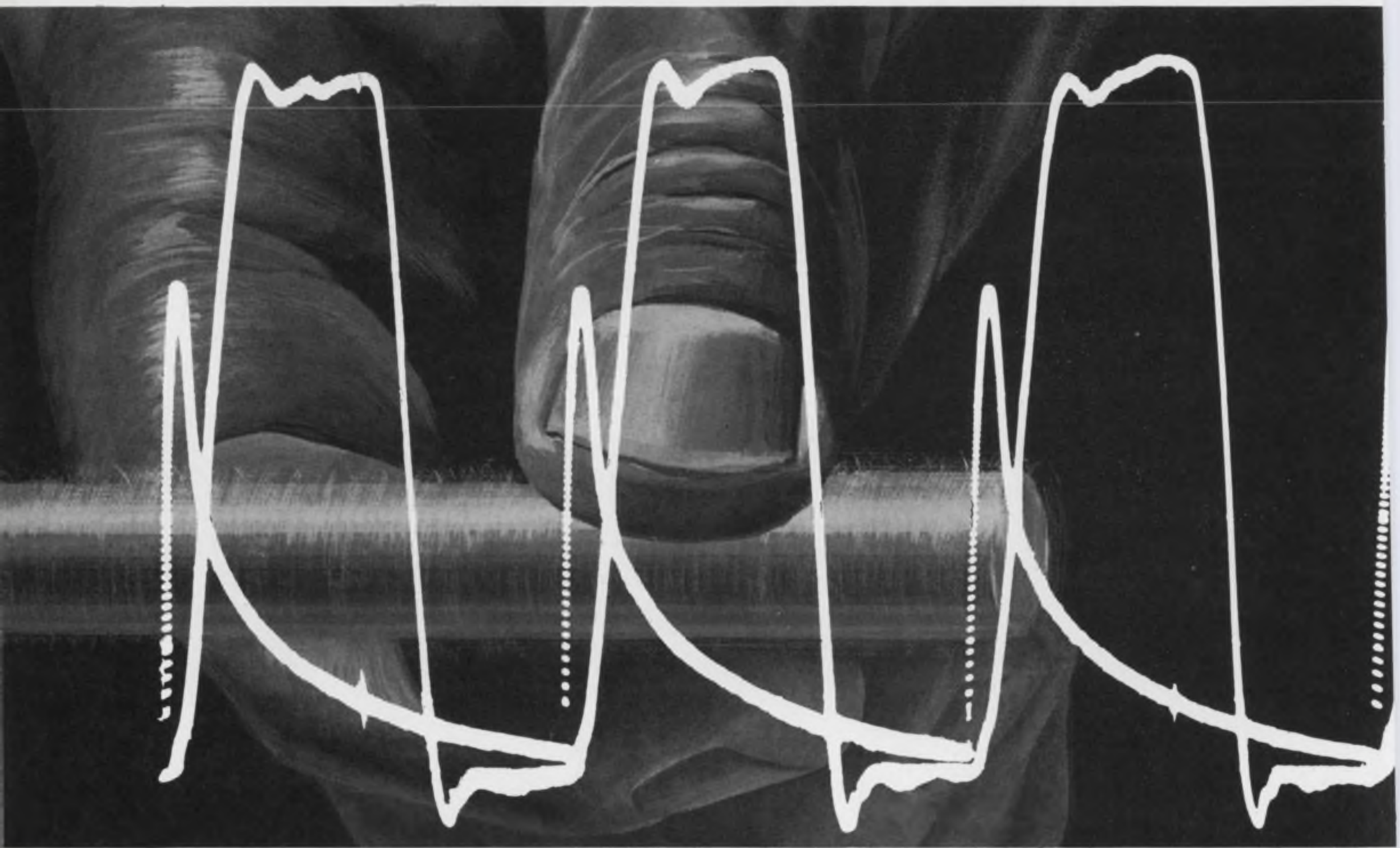
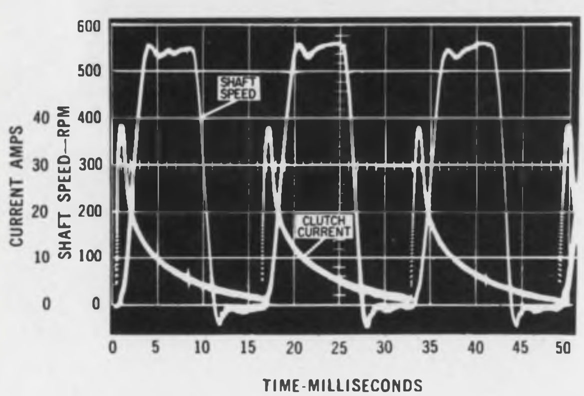
TELEPHONE (212) 392-8000

ON READER-SERVICE CARD CIRCLE 153

This is the fastest clutch or brake in the world!





The fastep offers the fastest response on the market today. This scope picture illustrates the capability of a fastep clutch and brake to perform a high speed indexing function. The rate is 60 steps per second and the external inertial load is 100 x 10^{-5} lb. in. sec.^{2}. When the slope of the shaft velocity trace becomes a straight line, full torque has been achieved. In this case, it is less than 1½ milliseconds from signal for constant acceleration, or full torque.

RESPONSE SO FAST YOU CAN HARDLY FEEL IT . . . PROVE IT ON YOUR OWN SCOPE!

LSI's fastep clutch represents a new state-of-the-art in Magnetic Particle units. Used as either a clutch or a brake, it attains fast response yet it doesn't sacrifice the inherent advantages of soft starts and stops. Its capabilities include long life and repeatability. In fact, customer tests have substantiated life expectancy of over 500 million cycles. LSI magnetic particle clutches and brakes are used in a variety of applications including tape drives, numerical control, printers, remote actuation, tensioning devices and business machines.

LSi

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B3403-LSA

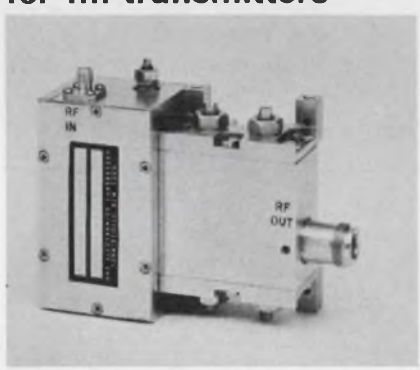
Latching switches carry 500 V rms

Microwave Associates, Burlington, Mass. Phone: (617) 272-3000.

Specs of this 500-V latching switch include 60-dB interposition isolation from dc to 12.4 GHz, VSWR of 1.5 and insertion loss of 0.5 dB. Units can be stacked side-by-side for multichannel double-throw and other multiple switching uses. Latching is advantageous in applications in which switching power drain must be limited.

Booth No. 3723 *Circle No. 374*

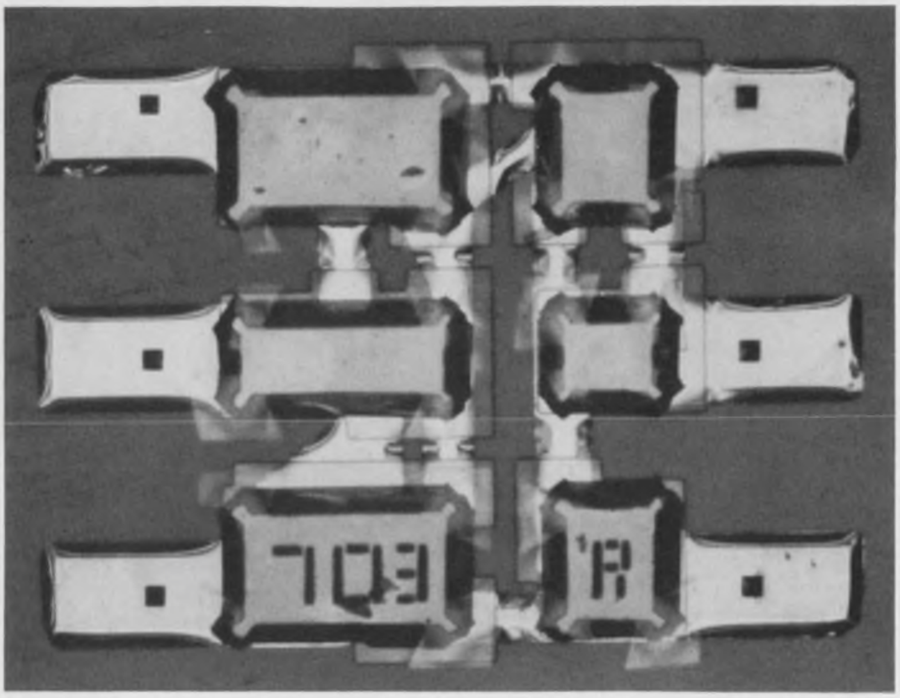
X-band multipliers for fm transmitters



RHG Electronics Laboratory, Inc., 94 Milbar Blvd., Farmingdale, N.Y. Phone: (516) 694-3100. P&A: $1495; 6 to 8 wks.

These units provide output powers to 2 watts is S band, 1 watt in C band, and 1/2 watt in X band. The use of step-recovery varactor multiplier diodes, coupled with an integral cavity filler assembly, provides efficiency with low spurious content.

Booth No. 3607 *Circle No. 377*



Beam leads, air isolation push 703 past 1 GHz for unity gain

Raytheon Semiconductors, 350 Ellis St., Mountain View, Calif. Phone: (415) 968-9211. P&A: about $5 for military market; 8 wks (sample quantities).

A beam-lead version of the standard 703 rf-i-f amplifier has been developed by Raytheon Semiconductors. Using air-isolation to reduce parasitics, the circuit's unity-gain frequency is pushed past 1 GHz.

The microcircuit's four resistors and two transistors are isolated from each other by air. Each component occupies its own little island of silicon, and the silicon islands are held together by thick gold leads, which also form the contacts.

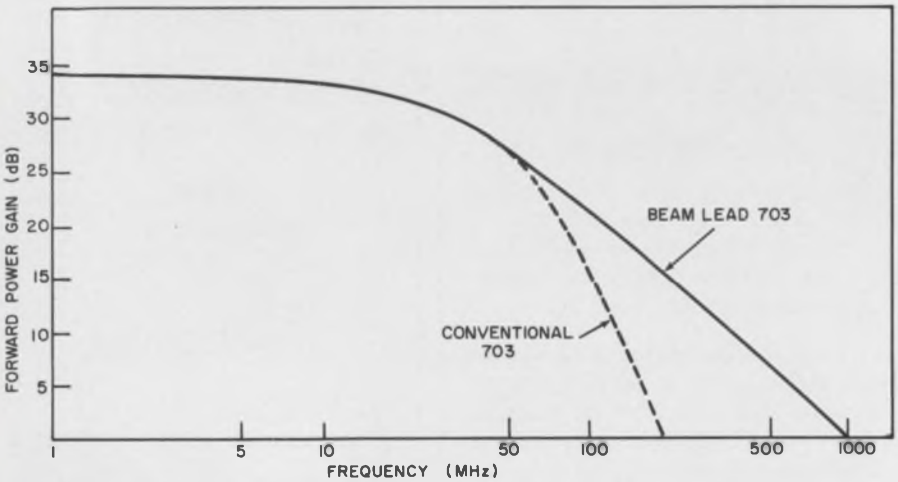
The isolation of its components allows the rf amplifier a substantially higher frequency response than its p-isolated counterpart. The latter's gain, for example, falls off to unity at about 100 MHz; the beam-lead version reaches 1 GHz.

Though the gold leads themselves are electroformed in the same way as the Bell Labs' beam leads (ED 4, Feb. 15, 1967, p. 17) the metallurgy that bonds the leads to the chip and makes good ohmic contact with the silicon is somewhat different. Where the Bell Labs method uses layers of platinum, titanium, and platinum between the gold lead and the glass, the Raytheon method uses a single layer of chromium. Where the Bell Labs method forms platinum silicide in the contact hole to insure low resistance between the silicon and the gold lead, Raytheon substitutes a different metal, which they choose not to reveal.

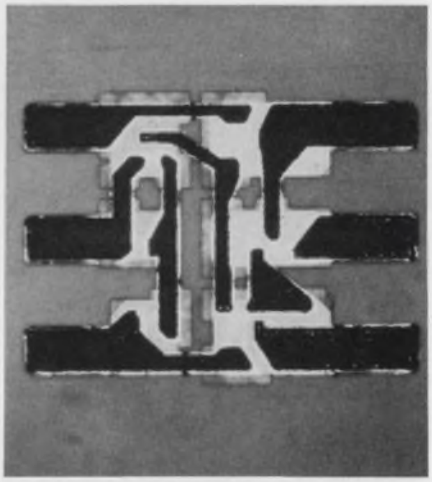
The advantage of the Raytheon system is that it does not require the use of sputtering or back-sputtering in the production of the chip. Instead, metal can be vapor deposited just as in the production of an ordinary circuit. Raytheon feels that the simplified production requirements of its metallurgy make it a natural for the development of high-volume, high-performance microcircuits.

The primary market for the new devices is expected to be in the area of military or satellite communications equipment. Since the air-isolation eliminates the substrate leakage currents, the beam-lead devices are much more resistant to high-radiation environments than are standard units.

Booth No. 4418 *Circle No. 461*



Reduced parasitics associated with air isolation improve roll-off of the 703. The 0-dB gain frequency moves from less than 200 MHz to past 1 GHz with 6-dB/octave roll-off. Component geometry itself is unchanged from the standard 703 layout.



'Bottom' view of the 703 shows thick gold leads (dark areas). Corresponding light areas on chip photo above are chromium.

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Model	250 DE	292	300	231	232	242	122	500	261
Range	.1Ω-12MΩ	.1Ω-1.2MΩ	.01Ω-500MΩ	.01Ω-12GΩ	.1Ω-500MΩ	.001Ω-120MΩ	.001Ω-100MΩ	.1Ω-111MΩ	10Ω-2MΩ
Accuracy	.1%	.05%	.02%	.01%	.01%	50ppm	0.2ppm	.01%	.1%
Price	$475	1380	875	2050	1075	3500	4000	2595	Appr. 350
Comments	R, C and L	R, C, L and G	R, E, I and Ratio			Ratio and deviation ranges	1:1, 10:1 ratios	Deviation ranges ±10% to ±.01%	1:1 ratio ±1%, 5%, 20% ranges

Resistance measurement is very much a local matter, requiring resistance measuring instruments designed to match your local needs. Whether the job is production testing, on-line inspection, or laboratory calibration and certification—you want an instrument specifically tailored to the task.

The chart illustrates the wide range of approaches ESI can offer to meet your resistance measuring needs. Among them, you're sure to find the ranges, accuracies and special features that suit your particular application. In many cases, you may be able to answer a number of different electronic measurement requirements in a single multi-purpose instrument.

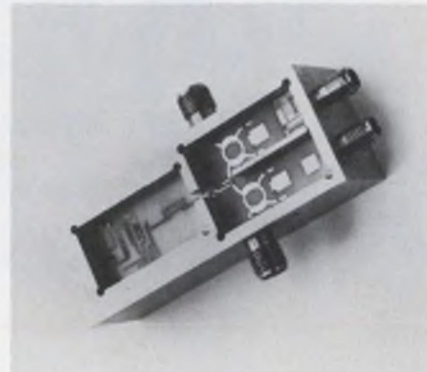
It's not by chance that every major manufacturer of precision resistors uses an ESI measuring instrument. You'll find, as they have, that ESI instruments are fast and easy to use. And they give you the greatest reliability and accuracy for your dollar. That's a good local cause to be supporting, ESI, 13900 NW Science Park Drive, Portland, Oregon 97229.

Electro Scientific Industries Inc. esi®

WESCON Booths 2717-18

ON READER-SERVICE CARD CIRCLE 156

Hybrid mixer/LOs shrink receiver size



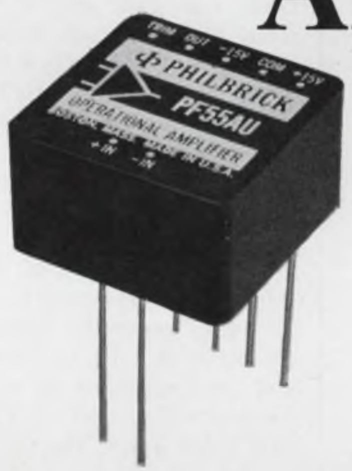
Microwave Associates, Burlington, Mass. Phone: (617) 272-3000.

A solid-state hybrid integrated mixer and local oscillator assembly using microstrip circuitry weighs 2 ounces with dimensions of 1 x 2.3 x 0.75 inches. Incorporated in the device are two Schottky-barrier diode balanced mixers and a transistor preamp in addition to an integrated microstrip local oscillator. This portion of the microwave receiver front end performs all of the mixing functions for the signal and afc channels, signal channel i-f preamplification and local oscillator generation. The two balanced mixers utilize two-element branch line couplers for the 3-dB power dividers and passivated silicon Schottky diode chips are mounted as the semiconductor device element. The balanced mixers have a 9-dB noise figure with an rf-to-i-f gain of 20 dB. The i-f frequency is 150 MHz with a 50-MHz bandpass. The LO module consists of an L-band transistor oscillator that has an output power of 200 mW. The oscillator feeds a X6 varactor multiplier and subsequently a bandpass filter for spurious rejection. The oscillator module has an output of approximately 10 mW at X-band with all spurious signals 30-dB down. An electronic tuning range of over 100 MHz is possible for electronic frequency control in an afc circuit.

The circuits use alumina substrates with the center conductors fired onto the alumina. The conductor is composed of silver, copper and gold. The coupling from substrate to substrate is made by a ribbon jumper soldered between the 50-Ω center conductors.

Booth No. 3723　　*Circle No. 259*

Buy this ten dollar Philbrick Operational Amplifier



...and let everyone think you paid twenty. They'll believe it, when they see its performance.

Plain language—our low prices come from volume-production savings and new packaging efficiencies. Others achieve them by cutting corners—thereby making your design job more expensive, more difficult, and more restricted.

Here's what we mean—Economy-Grade Philbricks give you *design resilience* the others don't have. Things like:

Safe, conservative operation at any supply voltage between ±7.5 V and ±22 V; a full ±11 V output swing with a ±15 V supply (even more at higher supply levels); gain to spare — enough to let you take full advantage of their low offset drifts; remarkably low quiescent power; exceptionally wide stability margins.

We know—that nine times out of ten, you would save money if you paid *twenty* dollars for a resilient Philbrick — but we don't ask you to; just pay what you would for a narrow-margin stiff one. Call us — we've got what you want, at low prices you'll be surprised to find.

EXAMPLE: This new PF55AU preformed-case epoxy encapsulated miniature has open-loop gain of 40,000 driving 10kΩ, 1.5 MHz bandwidth, CMR of at least 1000:1, will slew at 1.5 V/μsec, 20 μV/°C offset limit, and all the resilience described above. It outperforms the cut-spec cheapies, yet it's a genuine Philbrick, through and through. PF55AU price: In lots of 1,000 . . . $10.00 (even less in larger quantities.)

Send for new Operational Amplifiers price list and 12 page brochure: Bulletin 6111. Philbrick Researches, Inc.,46-G Allied Drive at Rte. 128, Dedham, Mass. 02026. Phone: (617) 329-1600 TWX: (617) 326-5754.

GOING THE MICROCIRCUIT ROUTE? There's a resilient easy-to-stabilize Philbrick in a modified TO-5 package, too — at only $6.95 (less in 100-lot quantities or more).

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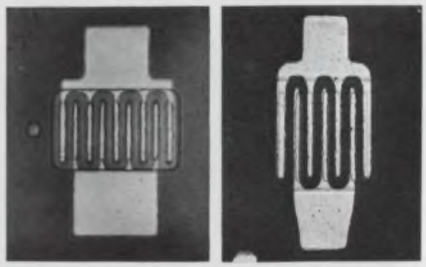
CIRCUIT COMPONENTS

Silicon transistor amplifies to 4 GHz



Texas Instruments, Inc., 13500 North Central Expressway, Dallas. Phone: (214) 238-3741.

A pair of microwave silicon transistors are designed for practical oscillator applications above 4 GHz with a third device useful as an amplifier to 4 GHz, with guaranteed noise and gain performance at 2 GHz. The L-187 and 187A are fundamental oscillators with typical power output (at 4 GHz) of 40 and 75 mW. Both can be tuned over octave ranges, attaining maximum frequency of oscillation of approximately 6 GHz.

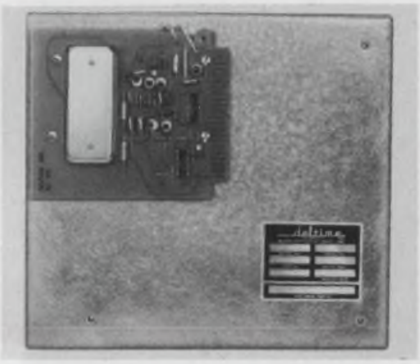
The amplifier, L-186, features a typical noise figure of 5 dB at 2 GHz. Common-emitter unneutralized gain under the same operating conditions is 8 dB. Higher gain with a slight increase in noise figure can be obtained by operating the device at 8 V and 5 mA. The 187 and 187A oscillators are also useful as amplifiers, delivering a somewhat higher saturated output than the 186. Gain is similar but noise figure is higher because of the higher operating current.

All three devices are npn double-diffused, epitaxial planar transistors, and all are available in a pill-type package for use in stripline circuitry. The package has common-lead inductance of 0.16 nH, and feedback capacitance of 0.02 pF. The oscillators are connected in a common-base configuration, and the amplifier common-emitter.

Booth No. 4105 Circle No. 357

For a complete listing of the technical papers at the show, see page U 112. For reprints of most of the papers, fill out the order form on page U 115.

Recirculating memory compatible with DTL



Sealectro Corp., Mamaroneck, N. Y. Phone: (914) 698-5600.

Fully compatible with ICs, (DTL 930), this recirculating delay line memory module accepts a variety of delay lines to provide storage capabilities between 20 and 10,000 bits and delays between 20 and 15,000 μs. Applications include sequential information storage for CRT displays, buffer memories for teletype information and programing for numerically controlled machines. The module operates on −10 V dc at 20 mA, +10 V dc at 21 to 56 mA, +5 V dc at 35 mA, and includes trigger, inhibit and clock inputs.

Booth No. 4309 Circle No. 256

Rf power transistors designed 'fail-safe'

Amperex Electronic Corp., Slatersville, R. I. Phone: (401) 762-9000.

Silicon npn rf power transistors feature high power output and high power gain with excellent fail-safe characteristics. The low-voltage devices are intended for use in 12-V battery-operated 175-MHz mobile communication systems. The units are designed to withstand higher current surges without going into secondary breakdown. This minimizes the effects of short or open-circuit antenna or load mismatch.

Using the A200 as a low-power stage driver, the transistors produce 36 watts from a 0.12-W input source with a 3-device series-parallel arrangement.

All are single-chip devices, with the A200 packaged in a TO-39 case and the A201 and A202 enclosed in a TO-60 stud package.

Booth No. 3912 Circle No. 356

WHO'LL make the next breakthrough in EDP design?

Could be YOU: with Mosaic's Fiber Optics!

EDP systems design engineers are only beginning to tap the potential of fiber optics. Yet, after a brief acquaintance with this broad, new technology, they have made breakthroughs already . . . obsolescing "standard" EDP design solutions. Advances like greater speeds. Design freedom. New capabilities. Reliability and lower costs.

Did you hear about the oscillograph equipped with a fiber optic cathode ray tube? The CRT tube's electron beam is the writing device. Printout is nearly 100 times faster (1 million inches per sec.) than any direct-writing system in existence!

Do you know the story on Mosaic's Fiber Optic systems? In new EDP readers, printers, punched tape and card verifiers . . . in keypunch and teletype equipment, they're more dependable, less complicated, less costly and over 4 times faster than heat, wear and friction-prone mechanical systems!

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Mosaic will work with you to solve your EDP design problems *now* . . . will help you design and develop,

from prototype to production, the specific EDP fiber optic hardware to put you way ahead!

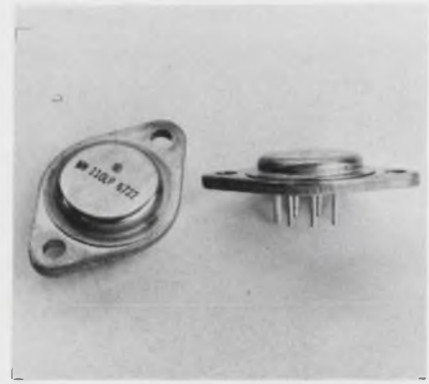
Call or write Mosaic Fabrications, Inc., Galileo Park, Sturbridge, Mass. 01518, (617) 347-9191 for descriptive literature today!

Bendix Electronics

ON READER-SERVICE CARD CIRCLE 160

CIRCUIT COMPONENTS

Monolithic regulators give 2-A output



Westinghouse, Molecular Electronics Div., Elkridge, Md. Phone: (301) 796-3666. P&A: $25 (over 50); stock.

The 2-A output of this unit is sufficient to drive 10-to-50-A power transistors to outputs from 5 to 25 A. For additional power-handling, a discrete power transistor can be added. The additional transistor will make the output stage a triple Darlington. The power transistor's heat sink must be isolated from the monolithic circuit's heat sink, and the power limitations of the IC must be observed. As a power supply regulator, it can produce 0 to 2 A from 8 to 48 V. An additional lead is provided so that external Zener references may be used. This permits the unit to be used for outputs less than 8 V. The case is at ground potential and it is possible in some systems to bolt the package to chassis or structural members for heat sinking without resorting to mica washers or other substances that impair the heat removal path. With a 5-mA constant current source, the WM 330 will deliver regulation of 0.1 to 0.2% for input variations of 20% and load variations of 0 to 1 A.

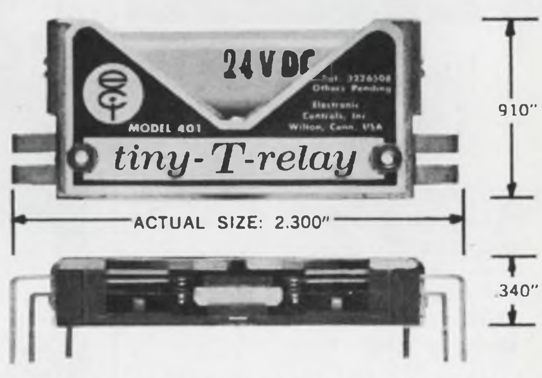
Short circuit protection is available by using a small series resistor at pin 2. This resistor connected to a transistor could cut the bias of the monolithic's Darlington and shut it down. The units can be used in systems as local regulators for noise isolation rather than one central power supply. The circuits can be inconspicuously spotted right onto the PC boards and mother boards for which they supplied the regulated power.

Booth No. 5205 *Circle No. 383*

INTRODUCING!

tiny-T-flatpack relay

- ***TINY-T® is the first relay of its kind***
- ***.340" off-the-board height***
- ***1000V. Interrupt***
- ***10 Milliohms or less contact resistance***
- ***Switches 150W. per contact***
- ***100-Million operating cycles***
- ***Inexpensive cost and operation***



OPERATIONAL SAMPLES AVAILABLE!

At last . . . here's the four-pole flatpack relay that everyone has asked for! Offering the ideal dimension off-the-board (.340"), the Tiny-T® features a standard .100 x .100 grid terminal layout, making it ideal for printed circuit board applications. ■ We'll gladly send you a sample at a special $4.00 introductory price so you can put Tiny-T® to the test. Our representatives are ready for your orders in all quantities. So are we! ■

electronic controls, inc.
T-Bar Switch/Relay Div. • Danbury Road, Wilton, Conn.
phone (203) 762/8351

Electronic Controls, Inc.
Switch/Relay Division
Danbury Road
Wilton, Connecticut 06897

- ☐ Enclosed is our Purchase Order for $4; please rush a Tiny-T Relay Sample.
- ☐ Have a representative call with more details.
- ☐ Send Bulletin #TB401 on the Tiny-T.

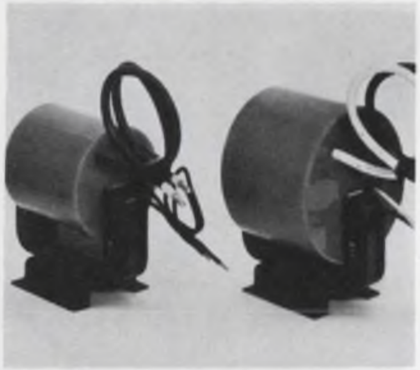
I anticipate using the Tiny-T Relay for________

NAME________ TITLE________
DIVISION________
FIRM________
STREET________
CITY________ STATE________ ZIP________

. . . See us at BOOTHS 5113-5114—WESCON '67 . . .

ON READER-SERVICE CARD CIRCLE 162

Pulse transformers trigger xenon lamps



Pek, Inc., 825 E. Evelyn Ave., Sunnyvale, Calif. Phone: (408) 245-4111. P&A: $125, $175, $250; stock.

Designed for series-triggering xenon flash lamps, these trigger pulse transformers have special applications in flash photolysis and high-performance pulsed laser operation. The three models feature long term secondary rms current ratings of 20, 30 and 40 A with peak secondary current ratings of 10, 14 and 12 kA. Saturated secondary inductance is 16 μH and secondary resistance is 2.5 MΩ.

Booth No. 4414   Circle No. 261

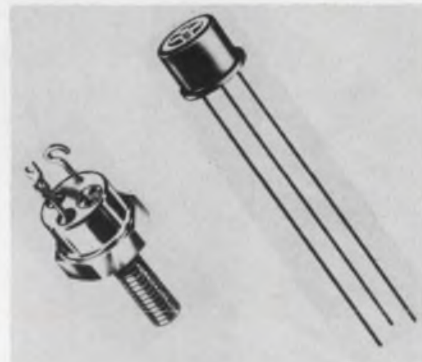
Economy hybrid isolator has infinite Z_{in}

Nexus Research Laboratory, Inc., 480 Neponset St., Canton, Mass. Phone: (617) 828-9000. P&A: $24 (1 to 9); stock.

This unity-gain noninverting isolation amplifier features very high input impedance and wide bandwidth. The amplifier has unity gain to an accuracy of typically 0.02%. Its impedance at dc is 10^{12} MΩ. Output voltage range is ±10 V into a 5-kΩ load.

Booth No. 2420   Circle No. 327

Silicon power transistor sustains 80 volts



Silicon Transistor Corp., East Gate Blvd., Garden City, N. Y. Phone: (516) 742-4100. P&A: $8 to $16 (100 lots).

A line of pnp silicon single-diffused power transistors offers sustaining voltages of 40 volts for the 2N5110 and 80 volts for the 5111. Both are offered in the TO-5 package. The equivalent 2N5112 and 5113 are packaged TO-59. All are designed with a 1-A collector current and dissipate 5 W at 25°C in the TO-5 package, 34 watts in the TO-59 package.

Booth No. 5323   Circle No. 349

Dc regulators give 1-A outputs

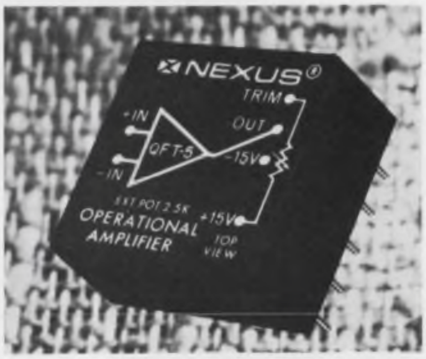
Bendix Corp., Semiconductor Div., Holmdel, N. J. Phone: (201) 747-5400. Price: $4 (1000 up).

Low cost 1-A dc voltage regulator modules are contained in a JEDEC TO-3 package and fit all standard heat sinks. They are available in units rated at 5, 6, 12, 18 or 25 volts, ±10% setting tolerance. Load regulation is ±2% from minimum to maximum load. Temperature coefficient is 0.1%.

Booth No. 2812   Circle No. 260

CIRCUIT COMPONENTS

Economy op amp has FET input



Nexus Research Laboratory, Inc., 480 Neponset St., Canton, Mass. Phone: (617) 828-9000. P&A: $29; stock.

The QFT-5 provides 10^{10} Ω differential and common-mode impedances, less than 1-nA of input offset current, and high tolerance to capacitive loads. Its output voltage range is ±11 V at ±5.5 mA. The supply voltage is ±15 V. The unit rolls off at 6 dB/octave.

Booth No. 2420 Circle No. 326

Molded MIL chokes available to 1000 μH

Cambridge Thermionic Corp., 445 Concord Ave., Cambridge, Mass. Phone: (617) 491-5400. P&A: 22¢ to 33¢ (100 to 249); stock.

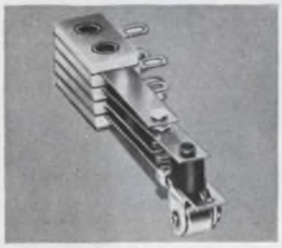
Molded chokes in 3 series conform to MS 75052, 75053 and 75054 respectively. The first covers inductance values from 47 to 150 μH in a 0.25-inch diameter by 0.56-inch long package. Q ranges from 18 to 75. The second covers 180 to 390 μH in a configuration of 0.31-inch diameter by 0.56-inch long. Q values span 80 to 75. Another series spans 470 to 1000 μH and measures 0.375-inch diameter by 0.625-inch long. Q values are 80 through 70. All chokes are hot molded using epoxy and are color-banded.

Booth No. 4103 Circle No. 265

For a complete listing of the technical papers at the show, see page U 112. For reprints of most of the papers, fill out the order form on page U 115.

An engineering forum is supposed to be a discussion. Somehow I get the feeling that Switchcraft is going to be doing all the talking.

We sincerely hope not. We want the Forum to be truly an interchange of ideas on the technical aspects of the products we make, let the chips fall where they may. A "switch craft" forum as well as a "Switchcraft Forum."



Typical stack switch assembly

We hope that, with a lively response from design engineers in the field, we can develop enough questions and ideas so that a future Forum might examine, for example, all sides of a single aspect of a single type of switch, whether you agree with our viewpoint or not.

(Obviously, as we are paying for the space, we will make a solid attempt to convert you to our viewpoint.)

For this, our first edition, we will have to start the ball rolling, which means we will be doing most of the talking.

We thought a good place to start would be a discussion of stack switches and, naturally, why our stack switches are best.

Naturally. But why lead off with stack switches? Why not one of the newer, more exotic circuit controls?

SWITCH CRAFT FORUM

Versatility can be pretty exotic. And that's what stack switches are. You have a wide selection of contact materials, insulation, mounting and actuation methods. Versatility is an integral part of stack switches and a quality line such as ours should be a basic component in every engineer's design arsenal.

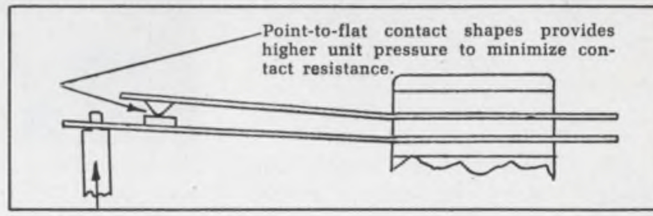
Impressive. But how about some specifics?

Quality is very specific. It is definitely related to materials and manufacturing techniques. Switchcraft quality is easy to explain.

For instance, all of our stack switches use a special nickel silver alloy for the contact and actuator springs. This material is fabricated to our specifications on hardness to assure proper characteristics for long switch life. We gain a 10% improvement in tensile strength over switches made with other spring materials.

Let's talk about contact assemblies. For typical medium level stack switch applications, we offer large silver contacts solidly staked to the spring. This forms a pointed contact which mates with a flat contact. The result is higher unit pressure and lower contact resistance. (See figure).

For dry circuit or low level applications, palladium, silver or gold contacts are welded, rather than riveted, to the spring for low contact resistance and bond strength uniformity.



Sounds good so far, but what other engineering factors are involved?

And you were worried that we would be doing all the talking. We don't have space here to even get into all the engineering parameters involved.

But we do have a comprehensive engineering article and a catalog we would be happy to send you. (Check the Reader Service Number below).

Just briefly, we could cover one more point. Insulation. XP and XXP Phenolic fibre insulators have about the same breakdown voltage.

XXXP has better insulation resistance, less leakage current. We use nothing but the XXXP.

In a nutshell, Switchcraft offers a well-designed, quality-constructed stack switch for just about every application an engineer would ever have for a stack switch. And Switchcraft prices are competitive, right down the line.

I'm beginning to think your Forum idea will work. But how are you going to get more engineers to join in? Ask the right questions? Come up with ideas?

That's what we're doing right here. If you have anything to ask, or say, about any type of switch we make, or for that matter any type of product we make, send us your questions or comments. If your questions are loaded, or controversial, so much the better. This is where product development comes from.

We're waiting to hear from you.

SWITCHCRAFT INC.®

5529 N. Elston Ave.
Chicago, Ill. 60630

ON READER-SERVICE CARD CIRCLE 166

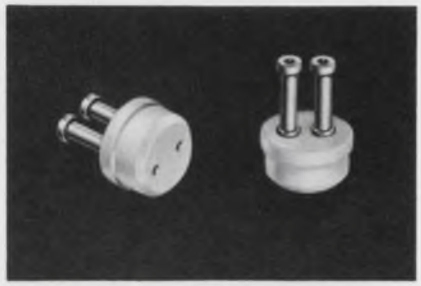
Time-delay relays fixed or adjustable

Potter & Brumfield, Princeton, Ind. Phone: (812) 385-5251. Price: $12.50.

Low-cost time-delay relays are designed for delay on operate applications in machine tool controls, coin-operated machines or process controls. Two versions, fixed time delay on operate and resistor adjustable, are offered in ac and dc models. Timing ranges of 1, 5, 10, 30, 60 and 120 seconds are available. Timing tolerance is ±5%, reset time is 100 ms. Relay contacts are rated at 10 A at 28 V dc or 120 V ac.

Booth No. 4101 *Circle No. 255*

Tubular feedthrough accepts 2 leads

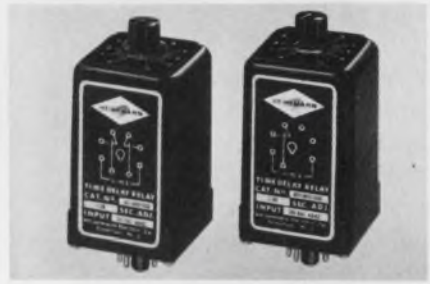


Sealectro Corp., 225 Hoyt, Mamaroneck, N. Y. Phone: (914) 698-5600.

With dual tubular lugs mounted in a single Teflon bushing, this two-pin feedthrough terminal is designed for multiconnection applications. Component leads come up from beneath the chassis, through holes in the lugs and are then soldered in place. Circuit wiring can then be attached to the outer lugs, completing the package. The unit is made of Teflon and has gold flash over silver-plated brass lugs measuring 0.207 inch and lugs with solder areas 0.045 inch in diameter.

Booth No. 4309 *Circle No. 263*

Time delay relays withstand line changes

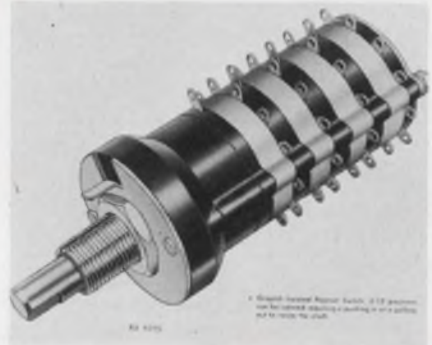


Heinemann Electric Co., Magnetic Dr., Trenton, N. J. Phone: (609) 882-4800. Price: $20 and $26.

Using a solid-state timing circuit, this relay's delay time, within the total range, is adjusted by a self-contained pot and is not subject to extreme time variations caused by changes in line voltage. A time interval repeatability of ±2% at 70°F and 115 V ac is not affected by line variations from 100 to 135 V ac. The unit is available in two models: delay-on-make and delay-on-break. Corresponding ranges are 1 to 60 and 1 to 30 seconds.

Booth No. 3921 *Circle No. 262*

Rotary switch ends knob twirling



Grayhill Inc., P. O. Box 373, Lagrange, Ill. Phone: (312) 354-1040.

An isolated-position rotary switch prevents knob twisters from turning on or turning off one or more circuits. Any combination of switch positions can be isolated by requiring either a push or pull of the rotary switch shaft by the operator before the isolated position can be reached. Typical applications include equipment that requires an off or calibrate position and/or a standby position. Externally, the isolating mechanism appears as an additional switch deck without terminals located immediately behind the detent system. This feature is available with up to 4 decks with 30° angle of throw.

Booth No. 4111 *Circle No. 252*

Vacuum fixed caps rated at 12 kV

ITT Jennings, P. O. Box 1278, San Jose, Calif. Phone: (408) 292-4025.

With capacities ranging 1 through 5 pF, these fixed capacitors combine a high-strength ceramic housing and low-loss copper plates with vacuum dielectric. The capacitors are 0.77 inch in diameter and 3.25 inches in length. Peak voltage is 30 kV at 60 Hz. Current ratings are as high as 12 A rms at 20 MHz. Operating temperatures are up to 125°C.

Booth No. 3807 *Circle No. 267*

Comar doesn't shy away from the tough one's

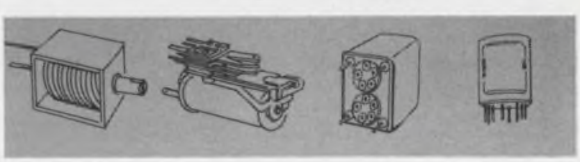
Anyone can handle the easy relay applications, but it takes a company with engineering knowhow, manufacturing superiority and just plain "guts" to take on the tough one's.

The engineers at Comar have an enviable record of rolling up their sleeves and burning the midnight oil to meet stringent relay specifications . . . shock, vibration, miss testing, humidity, special operating characteristics.

The next time someone tells you "it can't be done," call Comar. No miracles, just technical experience and the finest relay test laboratory in the world!

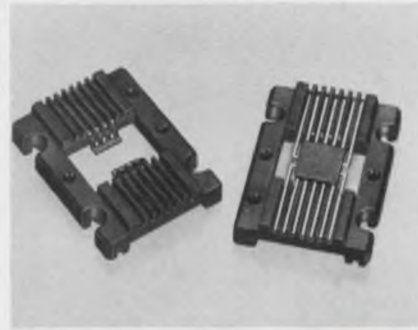
Comar electric company
3349 Addison Street
Chicago, Illinois 60618

TELEPHONE TYPE RELAYS • SUBMINIATURE RELAYS • RELAY ASSEMBLIES • SOLENOIDS • SOLENOID ASSEMBLIES



ON READER-SERVICE CARD CIRCLE 184

One-piece carrier for 1/4-inch flat packs



Barnes Development Co., 213 West Baltimore, Lansdowne, Pa. Phone: (215) 622-1525. P&A: 1¢ to 10¢; stock to 10 days.

For 1/4 x 1/4 inch flat packs, this carrier uses an integrally molded device retention feature that protects the IC. The carriers are molded of polysulfone for continuous operation from −65°C to 150°C. They are designed for automated and semiautomated testing and handling, including handling in both magazines and bowl feeders.

Booth No. 4905 Circle No. 358

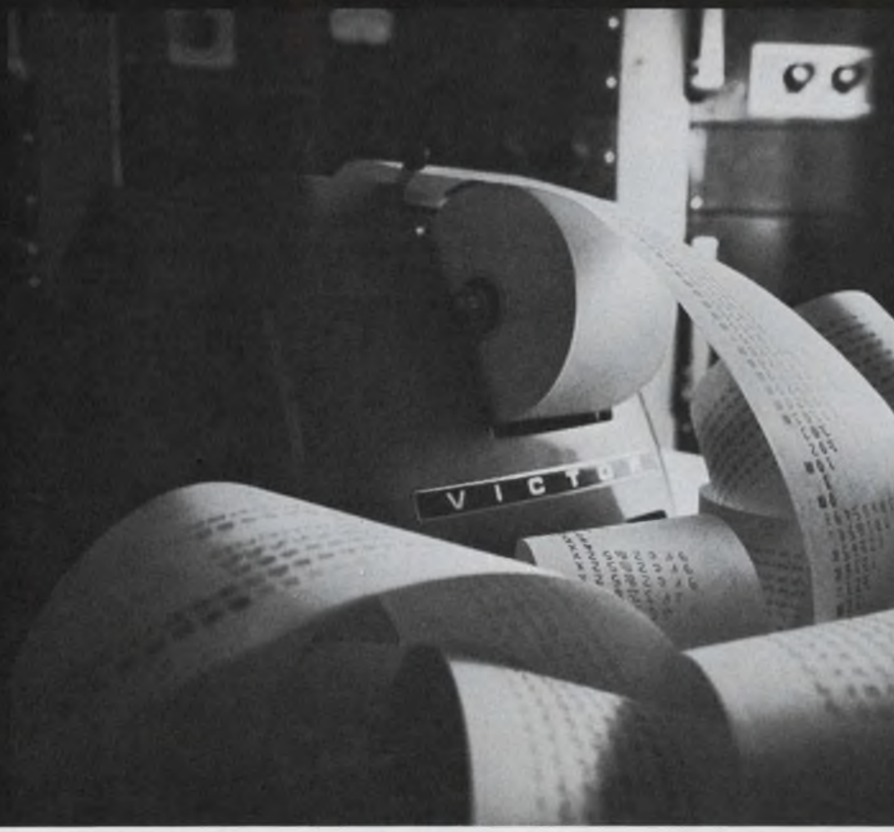
Turbine-impeller blower outdoes squirrel-cage

Rotron Manufacturing Co., Inc., Woodstock, N. Y. Phone: (914) 679-2401.

This turbine-impeller blower delivers more air with greater efficiency than conventional squirrel-cage units. The unit delivers up to 250 cfm at free delivery from a substantially smaller, maintenance-free package. No centrifugal starting switches or relays are used, eliminating the cause of most single-phase motor failures. The blower is designed for electronic cabinets requiring large volumes of cooling to be delivered against high static pressures.

Booth No. 4415 Circle No. 253

The Victor Digital Printer, just $335. $335?



That's right; the Victor Digit-Matic does what any high quality serial entry printer does. And for less money. The Digit-Matic lists 8-column figures from remote sources, on either 24 or 48 volt solenoids. Printing press action reduces wear, eliminates parts, and assures clear, uniform print-out under all conditions.

For just $50 more, the Digit-Matic will also add and subtract. Ten-column capacity, just $20 more!

Factory-trained service representatives located across the country. OEM and quantity discounts available.

Wherever clear print-out is required, call for a Victor Digit-Matic specialist. Write: Victor Comptometer Corporation, Business Machines Group, 3900 N. Rockwell St., Chicago, Ill. 60618.

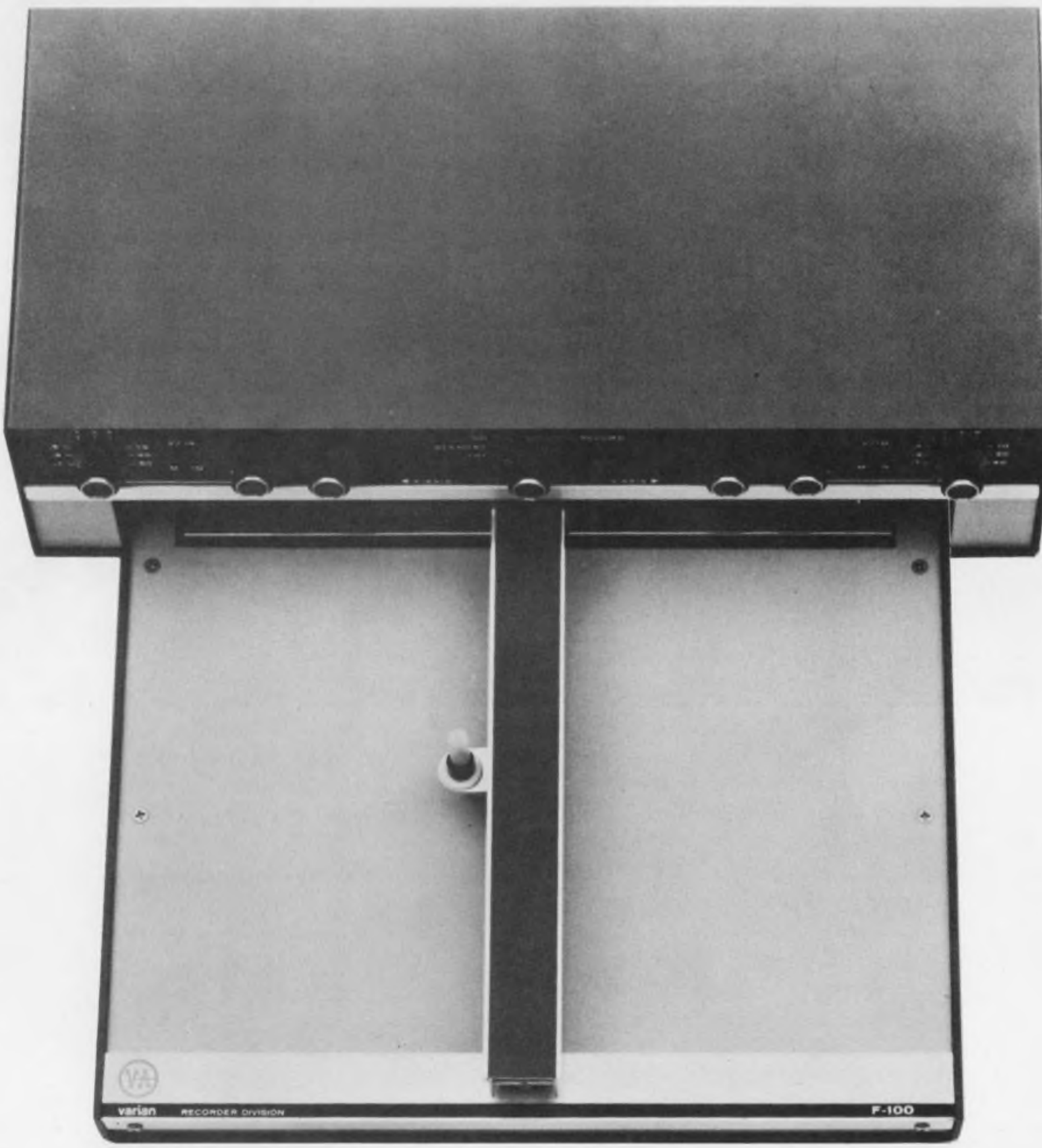
Call on Victor and you're in business.

VICTOR CALCULATORS • ADDING MACHINES • CASH REGISTERS • TEMPORARY HELP • ELECTROWRITER COMMUNICATIONS

ON READER-SERVICE CARD CIRCLE 187

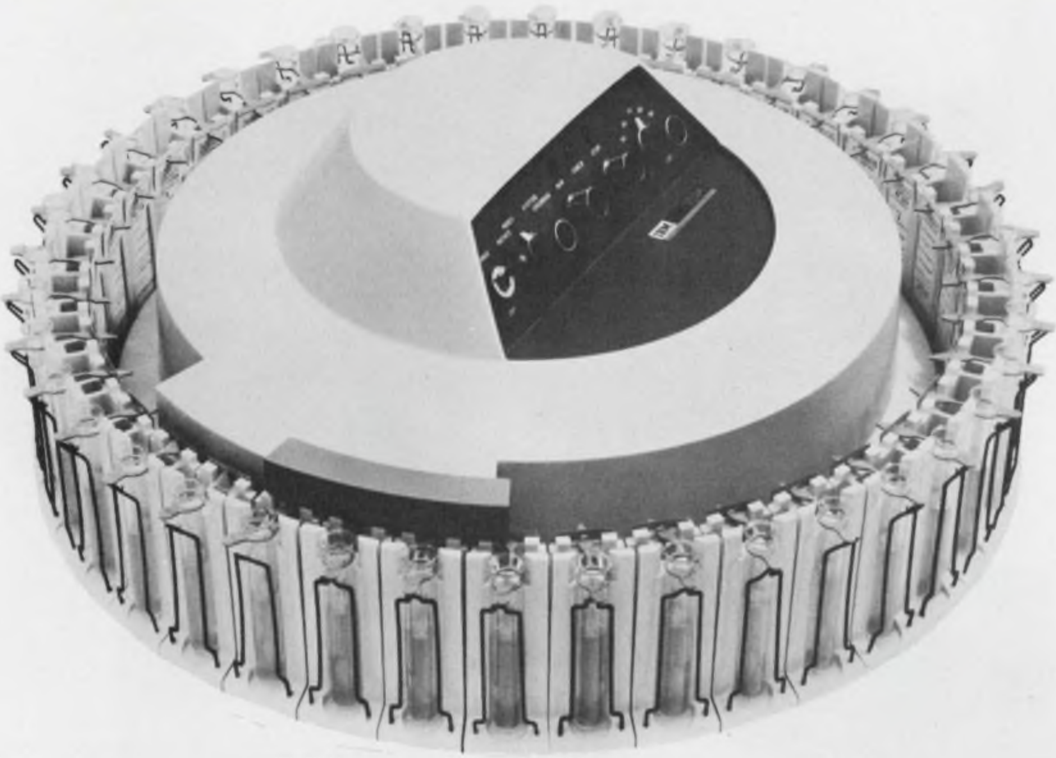
THE BEST IN PRODUCT DESIGN

Here are the six winners of WESCON's 1967 industrial-design awards of excellence and the 10 other finalists that competed against them. All these products will be on display at the show.



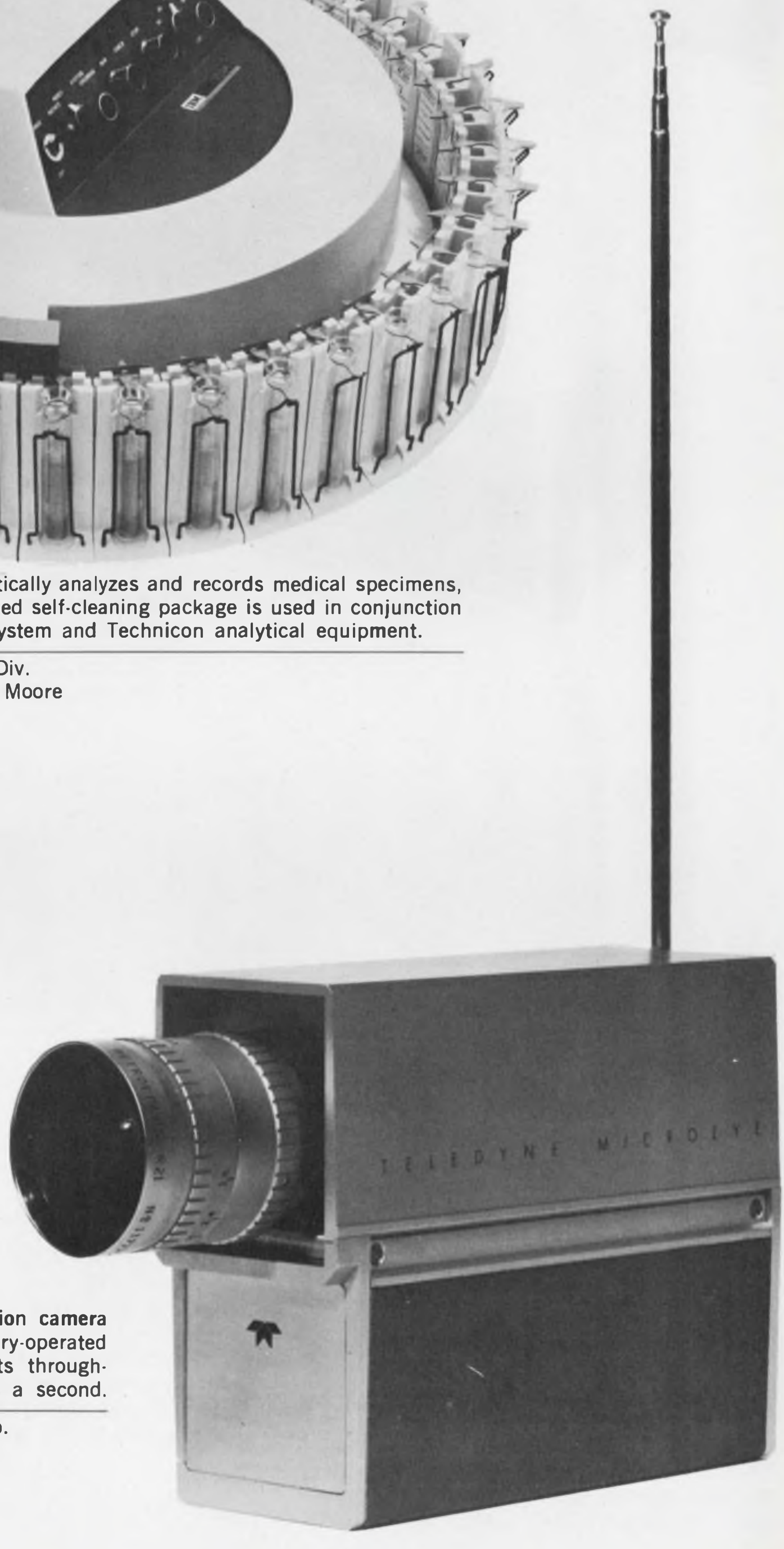
X-Y graphic recorder contains no moving parts; the reverse side of the chart paper is coated with a passive iron ink that holds the paper down on the platen, which acts as a large magnet. Nonmagnetized paper can be held down simply by throwing a paper clip on top.

Company: Varian Associates
Designer: Anthony P. H. Chan



Award-winning sampler reader automatically analyzes and records medical specimens, such as blood or urine. The sophisticated self-cleaning package is used in conjunction with the IBM 1080 data acquisition system and Technicon analytical equipment.

Company: IBM/Systems Development Div.
Designers: Donald H. Wood, Donald A. Moore
Consultant: Eliot Noyes

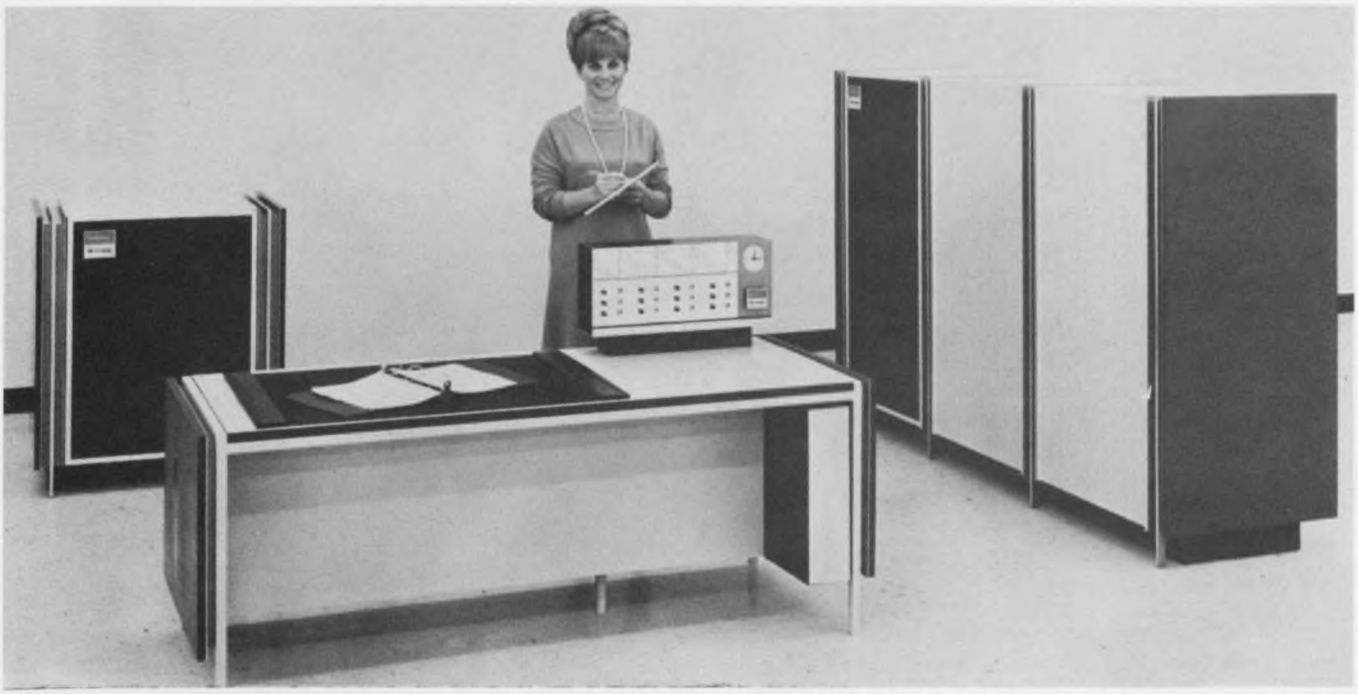


Award-winning microeye television camera weighs just 4 pounds. It is battery-operated and contains integrated circuits throughout. Its scan rate is 525 lines a second.

Company: Teledyne Systems Co.
Designer: H. E. Shanks

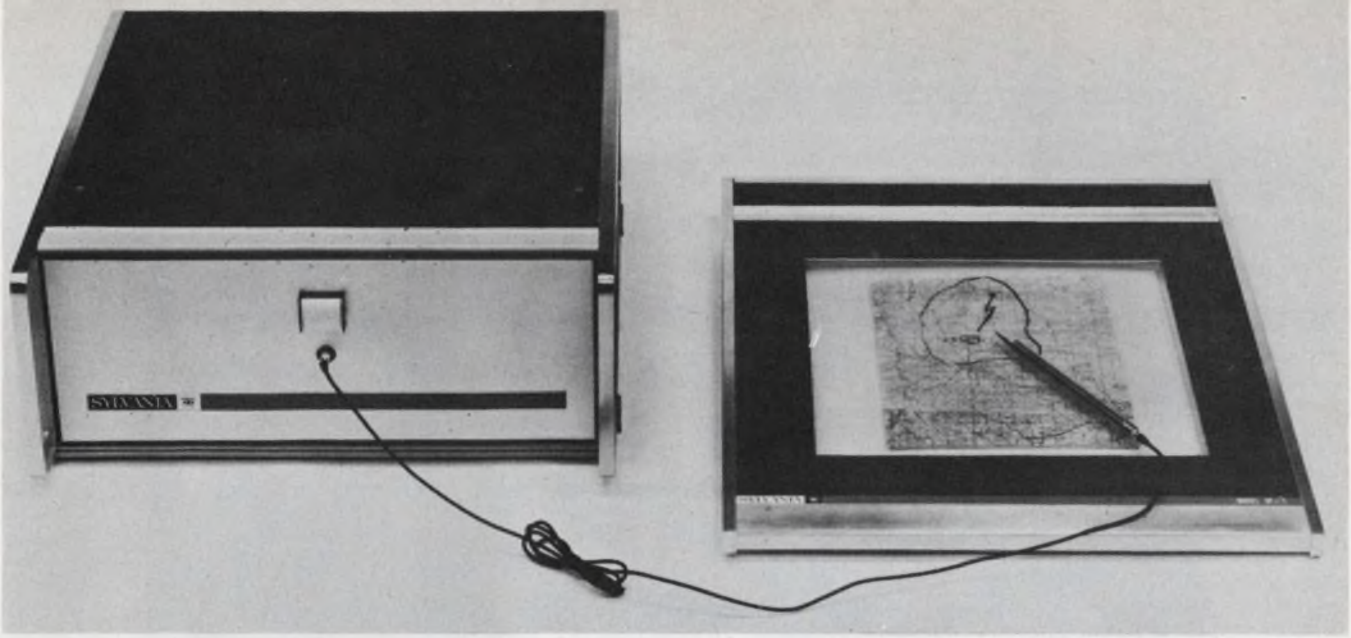
Portable video camera is part of a battery-powered video-tape-recorder-and-camera combination. It weighs less than 50 pounds and is designed primarily for remote high-speed taping of news events by a single operator.

Company: Ampex Corp.
Designer: Gene Bozarth, F. T. Walsh



Data communications system is designed to handle complete communications problems, including message protection and error control. The general-purpose system can handle inputs up to 400 characters per second and interfaces with a variety of terminal devices.

Company: Marshall Communications, Inc.
Designers: Clarence Zierhut, Moro Shimano, Robert Noyer

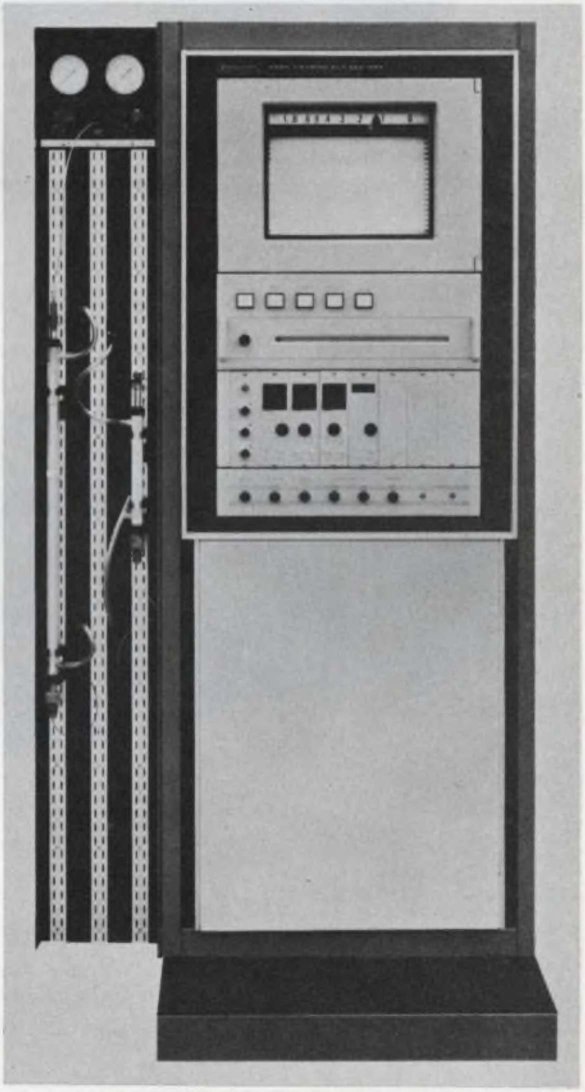


Computer graphical input system comprises an electronic pen and transparent conductive data tablet. Handwritten information is sampled and converted for computer storage and processing. Both analog and digital outputs are available.

Company: Sylvania Electronic Systems
Designer: Oskar Heininger

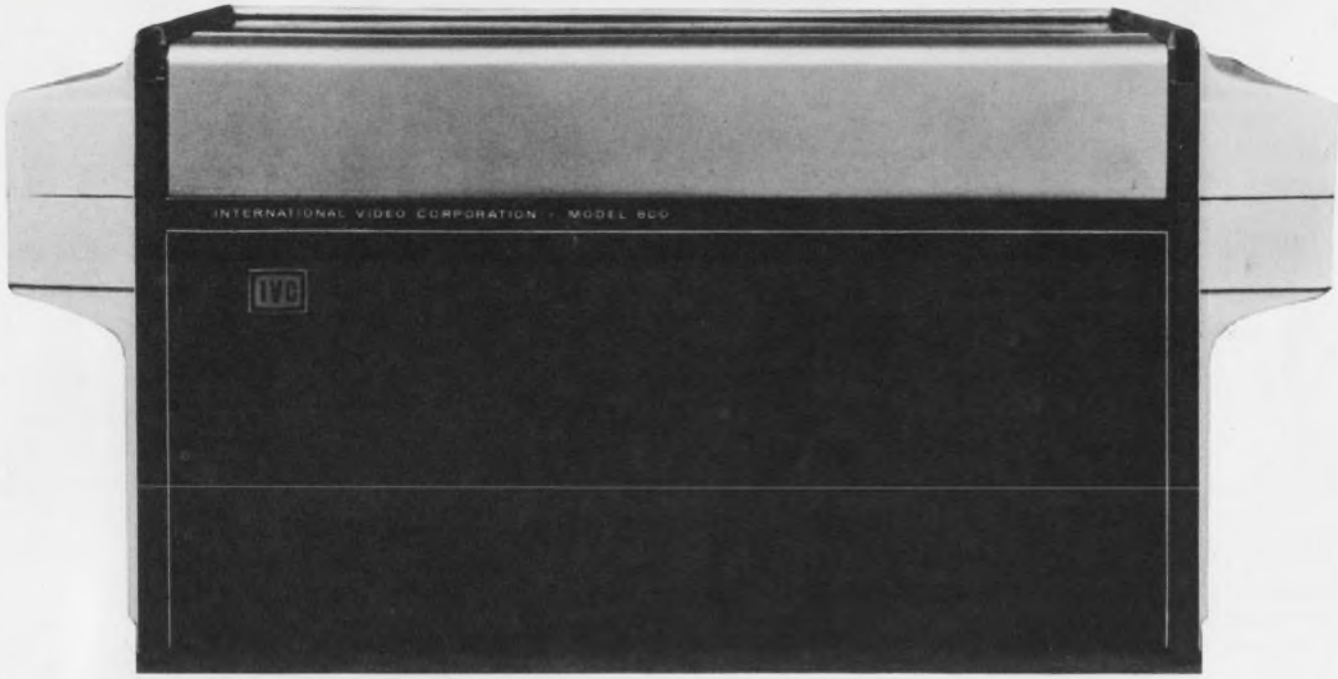
Multiple-beam interferometer used in surface microtopology (measurement of surface irregularities) can measure the thickness of film depositions down to 20,000 Å or 0.00008 inch.

Company: Varian Associates, Vacuum Products Div.
Designer: Anthony P. H. Chan



Amino acid analyzer identifies and analyzes amino acids and peptides for medical and pharmaceutical research by means of ion exchange chromatography. It is completely automated, so that the chemist needs only to start it.

Company: Beckman Instruments, Inc., Spinco Div.
Designer: Charles W. Dodge



Award-winning video tape recorder for closed-circuit color television can record with any standard camera and play back with any standard monitor or television receiver. It has a 5-MHz bandwidth and operates at 6.9 in./s to save tape.

Company: International Video Corp.
Design consultant: Gruye-Vogt-Opperman, Inc.

Award-winning infrared thermometer, carried in a holster, can measure temperatures of objects without physical contact. It comes in seven models with a total range of 60°F to 3000°F. One model, the Circuit Ryder, is specifically designed to measure the temperature of PC-board components.

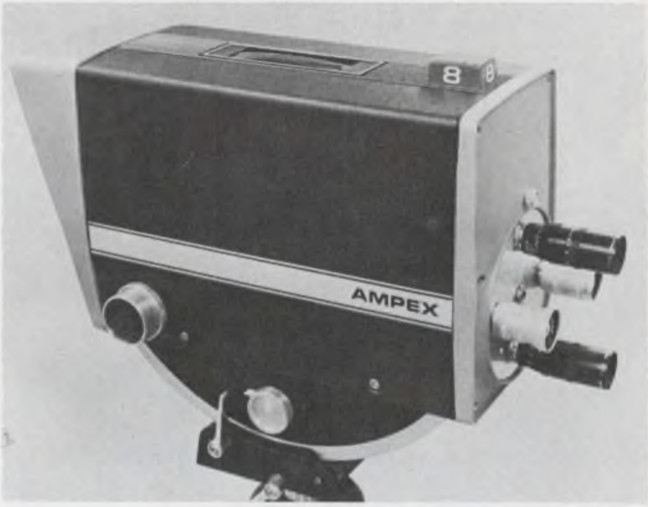
Company: Raytek, Inc.
Designer: J. Budd Steinhilber (Tepper/Steinhilber Associates)

Remote control unit and timer is part of an instant-replay color-TV recording system. It can play TV action back almost immediately at normal, fast and slow speeds and is capable of frame-by-frame stop action.

Company: Ampex Corp.
Designers: R. W. Bornschlegel, F. T. Walsh

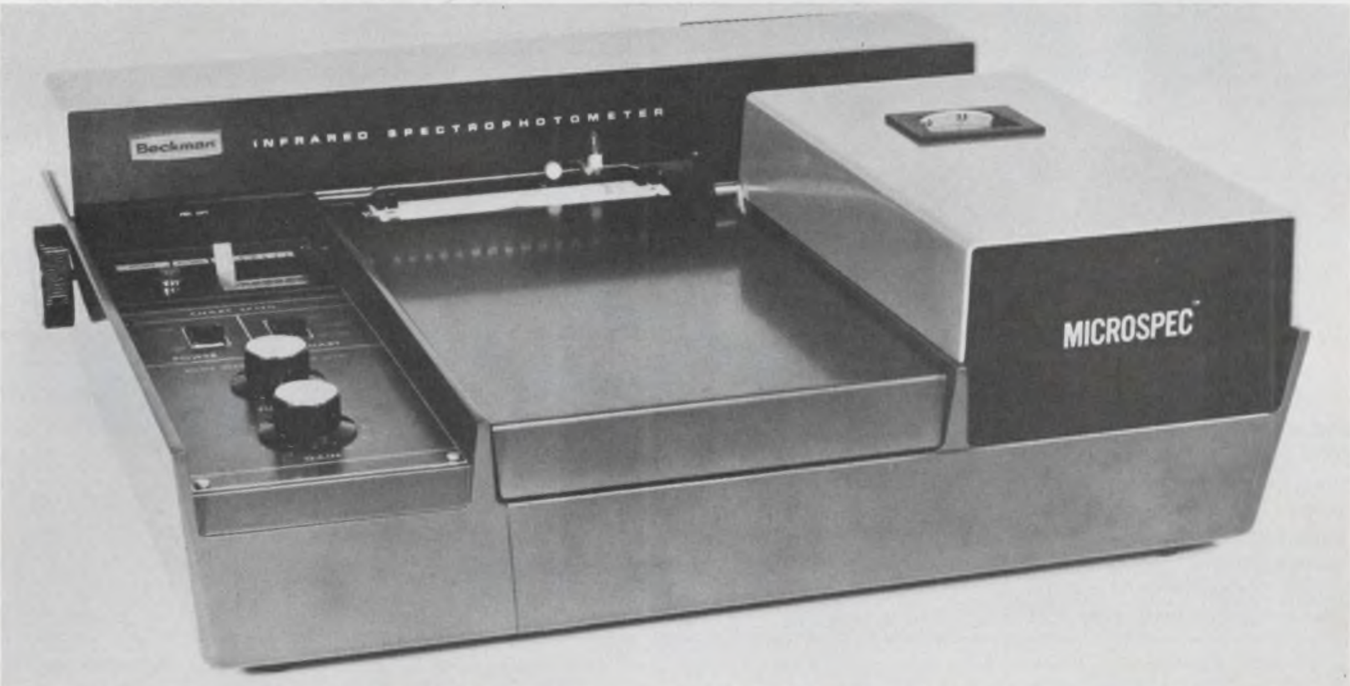
Studio camera is a highly flexible, low-cost unit capable of easy modification to suit customers' needs. It accommodates four lenses of any type, with front or rear zooms, and vidicon or plumbicon tubes. The modular circuitry is readily accessible through side housings locked in place by simple thumb screws.

Company: Ampex Corp.
Designers: Donald E. Leman, Stanley E. Lenhert, Mervin LaRue, Arden Farey, Rein Narma



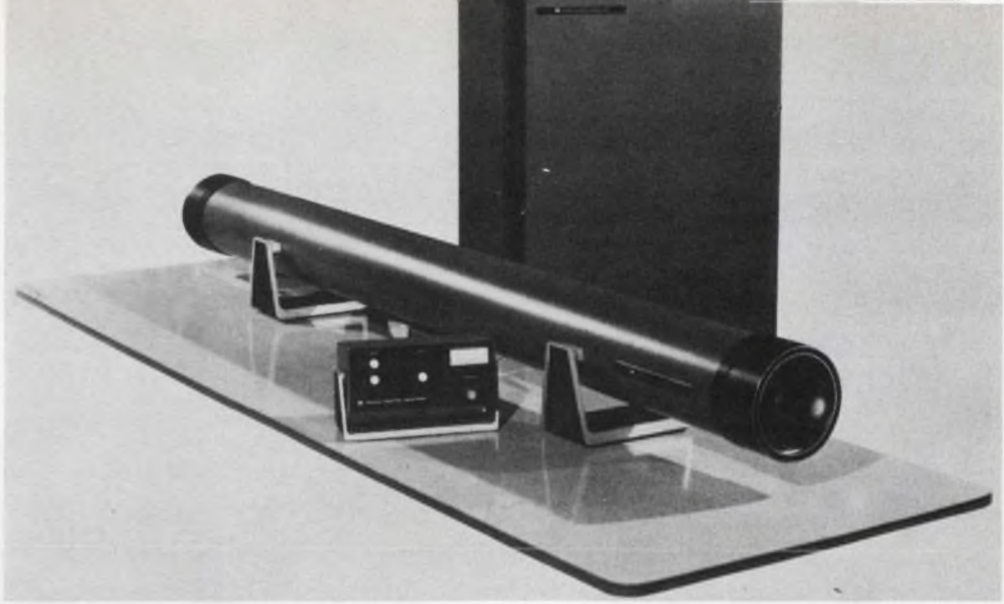
Microspec infrared spectrophotometer uses simplified monochromator optics to print out precise graphs of chemical compounds' absorbance or reflectance of IR wavelengths. Characteristic signatures of compounds are identified for clinical and industrial research.

Company: Beckman Instruments, Inc.
Designers: Robert L. Greene, Hugh O. Brown



Award-winning CO_2 gas laser system is specifically designed as a self-contained unit for industrial applications. It emits approximately 100 watts of continuous power at a wavelength of 10.6 microns, and is capable of some 200 hours of continuous operation on a single bottle of CO_2.

Company: Coherent Radiation Laboratories
Designers: W. Mefford, R. Rorden, S. Jarrett, C. Nunes
Consultants: Gruye-Vogt-Opperman, Inc.

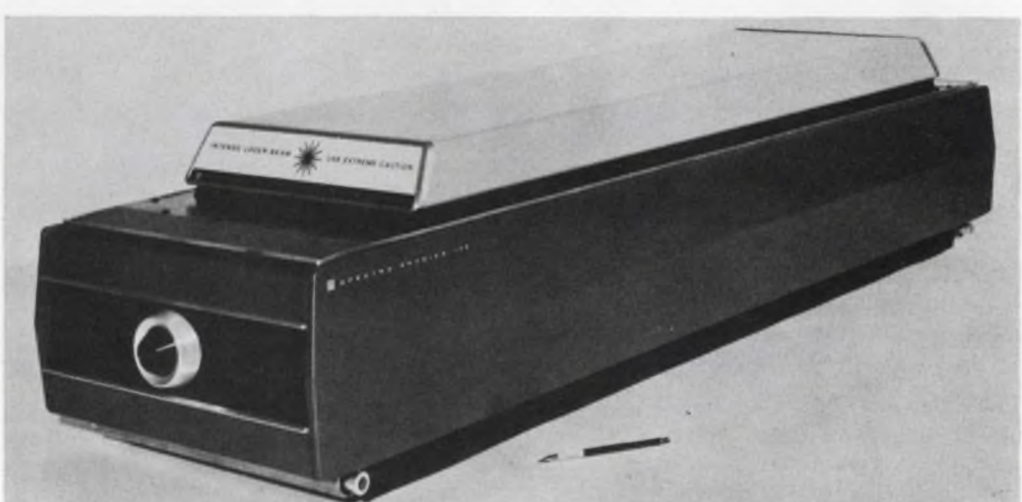


Award-winning ultracentrifuge for biochemical research is capable of 65,000 r/min, generating up to 420,000 g. Indicator lights on the well-grouped display panel pinpoint the location of any malfunction. Rotor temperatures can be precisely controlled from 5° below ambient to 0°C. The whole unit is enclosed in a vacuum chamber.

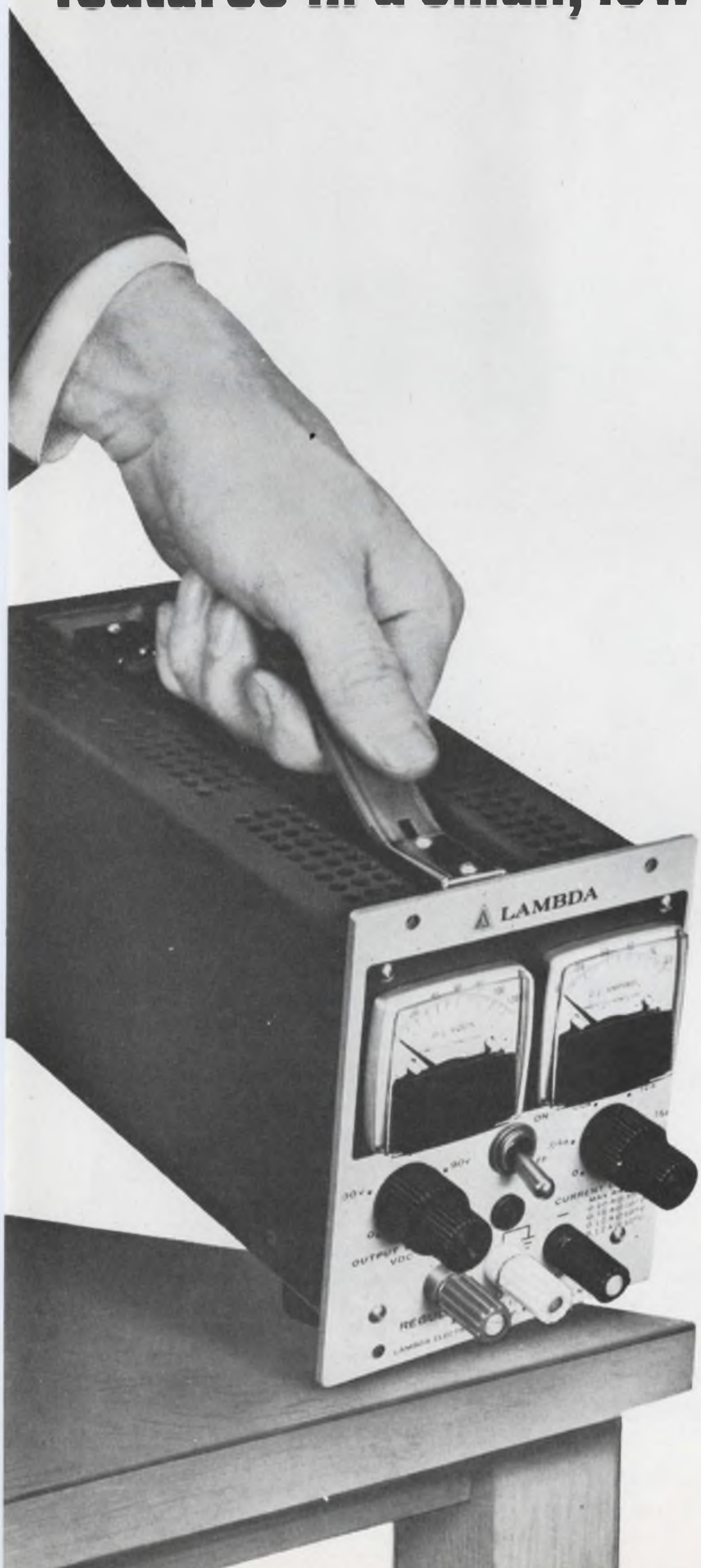
Company: Beckman Instruments, Inc., Spinco Div.
Designer: Charles W. Dodge

Induction ion laser provides 2-W cw output in the yellow-green—to—blue-violet spectrum. The closed glass ring containing argon or krypton serves as the secondary of an rf transformer. Excitation is applied through a coil.

Company: Spectra-Physics
Designer: Carl J. Clement



Only new Lambda LP Series lab power supplies provide all these big system features in a small, low-cost package.



Starting at only $114.

- High power output — up to 28 watts.
- Wide voltage range versatility — 0-10 VDC up to 0-250 VDC.
- Bench or rack use — without adapters.
- Unusually wide automatic current limiting — from 1% (or 5 MA) to 105% of rated output current.
- Two meters for voltage and current.
- Both coarse and fine adjustment of voltage and current.
- Over-temperature protection by thermal relay — prevents overheating.
- Convection cooled — no blower failures.

You can mount up to 4 units in a standard LRA-1 or LRA-2 rack adapter.

Other features

- Regulation (line or load): .01% + 1 MV.
- Ripple: 500 μV RMS, 1.5 MV p-p
- Temperature coefficient: .015% + .5 MV/°C.
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LP 412	0-40 VDC*	0.70A	0.65A	0.60A	0.50A	114
LP 413	0-60 VDC*	0.45A	0.41A	0.37A	0.33A	129
LP 414	0-120 VDC	0.20A	0.18A	0.16A	0.12A	149
LP 415	0-250 VDC	80MA	72MA	65MA	60MA	164

*Overvoltage Protection available as an accessory — $40.00 each.
¹Prices are for non-metered models. For metered models, add suffix (FM) and add $10.00 to price.

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Type 1S2 Sampling Unit for time domain reflectometry and general-purpose sampling

You can test transmission lines, cables, connectors, broad-band devices with ease and accuracy with the new Type 1S2 Sampling Plug-In Unit. It can be used in any Tektronix oscilloscope that accepts letter and 1-series plug-ins.

The $\leq$90-ps risetime of the vertical channel, and deflection factors to 5 mV/div make the Type 1S2 useful in many general-purpose sampling measurements. For this general-purpose use, a pretrigger or delay line is required. System risetime as a reflectometer is $\leq$140 ps.

The illustration shows a Type 1S2 in a Tektronix Type 549 Storage Oscilloscope being used to test a 50-Ω delay line. Information obtained from the upper trace includes electrical length of the line, nominal impedance, location and type of discontinuities. Lower trace is magnification of the discontinuity shown near the center of the upper trace. Deflection factors:

Upper trace — Vertical 0.25 ρ/div
Horizontal 20 ns/div
Lower trace — Vertical 0.025 ρ/div
Horizontal 5 ns/div

The Type 1S2 Manual Scan display mode was used in storing both traces to obtain optimum resolution.

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Dual, full-scale 10-division horizontal calibration is in distances of 10 m, 100 m, and 1 km, and in times of 0.1 μs, 1 μs, and 10 μs. The display can be expanded by a 7-step, calibrated, X1 through X100 magnifier for detailed examination of any discontinuities.

Illuminated readout of the horizontal scale factor, including any magnification, adds to the operating ease. And testing of either short or long lines is facilitated by internal generators that provide a 50-ps, 250 mV pulse and a 1-ns, 1-V pulse.

A front-panel switch provides for matching the horizontal calibration to the types of lines most commonly tested—air, TFE, and polyethylene. A variable control permits matching the calibration to lines using other dielectrics.

Vertical calibration is in both ρ(rho) and in volts, from 0.005/div to 0.5/div, in 7 steps, with an accuracy within ±3%. It is also variable between steps, uncalibrated. A ±2-V offset voltage, monitorable at the front panel, allows amplitude measurements, using slide-back techniques, with an accuracy within ±1%.

Vertical and horizontal outputs of 1 V/div of displayed signal are available at front-panel connectors.

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Includes: 2X and 5X attenuators, 50-Ω termination, 20-cm airline, 5-ns RG 8/AU cable, 2 GR elbows, 18" patch cord, and 2 manuals.

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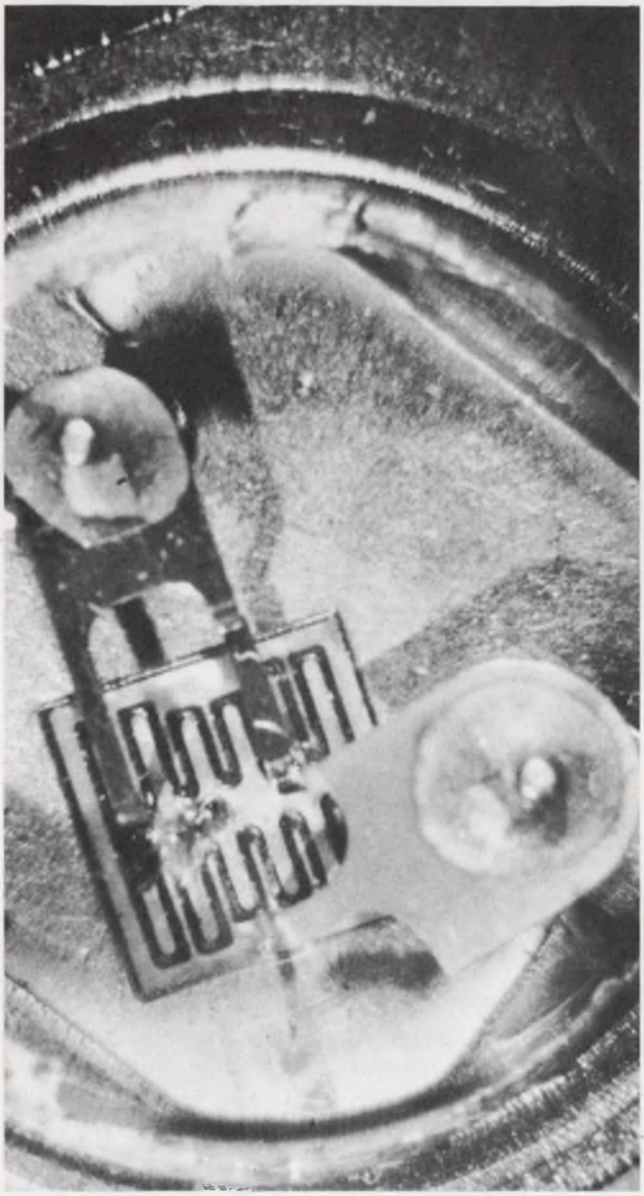
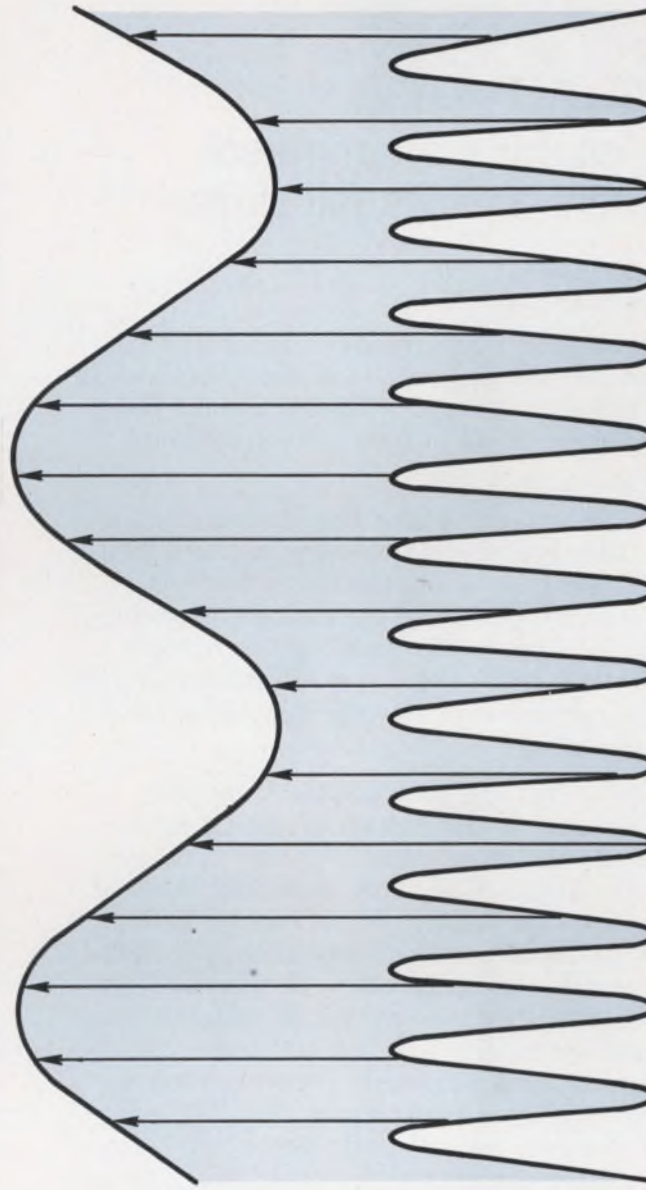


Ease the design of power-transistor circuits for switching high-inductive loads. Page 224



Beat "aliasing" in sampled data systems with the right filter and sampling rate. Page 236

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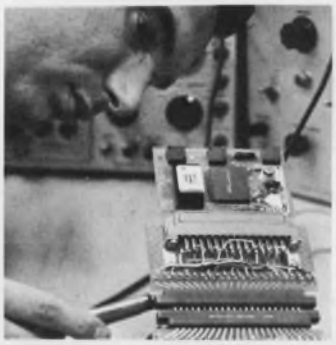


Design Directions

... AN EDITOR'S COMMENTARY

Digital ICs eye markets where analogs fall short

Maria Dekany
Technical Editor

Digital integrated circuits are beginning to cost less than the phone call that places the order. In addition, clever fabrication is shrinking their size every day by putting more circuits on a chip.

The advantages of low cost and small size are enticing engineers to find new uses for digital ICs. Attention is now turning to functions previously performed by analog components. The basic intent is to realize analog transfer functions with some sort of incremental process that can be performed with digital integrated circuits.

Digital ICs will permanently claim some areas now in the domain of analog devices, despite the phenomenal advances of linear microcircuits (see "Tiny exploding world of linear microcircuits," ED 15, July 19, 1967, p. 49 ff.). Besides the cost advantages, the digital approach sometimes offers performance characteristics that cannot be matched with linear devices—at least not with those available now. But even if linear microcircuits improve significantly in performance and cost, some trouble spots such as drift seem to be inherent in analog elements.

"Analog" functions, as referred to here, are continuous or, at worst, piecewise continuous. In the usual design analysis, these signals, or functions, are decomposed into their Fourier-series components in the frequency domain. The analog system that operates on these components is characterized by its transfer function in the frequency domain, $H\ (j\ \omega)$.

Digital signals are discrete, and are therefore more conveniently described in the time domain. The data appear as bits, one after another. The digital system that operates on this sequence of bits assigns some degree of significance to each bit; in short, it weights the input data.

The link between the two approaches—analog and digital—is a transfer function of a numerical operator, which meets a specified response characteristic in the frequency domain, and accounts for the quantization process of the digital operation.

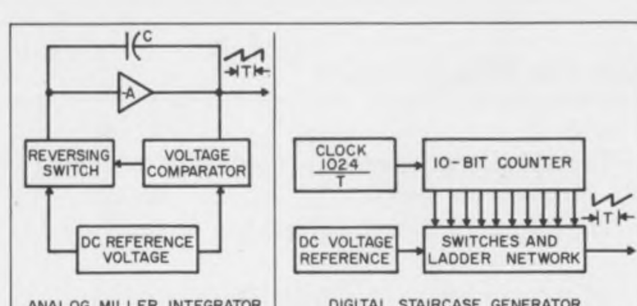
Analog networks are troubled by frequency and phase distortion. They also often need compensation for possible instability. Digital circuits, on the other hand, suffer from quantizing errors and round-off errors. But these digital system errors can be limited to a large degree, without much added complexity.

These two points indirectly help to answer the question of linear integrated circuits. Even if linear ICs were available at comparable costs, these fundamental error sources would still exist in analog circuits. In addition, digitalized systems share other advantages:

- **Digital systems are more accurate than analogs,** and their accuracy is predictable. Their precision depends on the controlling crystal clock and on the word length.

- **They don't have the component tolerance problems that plague analog designs.** In high-order filters, for example, the analog approach needs many, and very accurate, capacitances and inductances, which are expensive. In addition, their stray reactances still cause special problems.

- **Some functions cannot be approximated to any useful degree with analog systems.** An



Analog and digital versions of precision integrator.

averaging filter with a sharp, steep window can only be built by the digitalized approach—analog R-C types have a long "tail."

- **There is no dc drift.** The lack of dc drift with the digital approach makes possible systems like precision integrators.

- **With a little experience, the designer can avoid the breadboard stage,** which is imperative in most analog circuits. He may run into debugging problems in the software, but the cost is still generally less.

All of these "digitalized" systems may be called computers, but the name is misleading in a certain sense. Most engineers hearing the word "computer" envision a huge, all-purpose monster, which must be talked to in a special language and which, after some mysterious happenings inside, spews out answers on tons of paper or on cards with little holes.

But these "computerized" approaches can be grasped without extensive background in computer design and software, and the solution is usually in the form of an electrical response. For example, digitalized filters provide the same frequency-vs-gain-response curves as analog types (after a D/A conversion, of course).

The idea of a digitalized approach to analog functions is not new. Integration and differentiation with digital computers were worked out on paper some time ago. Simple transfer functions like $1/s$ and $1/(s + a)$ were shown to be realizable with digital circuits. But at that time the necessary hardware for widespread design was not available. Large-scale integration had to come along first before digitalized techniques could compete meaningfully with conventional analog techniques. A two-pole digitalized filter, for example, may need up to 40 to 50 flip-flops. With discrete components, it would mean just as many cans resulting in an expensive and large system. Now two flat packs can do the job, at reasonable cost.

A typical example of LSI is a MOS array for multiplication which contains 123 devices on a 0.049-in.-by-0.55-in. chip.

Familiarization with these techniques may take some time for engineers, but the rewards are worth it. Imagine working without large capacitors at very low frequencies. Or getting long sweeps with errors less than 0.1% with a couple of flat packs. There is no need for careful component selection and testing, to keep the dc and component drift within bounds; no dielectric saturation of the sweep capacitor; there are no transients, and no hysteresis effects.

Integrator has better accuracy

Consider, for example, a typical case when digital techniques offer definite advantages, according to an analysis performed at RCA Aerospace Systems Div., Burlington, Mass.—a precision integrator. This sweep function is basic in many radar operations and sweep accuracy is a prime criterion.

The analog Miller integrator and its digital version are shown in the sketch below. If the required tolerances of the time constant must be better than 5% in periods exceeding 1 second, the capacitances become very large in the analog system. Maintaining 5% accuracy with a digital system in a small package is well within reach. The main sources of errors are the resistors in the ladders, the voltage reference and quantization errors, that can be kept within bounds easily. The attractiveness of the digital system is further increased by the fact that the several hundred gates needed to perform the function of the operational amplifier can be obtained in a single chip.

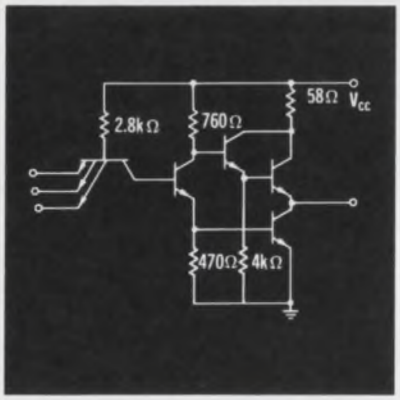
Engineers at Collins envision a digitalized filter-computer that can be placed in the front end of a receiver.

By pushing a button on its control panel, the engineer can select the frequency of interest in the incoming signal and reject all others. The filter would have zero attenuation at the frequency of interest and infinite attenuation at all others; thus finally making the ideal filter a reality. Tuning may be accomplished by changing the delay in a subroutine of the computer that performs cross correlation between the incoming signal and the stored information. This computing filter could be placed right up at the receiver, in front of the mixer and amplifier stages.

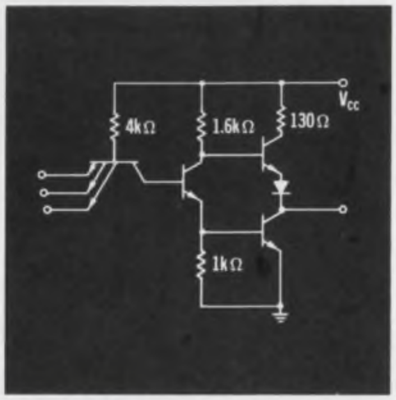
These examples are only a few of the cases where the digital approach is gaining ground. Do you know of some other design problems that would warrant this approach? If you do, why don't you give us a call, or drop us a note, to talk over your idea? "The Digital Approach to Analog Functions" is the theme of WESCON's technical session No. 10 on Thursday morning, August 24, sponsored by ELECTRONIC DESIGN. We will publish a special report on this field in our September 1 issue that will examine the mathematical design tools and trace the design of several widely applicable circuits, such as ramp generators, filters and sine-cosine generators. We welcome any follow-up articles—pro or con. ■ ■

23 new TTL circuits from TI

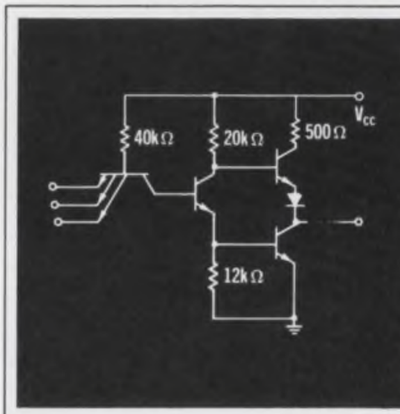
Series 54/74 features three levels of speed and power dissipation



Typical Characteristics	Gate	Flip Flop
Propagation delay	6 nsec	17 nsec
Power dissipation	22 mW	80 mW
Noise immunity	1 V	1 V
Fan-out		
Standard loads	12	12
High-speed loads	10	10



Typical Characteristics	Gate	Flip Flop
Propagation delay	13 nsec	40 nsec
Power dissipation	10 mW	60 mW
Noise immunity	1 V	1 V
Fan-out	10	10



Typical Characteristics	Gate	Flip Flop
Propagation delay	33 nsec	47 nsec
Power dissipation	1 mW	3.8 mW
Noise immunity	1 V	1 V
Fan-out		
Standard loads	1	1
Lower-power loads	10	10

16 Series 54H/74H high speed circuits feature 6 nsec propagation delay

This line offers the highest speed available in saturated logic . . . six nanoseconds per gate. Applications include critical portions of digital systems such as high speed computation and data processing sections.

Series 54H/74H circuits may also be combined with standard and low-power TTL circuits in a single system . . . giving you the advantage of speed where it is required while keeping system power consumption low.

Sixteen circuit functions include AND gates as well as NAND so you can design simpler less costly systems.

Circle 210 for data sheets.

27 standard Series 54/74 circuits include 3 new devices for added versatility

Standard Series 54/74 integrated circuits offer a combination of speed and power dissipation best suited for most applications. When used with the new high-speed and low-power circuits, they provide today's system designer with unprecedented flexibility . . . in selecting speed and power requirements.

Twenty-seven circuits are offered in the standard line, including many complex-function devices that perform up to forty gate functions. These complex-function circuits enable you to cut costs while simplifying system design and improving reliability.

Circle 211 for data sheets.

New series 54L low-power circuits feature 1 mW per gate power drain

This line of four circuits features power requirements less than one-tenth that of standard circuits . . . yet speeds are approximately twice as fast as other circuits with similar power dissipation.

TI's Series 54L/74L circuits are specifically designed for space systems, avionic systems and other applications where power consumption and heat dissipation are critical. They may be combined with standard and high-speed Series 54/74 circuits to provide almost any desired speed/power dissipation combination the system designer requires.

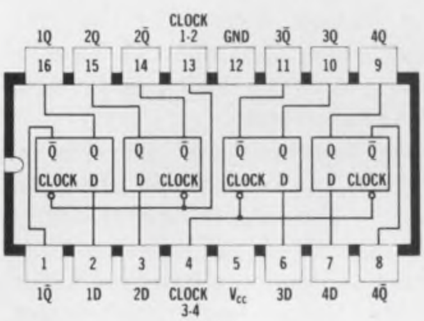
Circle 212 for data sheets.

New standard-line additions reduce cost, improve performance of systems using Series 54/74 TTL

With three speed ranges, three power dissipation levels, two lead arrangements, two packages, and two temperature ranges, TI's Series 54/74 family of 47 TTL integrated circuits is industry's most versatile and complete logic line. All circuits use the same 5 Volt supply voltage and all use the same familiar TTL design rules.

Here are three new additions to the standard line that open the way to further cost reductions and improvements in performance.

SN7475 quadruple bistable latch replaces four flip flops



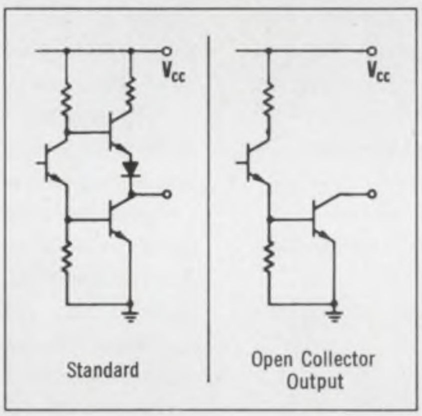
This specialized circuit was designed for readout tube applications. When used with the SN7490 decade counter and the SN7441 decoder/driver, the SN7475 will enable you to realize substantial savings in overall system costs.

This latest addition to TI's growing group of complex-function circuits features a propagation delay of 30 nanoseconds. Power dissipation is 40 milliwatts per latch.

Circle 213 for data sheet.

SN5401 NAND gate features open collector output for "Wire-OR" logic

This circuit enables designers to employ the economical "Wire-OR" logic function to simplify system designs. With the open collector output, the "collector-OR" function is built-in, permitting outputs to be connected directly.

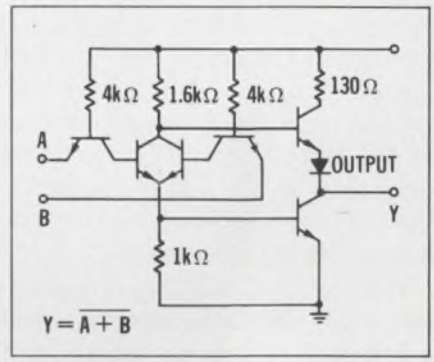


Before this circuit was developed, "Wire-OR" logic could only be used with DTL and RTL circuits. Now system designers can take advantage of this simplification and still benefit from the speed, economy and noise immunity of TTL.

Circle 214 for data sheet.

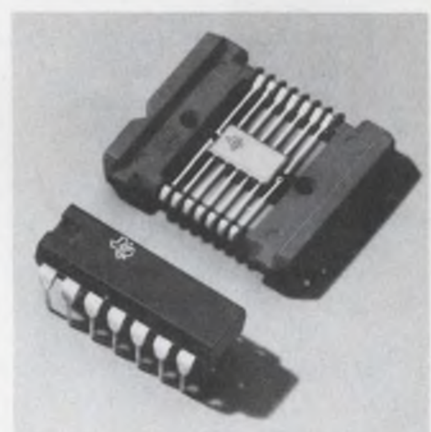
SN5402 NOR gate reduces package count and propagation delays

Here is a quadruple 2 input NOR gate that performs the "Not-OR" logic function directly. It eliminates the need for three or four NAND gates, making possible a 100 percent speed improvement as well as a 67 percent reduction in gate count.



Designers may use the SN5402 with other Series 54/74 circuits . . . including complex-function types . . . to reduce overall system costs significantly below that possible with any other logic types.

Circle 215 for data sheet.



No other high-performance IC family is as complete, versatile and economical as Series 54/74 TTL from Texas Instruments. For more information, contact your nearest TI field sales engineer or authorized distributor, or write P. O. Box 5012, Dallas, Texas 75222.

TEXAS INSTRUMENTS
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Switch high loads with power transistors

by knowing all about secondary breakdown, device selection, and methods of analysis and design.

How many engineers can design a power switching circuit for inductive loads, breadboard it, and then cut in the supply and put it through its operating cycle with complete confidence? There are a few, but most of us would have some qualms once the test data began to call for higher device ratings. More than once a puff of smoke from a power transistor has been sad and belated evidence of a minor oversight in the calculations.

This detailed analysis of power switching circuit design and device selection is the outcome of a study undertaken to put an end to such situations. The need was to switch high-inductive currents (tens of amperes) in a dc motor armature control system for tape drives.

To explain the behavior of these switching circuits fully, these areas were explored:

- Germanium vs silicon devices.
- Mechanism and prevention of secondary breakdown.
- Explanation of power transistor specifications given by manufacturers.
- Detailed design examples.
- Heat sink considerations.

Selecting the power transistor

The power circuit designer must first choose the transistor most suitable for his requirements. Two important criteria are maximum current and voltage. Maximum current can be defined as the largest current that the transistor must handle before the gain falls below some specified value. Maximum voltage is the largest reverse voltage that can be applied across each junction before breakdown occurs. Pnp germanium transistors are generally capable of handling much higher currents than npn silicon transistors, but the breakdown voltages of the npn devices are larger than those of equivalent pnps. Table 1 shows the representative relative capabilities of these devices.

Another important design consideration is the maximum power that will be dissipated. The maximum power rating of the device is a function of the junction temperature. In general, germanium transistors operate safely with a junction temperature of 100° C; silicon devices can tolerate temperatures up to 150° C. The higher junction temperature of silicon devices does not mean, however, that their dc current capability is higher than that of germanium devices. Rather, the reverse is true, because the junction saturation voltages in silicon devices are often twice as large as those in germanium devices for the same chip size. Typical values are shown in Table 2. Thus, a silicon npn device with a 50 per cent higher power rating than a germanium pnp unit may have an over-all lower dc current capability.

The leakage currents for silicon devices are considerably lower than for pnp devices. Typical values are shown in Table 3.

Leakage current is temperature-dependent and approximately doubles for every 10° C rise in junction temperature for Ge and 7° C rise for Si. So at 100° C the collector leakage current for the germanium devices may exceed 150 mA. This could seriously affect current-sensitive loads, and cause excessive dissipation in the off state.

Reverse-biasing the base-to-emitter junction to prevent such conduction can be difficult when the emitter is referenced to the largest circuit supply available. One way to put the device into a nonconducting state is to short-circuit the base-to-emitter junction. However, the leakage current is greater for a short-circuited base-to-emitter junction (I_{CES}) than for a reverse-biased junction (I_{CEX}). This is because collector leakage current flowing in the base lead produces a transverse voltage drop in the base region. The transistor may become forward-biased and cause the leakage current to increase significantly. At low temperatures, this voltage drop may be tolerable, but higher temperatures cause larger leakage currents.

Henry S. Smith, Associate Engineer, IBM, Systems Development Div., Poughkeepsie, N. Y.

Table 1. pnp and npn comparison.

	npn (Si)	pnp (Ge)
Max dc current	30 A	60 A
Max reverse voltage (BV_{CEO})	120 V for a 30-A device	60 V for a 60-A device

These values do not include special devices such as 750-V, 2-A npn units.

Table 2. npn—pnp sat. voltages.

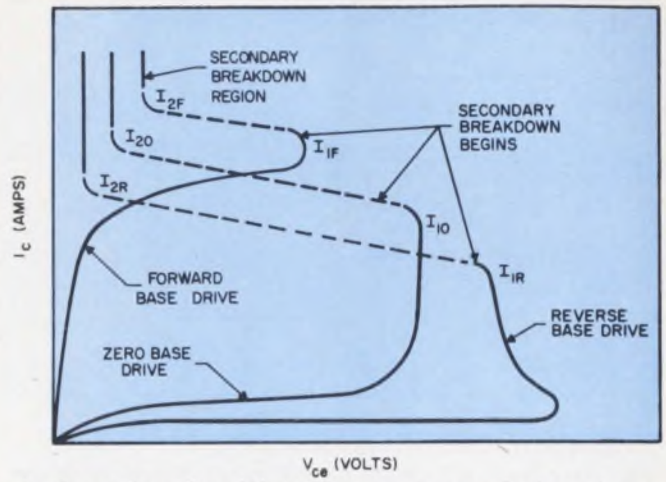
	npn (Si)	pnp (Ge)
$V_{BE\ sat}$ at 15 A	1.5 to 3.0 V	0.5 to 1.5 V
$V_{CE\ sat}$ at 15 A	0.7 to 2.5 V	0.2 to 0.4 V

Table 3. npn-pnp leakage currents.

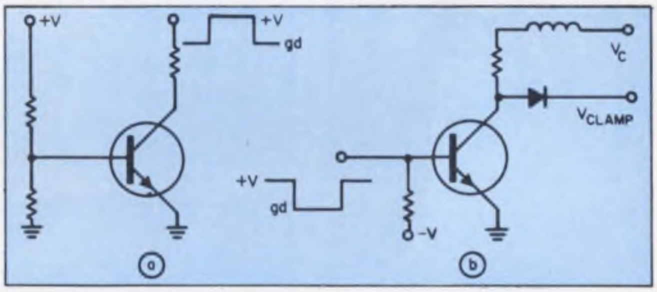
	npn at T = 100°C	pnp at T = 55°C
	$V_C = +80$ V $V_{BE} = -1$ V	$V_C = -80$ V $V_{BE} = +1$ V
Leakage Current (I_{CEX})	100 μA	10 mA

Table 4. Ge and Si devices.

Transistor	Advantages
Ge (pnp)	1. Lower cost. 2. Higher current capability. 3. Lower V_{BE} and V_{CE}, saturation voltages.
Si (npn)	1. Higher junction temperature. 2. Lower leakage currents. 3. Can be turned off without reverse bias. 4. Higher breakdown voltages.



1. **Secondary breakdown** can occur at various base-drives and is energy-dependent.



2. **Secondary breakdown testing** can be done either by applying a pulse to the collector through a current-limiting resistor (a), or by applying a pulse to the base of a transistor (b) and switching off an inductive load.

The net result is a greater voltage drop across the base resistance and more forward bias to the device. Usually this will not be a problem with silicon devices because of their lower leakage currents and the higher base-to-emitter forward voltages needed for conduction. But, a germanium device may actually go into a conducting state when its junction is short-circuited. For this reason a germanium transistor should not be used if a reverse bias is not available.

Besides the electrical characteristics, the price of the device will influence the choice. Pnp devices are now considerably cheaper than comparable npn devices; where 30 A npn prices range from $25 to $50, a 60 A pnp sells for $4 to $10. The relative merits of silicon and germanium devices are compared in Table 4.

Understand secondary breakdown

After choosing the transistor, the designer faces problems not normally encountered in low-power circuit design. The biggest is that of secondary breakdown, which is usually the result of switching inductive loads. Because secondary breakdown is normally a catastrophic failure and does irreparable transistor damage, the causes and solution of the problem must be thoroughly understood. Often secondary breakdown can be avoided only by external modification of the circuit to shift the load line.

Secondary breakdown is a condition that makes the transistor output impedance change instantaneously to a small positive value. This is shown in Fig. 1 for various base-drive conditions.

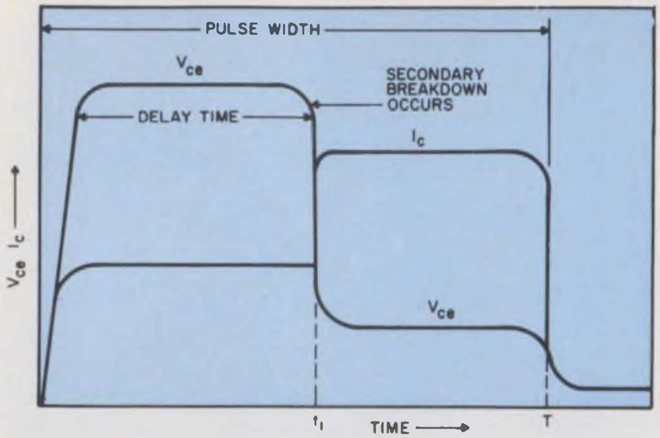
The most obvious characteristic of secondary breakdown is an abrupt decrease in collector-to-emitter voltage and an increase in collector current. It is similar to avalanche breakdown* with two exceptions:

- The final limiting voltage is much less than the avalanche condition.
- Secondary breakdown seems to be energy-dependent.

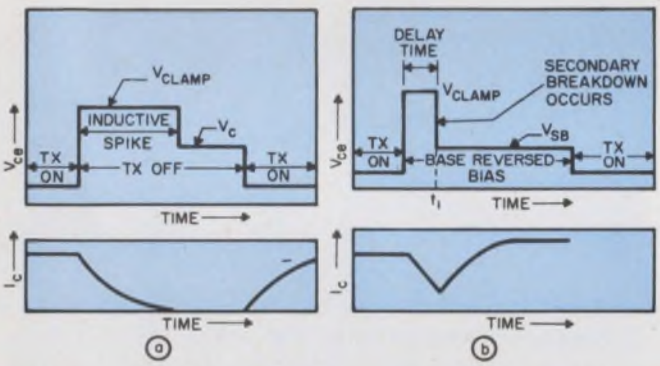
Testing for secondary breakdown

Two pulse methods can be used to observe secondary breakdown. One is to apply—under the desired forward base-drive conditions—a rectangular voltage pulse to a current-limiting resistor in series with the collector of a transistor, as in Fig. 2a. The other method is to apply a rectangular voltage pulse

*Negative resistance region where large changes in current accompany small changes in applied voltage.



3. **Secondary breakdown occurs** at t_1 in the circuit of Fig. 2a during a forward base-bias condition. Note the drop in voltage and jump in current.



4. **Switching an inductive load** with the circuit of Fig. 2b with no secondary breakdown results in waveforms (a). Voltage and current waveforms during the secondary breakdown are shown in (b).

5. **Results of secondary breakdown** are seen on an npn silicon chip. The damaged area is indicated by the arrow.

to the base and to switch off an inductive load in series with a current-limiting resistor, as in Fig. 2b. In both cases, the collector voltage and current are monitored as a function of time.

Figure 3 shows secondary breakdown occurring at t_1 during a forward base-bias condition. The waveforms correspond to those that would be observed at the collector of the circuit in Fig. 2a.

Figure 4a shows the normal waveforms that would appear at the collector of the circuit in Fig. 2b when no secondary breakdown occurs.

Figure 4b shows secondary breakdown occurring at t_1 during a reverse base-bias condition. The waveforms are what would be observed at the collector of the circuit in Fig. 2b.

What causes secondary breakdown?

In both pulse methods, there is always a delay time before the collector voltage decreases and the collector current increases. Hence the theory that the transistor must dissipate some energy before secondary breakdown can occur. Some portion of the transistor must therefore reach a critical temperature before the process is started. Physically, then, secondary breakdown appears to be caused by a local thermal runaway induced by severe current concentrations. These current concentrations may be caused by:

- Defects in the transistor structure.
- Application of a reverse base drive.

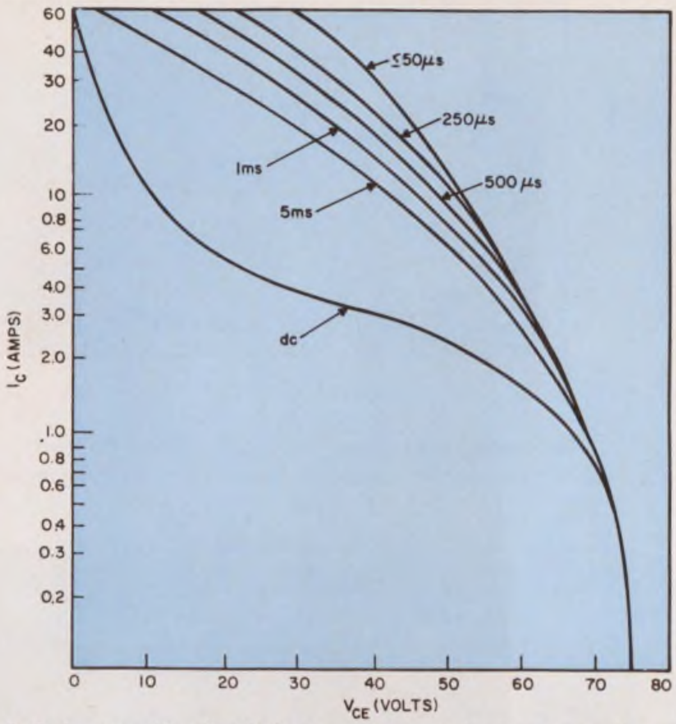
That is, when the base current is flowing in the reverse direction, potential gradients may reverse-bias the periphery of the base but forward-bias its center. The injected current from the emitter flows in a small area toward the center of the base and causes a concentration of current.

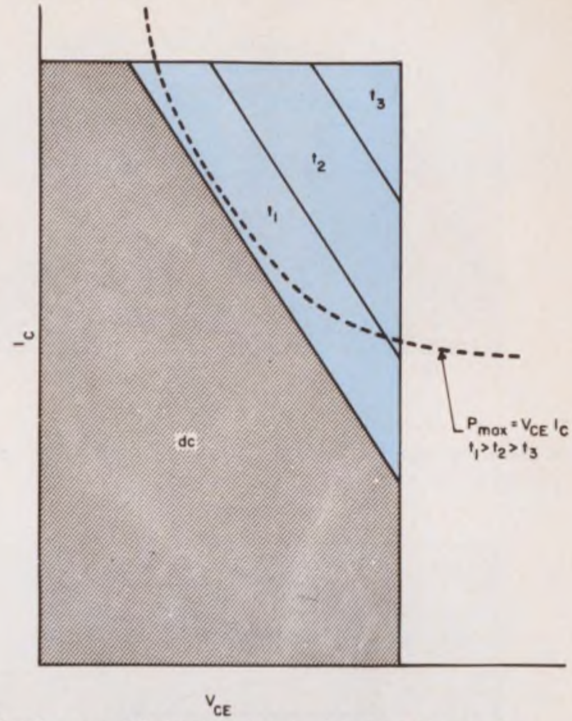
The high current density increases the temperature of the area; the temperature increases the current. The condition, if allowed to continue, will result in a local thermal runaway. This will usually cause a collector-to-emitter short circuit or alter the transistor characteristics, such as lowering the device's BV_{CEO}. The magnified view of an npn silicon transistor chip after secondary breakdown in Fig. 5 shows the destruction of the emitter due to a concentration of current in a small area (the arrow indicates this area). When tested, the transistor was found to have a typical collector-to-emitter short circuit.

Manufacturers will usually supply safe-operating-area curves that indicate the energy (I_C x V_{CE} x t) limits below which the device will not go into secondary breakdown. Two examples of such curves are given in Fig. 6.

Switching inductive loads

Since secondary breakdown occurs most often when





6. **Safe operating limits** for a power transistor are usually specified by the manufacturers in graphs like these two.

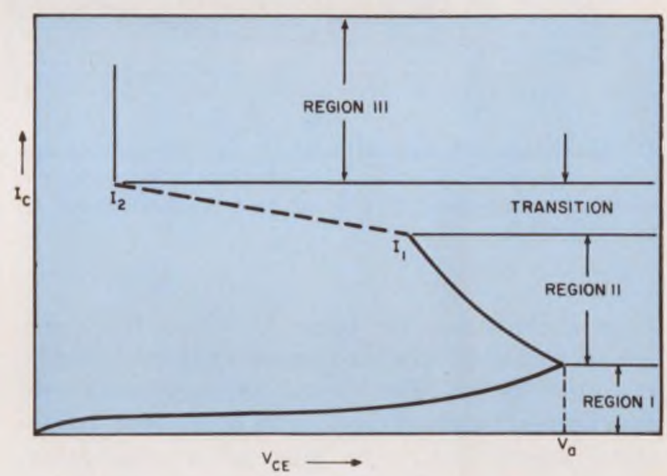
switching inductive loads, this area will be examined in detail. Figure 7 shows the characteristic output curve of a transistor when the base is reverse-biased.

In Region I, the transistor is cut off and has a high resistance. At voltage V_a, the transistor exhibits a negative resistance (avalanche breakdown condition). When the current reaches I_1, a sharp breakdown occurs, and the characteristics jump into Region III, the low-positive-resistance region. This is referred to as the second breakdown. If reduced, the current jumps back into Region II at the point $I = I_2$.

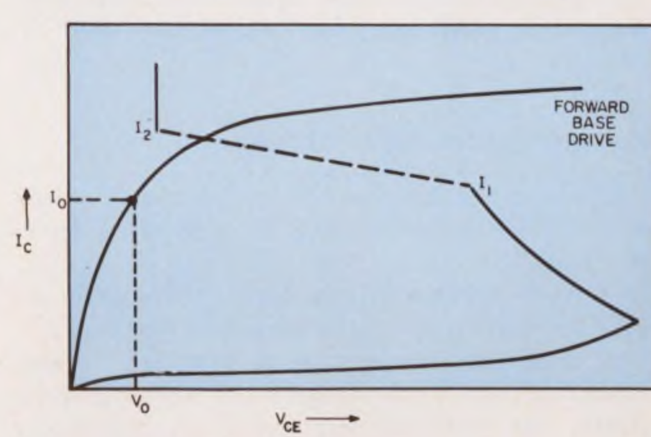
On the same set of curves, the forward-bias output characteristic of the transistor can also be plotted (Fig. 8). I_0V_0 is the quiescent operating point of the device. Point I_0 is below breakover point I_2. If the transistor is suddenly reverse-biased and switches off an inductive load, the turn-off path will resemble that in Fig. 9.

The turn-off path will depend on the L/R time constant of the load and transistor, and the amount of energy that was stored in the inductor. The initial jump in voltage occurs because the inductor current cannot change instantaneously. For the case shown in Fig. 9, no transistor damage occurs if the turn-off path is within the safe operating area. With a different turn-off path, as in Fig. 10, the energy stored in the inductive load is so large that the initial jump in voltage causes the turn-off path to hit the negative-resistance region. If the energy delivered by the inductor is greater than the maximum energy that can be dissipated by the transistor, the device will be destroyed.

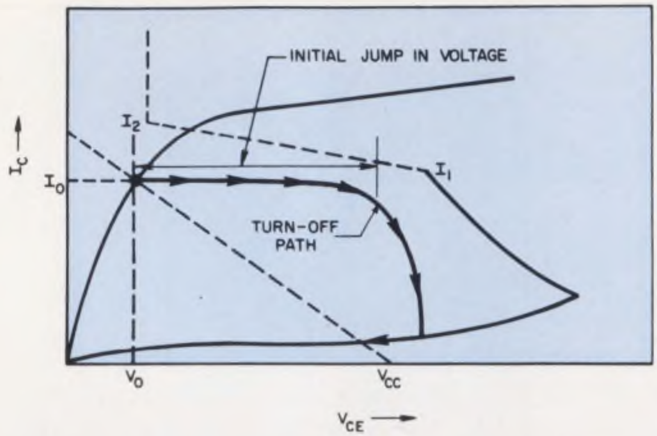
A second condition that can cause catastrophic failure appears in Fig. 11. In this instance, point



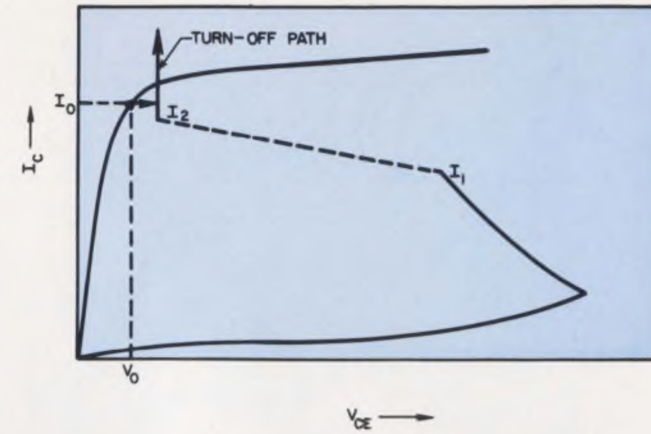
7. **Characteristic output curve** of a power transistor with base reverse-biased pinpoints safe operating areas.



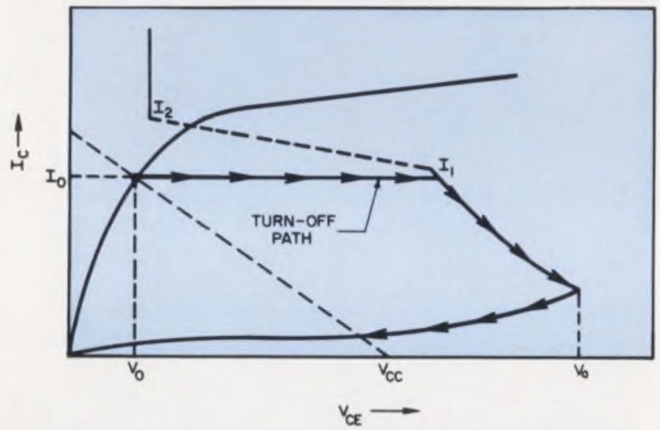
8. **Characteristic output curve** with base forward-biased, superimposed on the curves of Fig. 7, shows the relationship of two biasing modes to the secondary breakdown current value.



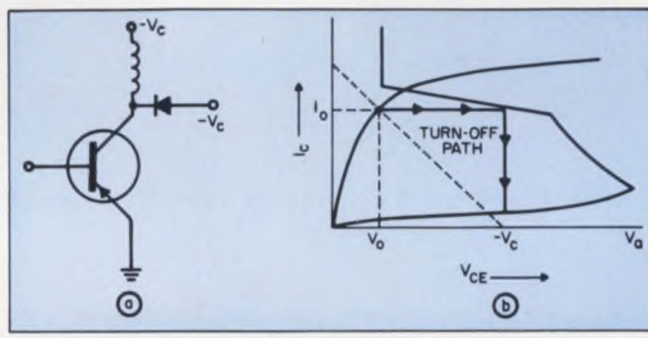
9. **Safe turn-off path** for an inductive load must lie within the forward- and reverse-biased curves.



11. **Secondary breakdown** will occur during the turn-off when the quiescent current I_0 is near the positive resistance region.



10. **Maximum safe turn-off path** follows the reverse-bias curve. If the energy delivered by the inductive "kick" exceeds the transistor dissipation, the transistor will be destroyed.



12. **Diode clamping** (a) prevents secondary breakdown in switching an inductive load (b).

I_0 is above breakover point I_2. When the transistor is turned off, the load line hits the low-positive-resistance region. The current then increases until it is limited by the dc resistance of the load. In this state, energy dissipation may again cause transistor destruction. The higher the limiting voltage in the negative-resistance region, the more rapid the transistor destruction. And in any case, destruction will usually result in a collector-to-emitter short circuit.

Preventing secondary breakdown

How can the designer prevent secondary breakdown? The simplest method is to choose a device that has:

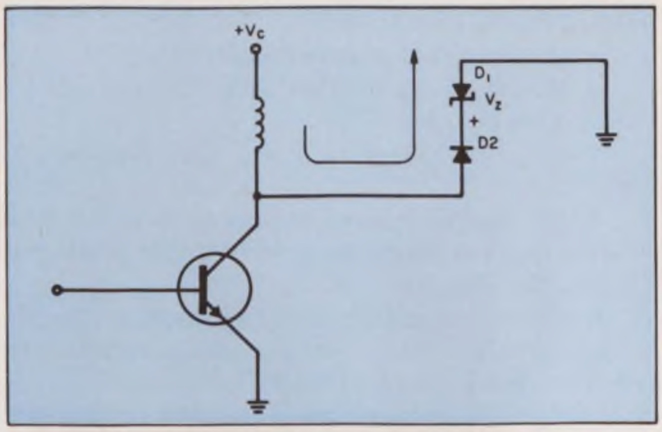
- An I_2 breakover point higher than maximum collector current I_0 at the maximum temperature. The maximum temperature is specified because breakover point I_2 decreases with increasing temperature. At room temperature, I_2 may be above I_0, but at maximum junction temperature, I_2 will have fallen below I_0 and will cause the transistor to be destroyed when it is turned off.
- A large enough first breakover point V_a for the inductive load line not to hit this part of the characteristic. This point is also temperature-dependent and will move to the left with increasing temperature.

Either of the above criteria can be used in choosing a device to fit the application. They may not always be feasible, however, and an external-load-line modification—such as a conventional diode clamp, Zener diode clamp, capacitor-resistor network, or paralleling devices—may be necessary to protect against secondary breakdown.

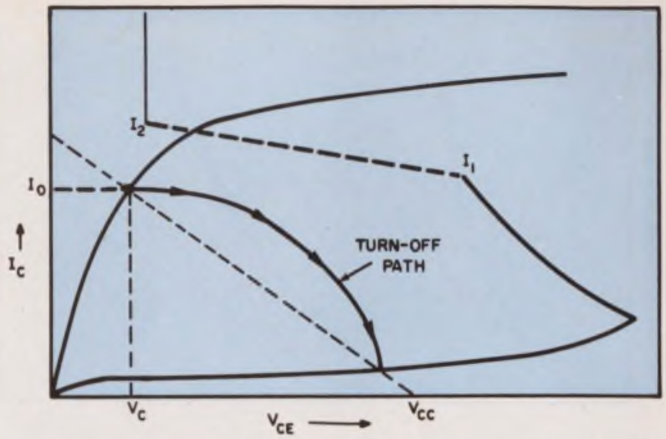
Figure 12a illustrates the simplest of these techniques. A diode is connected from the collector to voltage $-V_C$. The turn-off path never reaches the negative resistance region if $-V_C$ is less than the avalanche breakdown voltage. The turn-off path resembles that in Fig. 12b. When the transistor is on, the diode is reverse-biased and has no effect on circuit operation.

Although the voltage is clamped to $-V_C$, the turn-off path may still be outside the safe operating area and the transistor may go into secondary breakdown. One method to correct this is shown in Fig. 13.

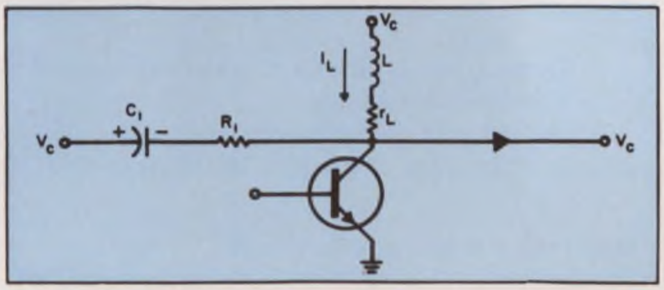
Zener diode *D1* and conventional diode *D2* are series-connected from the collector to ground. When the transistor is turned off, the collector voltage will be clamped to V_Z, the Zener breakdown voltage which is usually considerably less than $+V_C$. The



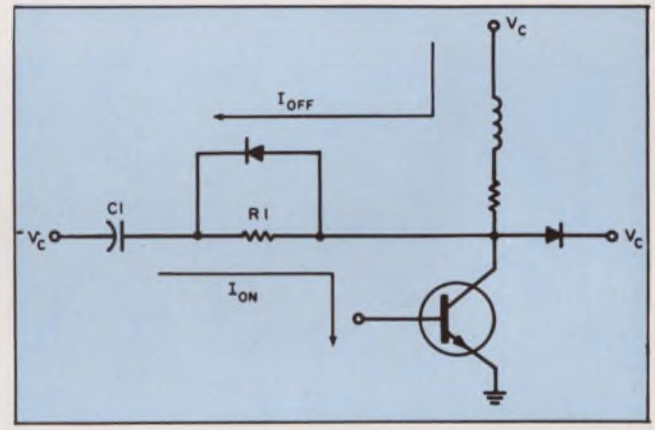
13. **Zener-diode clamping** reduces the possibility of the secondary breakdown even further.



15. **Turn-off path** for the RC network of Fig. 14 is well within the safe limit.



14. **An RC network** can also be used to prevent the secondary breakdown where the energy dissipated during the turn-off is too high for the transistor involved.



16. **Quick transfer of energy** from the inductive load into the capacitor can be enhanced by a shunting resistor with a diode due to its very low forward resistance which is used in this mode.

conventional diode prevents any current from flowing in the forward direction through the Zener diode when the transistor is on. Since the turn-off voltage has been reduced, a smaller amount of power is dissipated, and the transistor can safely operate in this region for a longer period of time.

In many cases it is impractical to use a Zener diode or the energy dissipated during turn-off may still be too high for the transistor involved. Then an *RC* network may be placed in the collector circuit (Fig. 14).

During the time the transistor is conducting, *C1* will charge to a voltage $V_C - V_{CE}$. The inductor will be conducting a current I_L. When the transistor attempts to turn off, the current through the inductor and the voltage across the capacitor cannot change instantaneously. Current I_L will be used to discharge *C1* and the collector-to-emitter voltage will not reach V_C until the capacitor has completely discharged. This turn-off path is shown in Fig. 15. *R1* limits the collector current during turn-on and determines how long it will take *C1* to charge to $V_C - V_{CE}$.

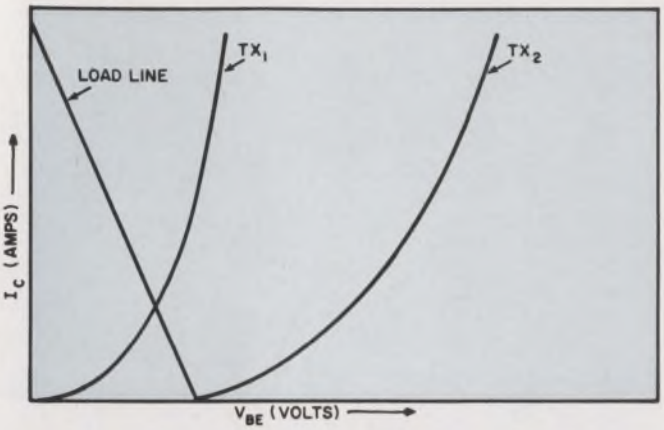
It is possible to bypass *R1* during turn-off by placing a diode across it (Fig. 16). *R1* still limits the turn-on current, but it is shorted by the diode during turn-off. The values of *R1* and *C1* can be chosen so that the turn-off path falls inside the safe operating area.

If the maximum collector current is so large that none of these methods will protect the transistor, it is necessary to parallel two or more transistors. This reduces the collector current that each device will have to handle. At first sight, one might expect the current to split equally between the two devices. This is not so. Transistors of the same type do not always have identical characteristics and may not accept equal portions of the load. It may even be possible for one of the transistors to carry the entire load. This can readily be seen from the I_C-vs-V_{BE} curves of the devices as in Fig. 17.

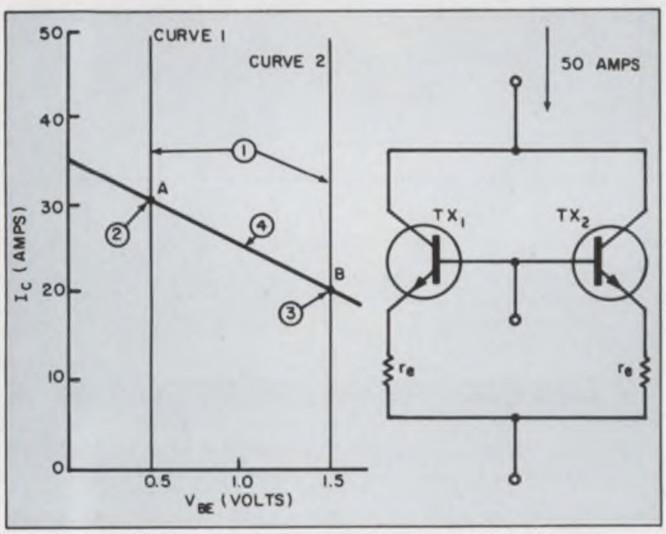
Owing to the spread of the V_{BE} characteristics, one transistor may be fully on while the other is off. This is because TX_1 clamps the base-to-emitter potential to a value below the knee of the characteristics of TX_2. A small resistor should be placed in the emitters of both transistors, to compensate for the variations in the characteristics. The value of the resistor will depend on the desired ratio of current-sharing. A numerical example demonstrates a graphical solution to determine the resistor value.

How to parallel power transistors

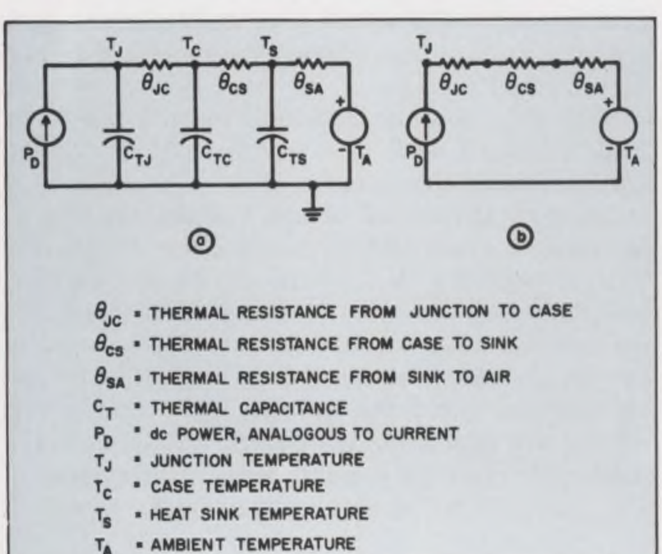
Emitter resistors for parallel transistors are to be



17. **In paralleling two power transistors,** differences in the I_C-vs-V_{BE} characteristics may result in one transistor carrying all the load, unless some compensation is provided.



18. **Dividing the load current** between two transistors involves selecting the proper emitter resistors (see text).



19. **Electrical analogs** of general (a) and steady-state (b) thermal models of a transistor pinpoint all the parameters involved in calculating transistor power dissipation.

chosen for these conditions:

- Maximum total current equals 50 A.
- Maximum current that each device is capable of handling is 35 A.
- $V_{BE\,sat}$ is guaranteed to fall between 0.5 and 1.5 V.
- The desired current-sharing ratio is 3:2. This means that the maximum current either device will have to handle is 30 A.

The procedure is as follows (see steps in Fig. 18):

1. Plot the ideal I_C-vs-V_{BE} characteristics for the best- and worst-case device.
2. Mark the point on curve 1 that corresponds to 30 A (point *A*). This is the maximum current that one device has to handle.
3. Mark the point on curve 2 that corresponds to 20 A (point *B*). This is the current that the other device has to carry.
4. Connect points *A* and *B* with a straight line. This is the emitter load line.
5. The value of the emitter resistor will equal the inverse of the slope of the line. In this case $r_e = 0.1\Omega$.

Understand device power ratings

For a complete understanding of power transistors, the designer must know how to interpret and use the device power ratings. These include maximum steady-state and peak power, and maximum junction temperature.

The average or steady-state power dissipated in a transistor is:

$$P_D = I_B V_{BE} + I_C V_{CE}, \tag{1}$$

which is the sum of the base and collector power. This expression can be better understood by writing it as the sum of the power dissipated in each junction:

$$P_D = V_{BE}(I_B + I_C) + V_{CB}(I_C). \tag{2}$$

If an analogy between heat and current is made, then an equivalent thermal circuit can be drawn for any transistor (Fig. 19a). (The values used in this figure will be used throughout the analysis.)

In the steady-state condition (C_T=open circuit), the equivalent thermal circuit can be simplified to look like that in Fig. 19b. The total thermal junction-to-air resistance is:

$$\theta_{JA} = \theta_{JC} + \theta_{CS} + \theta_{SA}. \tag{3}$$

The steady-state or dc junction temperature can be calculated as:

$$T_J = P_D \theta_{JA} + T_A. \tag{4}$$

If the maximum allowed junction temperature, T_J, is specified (100°C for germanium and 150° for silicon), the maximum allowable dc power can be found from:

$$P_{D\,max} = (T_{J\,max} - T_A)/\theta_{JA}. \tag{5}$$

The formulas are somewhat more complex for the transient case because the pulse power dissipation effects now depend on the thermal capacitance as well as the thermal resistance. Before an attempt is made to solve for a repetitive power pulse, look at a single rectangular pulse of width t_1. Assume that there is an infinite heat sink.

This means that the case temperature is equal to the ambient temperature. The equivalent circuit and power pulse are shown in Fig. 20.

The junction temperature at the end of the pulse is:

$$T_J = T_C + P_p \theta_{JC} \left[1 - \exp(-t_1/\tau_{JC})\right], \quad (6)$$

where τ_{JC} represents the junction-to-case thermal time constant, which is equal to $\theta_{JC} \times C_{TJ}$. This can be defined as the time required for the junction temperature to rise to 63 per cent of its final value. τ_{JC} will usually be specified by the manufacturer. The term $\left[1 - \exp(-t_1/\tau_{JC})\right]$ is usually represented by $1/C_{PJC}$.

C_{PJC} is referred to by manufacturers as the transistor coefficient of power. The coefficient of power may be plotted (Fig. 21) as a function of the ratio of power pulse width, t_1, to the thermal time constant of the device, τ_{JC}, for a single nonrepresentative pulse.

From Fig. 21 it can be seen that, if the pulse width is less than approximately one-third of the time constant, the relationship between the coefficient of power and pulse width is almost linear. Thus, for the linear portion of the curve:

$$1/C_{PJC} \approx t_1/\tau_{JC}.$$

The same relationship may be obtained by expanding $\left[1 - \exp(-t_1/\tau_{JC})\right]$ into a power series:

$$\epsilon^{-t_1/\tau_{JC}} = 1 - \frac{t_1}{\tau_{JC}} - \left(\frac{t_1}{\tau_{JC}/2}\right) - \left(\frac{t_1}{\tau_{JC}/3}\right) - \cdots - \left(\frac{t_1}{\tau_{JC}/n}\right). \quad (7)$$

If t_1 is much smaller than τ_{JC}, the high-order terms in the series are insignificant and $\exp(-t_1/\tau_{JC})$ can be appromixated by $1 - t_1/\tau_{JC}$.

Therefore:

$$1/C_{PJC} = 1 - \epsilon^{-t_1\tau_{JC}} \approx 1 - (1 - t_1/\tau_{JC}) = t_1/\tau_{JC},$$

which is the relationship obtained from the curve, t_1/τ_{JC} can now be substituted into the expression for junction temperature. Equation 6 now becomes:

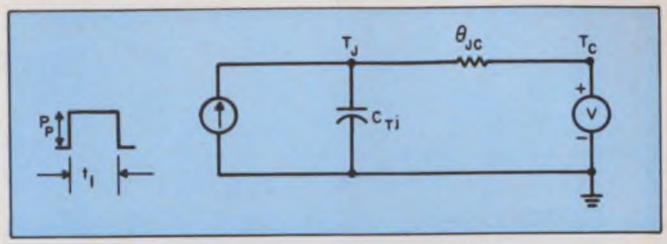
$$T_J = T_C + P_p \theta_{JC} t_1/\tau_{JC}. \quad (8)$$

The term $P_p t_1$ is equal to the energy contained in the pulse E_p so that the change in temperature, $T_J - T_C$, can be represented as:

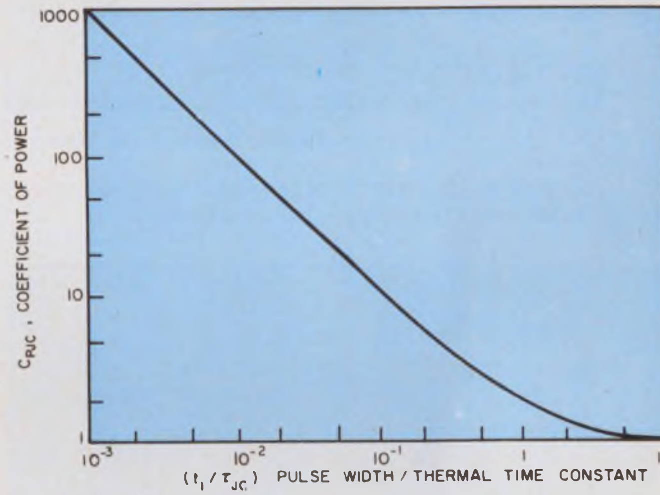
$$T_J - T_C = \theta_{JC} E_p/\tau_{JC}. \quad (9)$$

Equation 9 leads to an important conclusion. For short pulses, the change in temperature depends only on the total energy of the pulse, not on its shape. This means that the temperature change due to a narrow, irregularly shaped pulse could be calculated by integrating the area under the curve to get the total energy, E_p, and converting it to an equivalent rectangular pulse with the same energy. A good approximation for the original wave shape can be obtained by making the height of the rectangular pulse equal to the maximum amplitude of the original pulse. The width is then equal to the total energy divided by the height.

Now suppose that repetitive power pulses with



20. **Junction temperature of a transistor** in the case of a single applied pulse can be computed with this equivalent circuit.



21. **Coefficient-of-power characteristic** supplied by manufacturers can be used to calculate junction temperature for a simple nonrepetitive pulse.

period T and width t_1 are applied to the device, with an infinite heat sink. With the same electrical analog as for the rectangular pulse, the expression for the rise in temperature is:

$$T_J - T_C = P_p \theta_{JC} \left[(1 - \epsilon^{t_1/\tau_{JC}})/(1 - \epsilon^{T/\tau_{JC}})\right]. \quad (10)$$

This expression is obtained from linear network analysis by methods of steady-state responses to periodic excitations. The term $\{\left[1 - \exp(-t_1/\tau_{JC})\right] / \left[1 - \exp(-T/\tau_{JC})\right]\}$ now represents $1/C_{PJC}$ and C_{PJC} can now be plotted as a function of t_1/τ_{JC} for various duty cycles, as shown in Fig. 22. Once C_{PJC} is obtained from the curves, the equation for the change in junction temperature is:

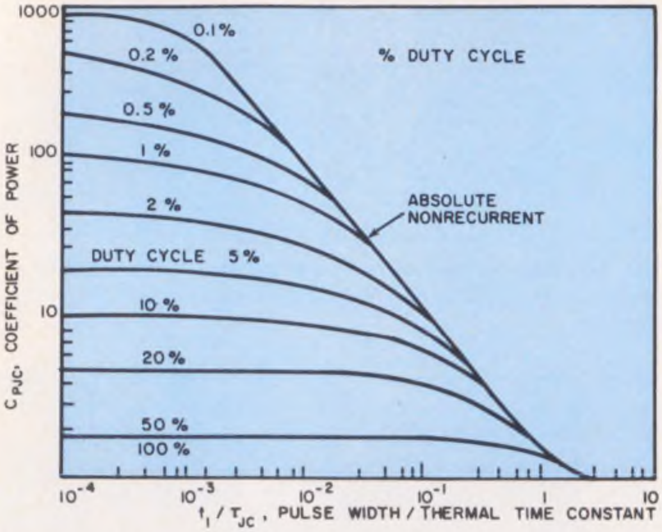
$$T_J - T_C = P_p \theta_{JC}(1/C_{PJC}),$$

and:

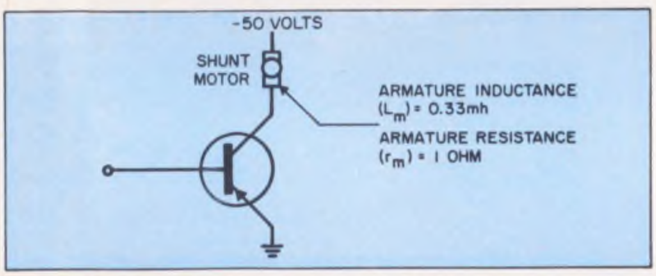
$$P_{max} = C_{PJC}(T_{J\,max} - T_C)/\theta_{JC}. \quad (11)$$

If there is no infinite heat sink, there will be some thermal resistance and capacitance between the case and ambient. Usually the thermal time constant of the case and heat sink is very large in comparison with the time constant of the transistor and the width of the applied pulse. The case-to-air coefficient of power, C_{PCA}, where $1/C_{PCA} = \left[1 - \exp(-t_1/\tau_{CA})\right] / \left[1 - \exp(-T/\tau_{CA})\right]$, can be approximated by T/t_1 for repetitive, short pulses (letting τ_{CA} approach infinity), and by τ_{CA}/t_1 for nonrepetitive, short pulses (letting T approach infinity).

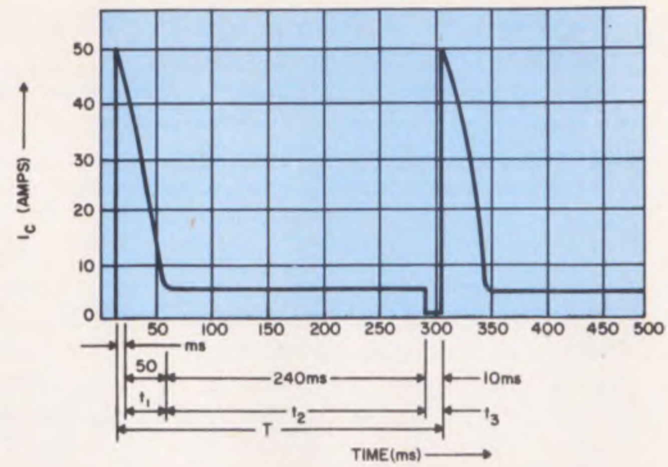
The rise in case temperature for short, repetitive



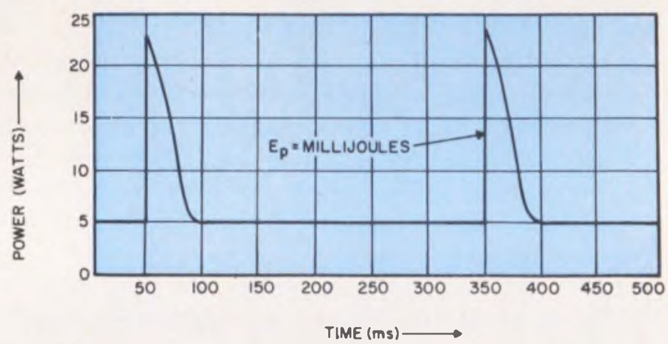
22. **Coefficient-of-power characteristic** for repetitive pulses takes into account various duty cycles.



23. **Practical motor switching circuit** can be made with a single power transistor. See text for design details.



24. **Transient and steady-state** collector current for the circuit of Fig. 23 shows this waveform.



25. **First step in the motor control circuit design** is to convert the current waveform of Fig. 24 into this power-vs-time plot.

pulses can be found on the basis of the case-to-air coefficient of power:

$$T_C = T_A + P_p \theta_{CA}/C_{PCA} = T_A + P_p \theta_{CA}/(T/t_1). \quad (12)$$

If this combined with the equation for maximum peak power for an infinite heat sink, Eq. 11, the result is:

$$P_{p(max)} = \left[T_{J(max)} - T_A\right] / \left[(\theta_{JC}/C_{PJC}) + \theta_{CA}(t_1/T)\right]. \quad (13)$$

This is the allowable peak power for a finite heat sink on the assumption of no steady-state power. Generally, however, there will be some steady-state power and this will reduce the amount of tolerable peak power. The steady-state power results in a certain junction temperature when no pulse power is present. This can be introduced into the equation by representing this steady-state junction temperature as an increase in ambient temperature. The peak power can now be calculated as:

$$P_{p(max)} = \frac{T_{J(max)} - T_A \ (\theta_{JC}/C_{PJC}) + \theta_{CA}(t_1/T)}{(\theta_{JC} C_{PJC}) + \theta_{CA}(t_1 T)} \quad (14)$$

It is very important to note that the peak allowable power is based solely on the maximum junction temperature that the transistor can tolerate. The calculated power value must be compared with the power values given in the safe operating area (Fig. 6). If the maximum temperature is exceeded, the transistor will go into secondary breakdown. Thus, both safe areas and allowable power limits must be observed when designing a power circuit.

Calculating maximum junction temperature

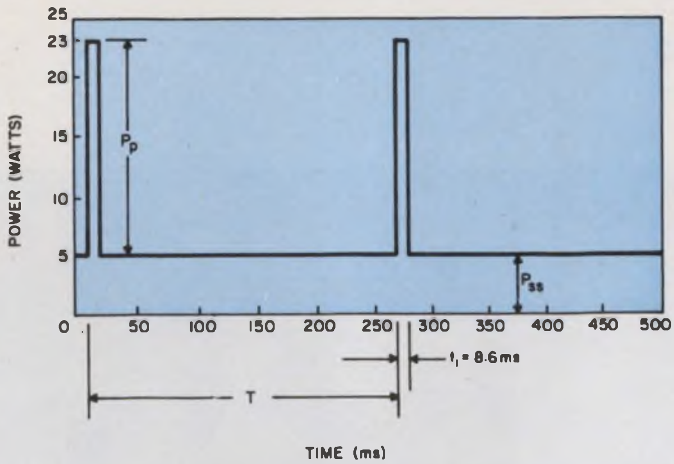
Suppose that a power transistor is being used to drive a dc shunt-field motor (see Fig. 23). The motor can be represented by an inductor in series with a resistor. When the transistor is turned on, the current will increase to a maximum of $50 - V_{CE(sat)}/r_m$ with a time constant L_m/r_m. As the motor speed increases, a back emf builds up and opposes the flow of current. The current decreases until the motor reaches its steady running speed. At this point, the current is equal to $(50 - V_{CE(sat)} - V_{emf})/r_m$ and remains at this value until the transistor is turned off.

The waveform of the collector current appears in Fig. 24. It is assumed that the transistor always operates in the safe operating area. The problem of secondary breakdown during turn-off is not to be considered.

The problem is to determine if the maximum junction temperature will be less than the value specified by the manufacturer. The following data are available.

I_{ceo} = 10 mA

$V_{CE(sat)}$ = 0.4 V max



26. **To simplify analysis** an equivalent power-vs-time plot is obtained. Note the rectangular pulses.

$V_{BE\ sat}$	$= 1.5$ V max
h_{FE}	$= 25$ min at 50 A
θ_{JC}	$= 0.5°$ C/W
θ_{CS}	$= 0.75°$ C/W
θ_{SA}	$= 1.25°$ C/W with an air flow of 100 ft/min
τ_{JC}	$= 50$ ms

Ambient Temperature = 55° C max

C_P vs t_1/τ_{JC} is shown in Fig. 22.

The design procedure is as follows:

1. Convert the current waveform into an equivalent power dissipation waveform (Fig. 25):

$$P_{on} = I_C V_{CE\ sat} + I_B V_{BE\ sat}.$$

If the turn-on transition, which is very small compared with the total on-time and the transistor time constant, is neglected $I_C V_{CE\ sat}$ can be plotted by multiplying all points on the curve by $V_{CE\ sat}$. To this curve, add a constant $I_B V_{BE\ sat} = 2(1.5) = 3.0$ W. Under worst-case conditions, assume that 2 A of base current are supplied continuously, i.e.:

$$I_B = I_C/h_{FE} = 50/25 = 2 \text{ A}.$$

In the off state:

$$P_{off} = I_{CEO}V_{CE} + I_{EBO}V_{BE}$$
$$= (10 \times 10^{-3})(50) + (\approx 0) = 0.5 \text{ W}$$

To simplify the waveform, neglect the power dissipated during the off time and extend the on time for 10 ms. This gives a condition that is worse than would actually exist but it simplifies the calculations. Thus the simplified power-vs-time curve shown in Fig. 25 is obtained.

2. Calculate the energy under the pulses in Fig. 25 and convert them into equivalent rectangular pulses with the same energy value. This is done simply by counting the squares underneath the pulses. This value is approximately 197 mJ. The height of the rectangular pulse is made equal to the maximum height of the original pulse. This value is 23 W. The width is found to be equal to:

$$E_p/height = 197 \text{ mJ}/23 \text{ W} = 8.6 \text{ ms}.$$

The waveform is shown in Fig. 26.

3. Calculate the steady-state power:

$$P_{ss} = I_C V_{CE\ sat} + I_{BE\ sat} V_{BE\ sat} = 5(0.4) + 2(1.5) = 5 \text{ W}.$$

4. Find C_{PJC} from the curve of Fig. 22. First, calculate the duty cycle, which is:

$$t_1/T = 8.6 \text{ ms}/258.6 \text{ ms} = 3.3\%,$$

and then:

$$t_1/\tau_{JC} = 8.6 \text{ ms}/50 \text{ ms} = 0.172.$$

The value of C_{PJC} is approximately 9.

5. Solve for $T_{J\ max}$ by rearranging the peak power equation:

$$T_{J\ max} = P_{p\ max}\ \theta_{JC}/C_{PJC} + \theta_{CA} t_1/T + T_A + \theta_{JA} P_{ss}.$$

Substituting all the values, $T_{J\ max} = 70.2°$ C, which is below the maximum allowable temperature specified by the manufacturer. Thus, the transistor can safely be used in this application.

Choose proper heat sink

The maximum power that could be dissipated has been determined on the basis of a given thermal resistance. Often, the maximum power that can be dissipated is given and a choice of the proper packaging and cooling to keep the junction temperature below the specified limit must be made. Since the internal thermal impedance from junction to case is a function of the device package, maximum performance can be obtained only by reducing the thermal impedance from case to sink and sink to ambient. The device mounting will determine θ_{CS} and the choice of heat sink and air flow will determine θ_{SA}. ■ ■

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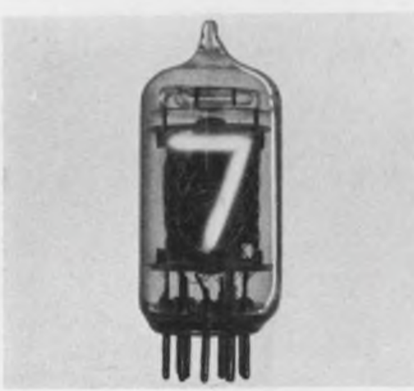
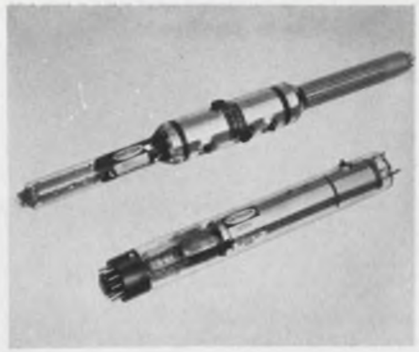
New Raytheon Projectoray* Tube produces more than double the light output of standard projection-type cathode ray tubes. The tube's light output is 30,000 foot lamberts, which results in a light level of 15-foot lamberts on a 3' x 4' lenticular screen.

The tube's expected minimum operating life is 500 hours — 20 times the life of a standard projection tube.

The Projectoray's high light output and long life are due to its novel design. The design incorporates liquid cooling of the phosphor backplate. This allows the phosphor to be energized with a very intense electron beam. At high beam levels, very high peak light output is obtained. The light image is projected through a 5" optical window in the face of the tube. The electron gun is set at an angle to the phosphor and the deflection system compensates for keystone effects.



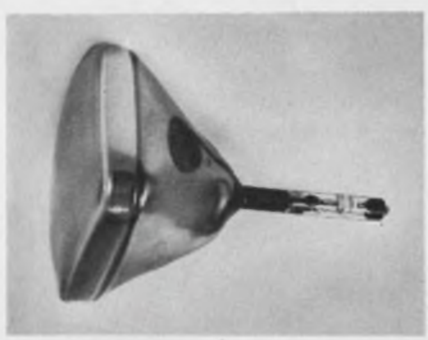
Datavue* Side-View Tubes. New Type CK8650, with numerals close to the front, permits wide-angle viewing. These side-view, in-line visual readout tubes display single numerals 0 through 9 or preselected symbols such as + and − signs. Their 5/8"-high characters are easily read from a distance of 30 feet. Less than $5 each in 500 lots, they also cost less to use because the bezel and filter assembly can be eliminated and because their mating sockets are inexpensive.



Recording Storage Tubes. The miniature tubes shown here are Raytheon's single-gun (CK1518) and dual-gun (CK1519). They provide high resolution, long storage, and fast erase capability.

Raytheon electronic input-output storage devices feature the above capabilities and immediate readout. Information can be written and stored by sequential techniques or by random-access writing. Complete, gradual or selective erasure is possible.

Raytheon storage tubes are readily available for applications in radar scan conversion, slow-down video, signal processing, signal enhancement, time delay, and stop motion.



Dataray* Cathode Ray Tubes. Raytheon makes a wide range of industrial CRTs —including special types—in screen sizes from 7" to 24". Electrostatic, magnetic, and combination deflection types are available for writing alphanumeric characters while raster scanning. All standard phosphors are available and specific design requirements can be met. Combination deflection or "diddle plate" types include CK1395P (24" rectangular tube), CK1400P (21" rectangular), and CK1406P (17" rectangular).

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Datavue* End-View Tubes. Raytheon makes round (CK8421) and rectangular (CK8422) Datavue indicator tubes on automated equipment capable of high production rates and top quality. The CK8422 rectangular tube is also available with decimal point, ± symbols, and in other special versions. Both round and rectangular types fit existing sockets and conform to EIA ratings. These ultra-long-life tubes are designed for 200,000 hours or more of dynamic operation.

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Undercover signals are unmasked

'Aliasing' in sampled data systems is avoided by using a presampling filter and the correct sampling rate.

Telemetry systems often require digital transmission of continuous inputs. Reconstituting digital information can occasion incorrect waveforms due to "aliasing." An example of this problem is shown in Fig. 1b. Choosing the correct sampling rate and presampling filter can prevent this from happening.

A sampled data system using periodic sampling of a continuous input signal must have a sampling rate that fulfills two criteria, if the recovered signal is accurately to portray the input:

- The sampling must be instantaneous, that is, be an impulse function.
- The sampling rate, f_s, must be more than twice the highest signal-base-band frequency. One-half the sampling frequency is often called the Nyquist frequency, $f_s/2$.

Neither of these conditions can be satisfied completely. Realizable sampled-data links use non-zero sampling durations because of circuit or response limitations. The second condition implies that the input signal is band-limited, an ideal characteristic that is physically impossible to attain.

A realizable signal will have a spectrum that contains energy at frequencies greater than the Nyquist frequency. This energy is transposed downward in frequency by the sampling process and may appear in the output—a mechanism known as aliasing. As an extreme example, consider a sinusoid, sampled at a rate eight times its frequency (Fig. 1a), from which a good reconstruction can be achieved. A higher-frequency signal (Fig. 1b) sampled at a rate that is eight-sevenths of its frequency gives identical sampled data, which will lead to a reconstructed signal identical to the first. Such an error may arise in a time-division multiplex link (Fig. 2).

The magnitude of this aliasing error is a function of the input signal spectrum and of the filter network interposed between the sampling device and the signal source.

The presampling filter should have a sharp cutoff at the Nyquist frequency, so that spectral components higher than the Nyquist frequency will produce a negligible aliasing error.

R. J. Rechter, Head of Signal Analysis Group, Hughes Aircraft Co., Los Angeles, Calif.

Calculating the aliasing error

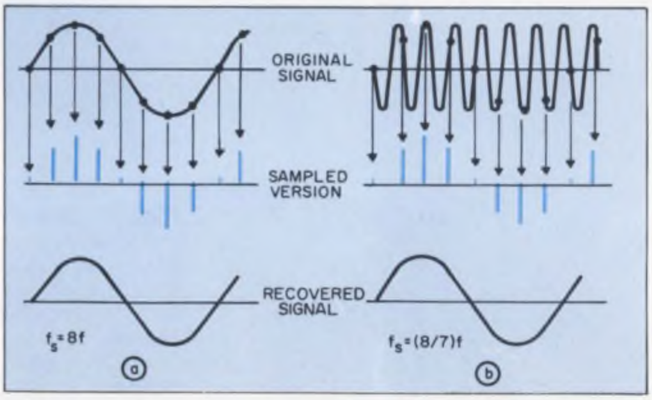
The mean square aliasing error is given by the mean power that exists over signal spectral frequencies greater than the Nyquist frequency.[1] Then the power spectrum presented to the sampler, $G^2(f)$, is given by:

$$G^2(f) = S^2(f)H^2(f),$$

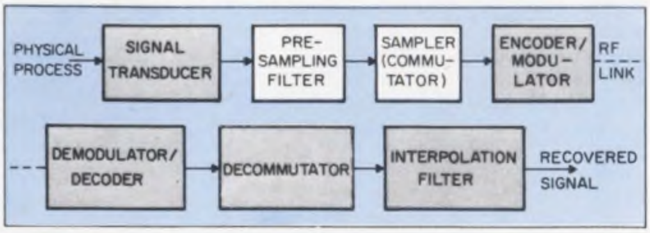
where $S^2(f)$ is the signal power spectral density, and $H(f)$ is the presampling filter amplitude response.

The aliasing error is obtained by integrating over the filtered signal spectrum, from the Nyquist frequency to infinity:

$$P_a = \int_{f_s/2}^{\infty} G^2(f)\, df \text{ (watts)}.$$



1. **Sine wave has good reconstruction** where sampling rate is eight times its frequency as in (a). Higher frequency signal, sampled at 8/7 its frequency, gives reconstituted signal (b) identical to (a). Process is known as aliasing.



2. **Typical time-division multiplex link** uses a presampling filter to minimize signal components above the Nyquist frequency.

This can be normalized by taking a ratio of aliasing power to signal power. The mean signal power is given simply by:

$$P_s = \int_0^\infty S^2(f)\, df \text{ (watts)}.$$

The rms aliasing error can then be defined by the square root of the power ratio of aliasing power to signal power:

$$\epsilon_a = (P_a/P_s)^{1/2}.$$

An example of this technique has been worked out[2] for a presampling spectral density given by the Butterworth power transfer function. In this example, the filtered signal spectral density, $G^2(f)$, can be assumed to be identical to the Butterworth power transfer function:

$$G^2(f) = K/[1+(f/f_c)^{2m}],$$

where:

K = constant,
f_c = the −3-dB bandwidth,
m = the order of the function.

This spectrum would be obtained if a uniform spectral density signal were filtered by an m^{th}-order Butterworth low-pass presampling filter. The shaded region in Fig. 3 is proportional to the aliasing power. The maximally flat spectral characteristic may be approximated by:

$$G^2(f) \approx K(f_c/f)^{2m},$$

when $f_s/2 >> f_c$.

Then the aliasing power is given by:

$$P_a = \int_{f_s/2}^\infty G^2(f)\, df = \int_{f_s/2}^\infty K(f_c/f)^{2m}\, df$$
$$= [2^{2m-1} K f_c/(2m-1)](f_c/f_s)^{2m-1}.$$

Similarly, the total signal power is:

$$P_s = \int_0^\infty G^2(f)\, df = \int_0^\infty \{K\, df/[1+(f/f_c)^{2m}]\}$$
$$= (\pi K f_c/2m) \csc(\pi/2m).$$

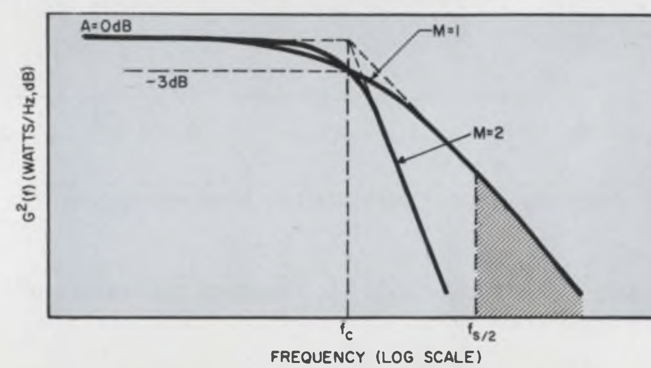
Finally, the rms aliasing error is:

$$\epsilon_a = (P_a/P_s)^{1/2}$$
$$= 2^m\{[m/\pi(2m-1)][f_c/f_s]^{2m-1} \sin(\pi/2m)\}^{1/2}.$$

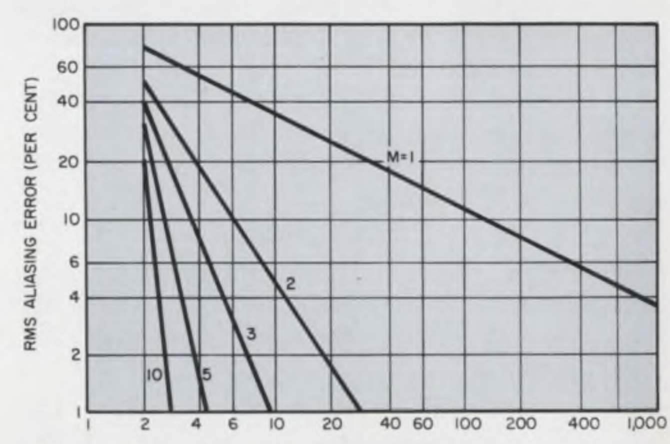
This aliasing error can be plotted against a normalized sampling-rate/presampling-bandwidth factor for a family of Butterworth filters of various orders (Fig. 4).

It has already been stated that the presampling filter should have a sharp cutoff at the Nyquist frequency if a low value of aliasing error is to be achieved. Consider an example which uses a first-order RC filter ($m = 1$). A uniform signal spectral density is assumed. Now, even if the sampling rate is as high as 100 times the filter cutoff frequency, Fig. 4 shows that an aliasing error of 8% will occur! Most physical signals, of course, do not exhibit uniform spectra, as for example, in television cameras where the signal spectral density is inversely proportional to the signal frequency. But the point is clear: very se-

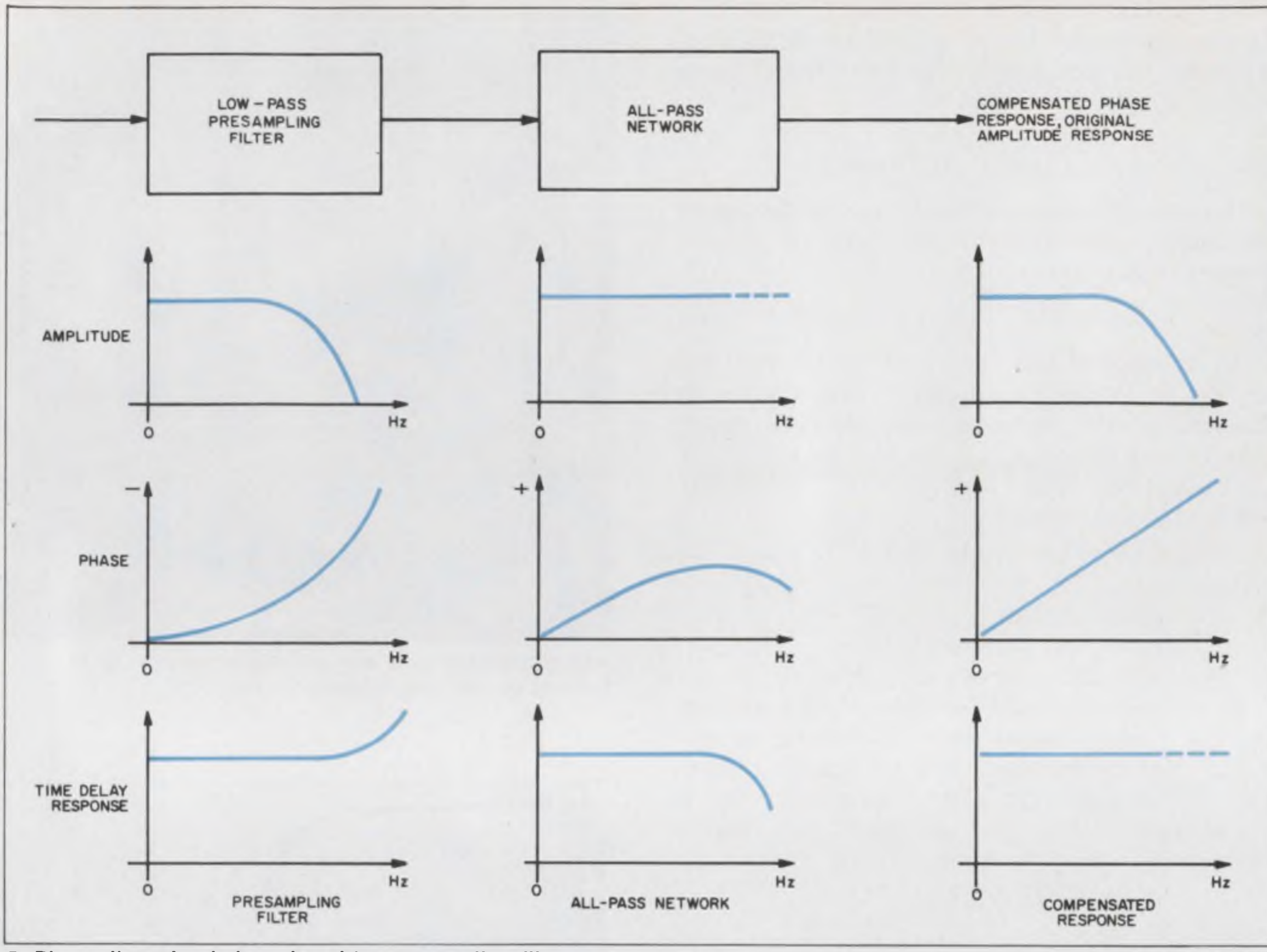
Author Rechter gets the message through to his colleagues on reducing aliasing errors.



3. **Butterworth low-pass presampling filter** of second order may be designed to achieve sharp cutoff at less than twice the sampling frequency. Shaded region is aliasing power obtained with first-order filter.



4. **Percentage aliasing error for family of filter orders** with a normalized sampling frequency enables error to be estimated. For example, RC (m = 1) filter and f_s 100 times f_c will result in rms aliasing error of 8%.



5. **Phase distortion is introduced by presampling filter** but addition of an all-pass network may be used to compensate.

lective filters are needed to ensure small values of aliasing error.

Transmission link requirements

The transmitter power required for a PCM, FM, phase-modulated link is directly dependent on the predetection signal-to-noise ratio and sampling rate specified. The following analysis of basic parameters for such a system shows how this dependence is derived.

In a typical PCM/FM/PM link, if a non-return-to-zero pulse train is assumed, a predetection threshold signal-to-noise ratio, S_T, must be satisfied. For the i^{th} channel:

$$P_{sc_i}/N_{sc_i} \geqq S_T, \quad (1)$$

where P_{sc_i} is the signal power present in the i^{th} subcarrier predetection bandwidth, and N_{sc_i} is the noise power present in the same bandwidth. The signal power is:

$$P_{sc_i} = P_R \, M \, L_{sc_i}, \quad (2)$$

where P_R is the received power and ML_{sc_i} is the modulation loss of the i^{th} channel. The noise power is:

$$N_{sc_i} = k \, T \, B_{sc_i}, \quad (3)$$

where k is Boltzmann's constant, T is the effective system temperature in degrees Kelvin, and B_{sc_i} is the i^{th} subcarrier bandwidth in hertz. If P_R is expressed as αP_T, where α is a constant determined by transmitter and receiver antenna and circuit losses, and P_T is the transmitter power, then Eq. 1 can be written as:

$$\alpha P_T \, ML_{sc_i}/k \, T \, B_{sc_i} \geqq S_T, \quad (4)$$

or $P_T/B_{sc_i} \geqq r$, where $r \equiv S_T \, k \, T/\alpha M \, L_{sc_i}$.

Since $k \, T/\alpha ML_{sc_i}$ is a constant for a particular system, r is dependent on the desired threshold signal-to-noise ratio. Hence, for a given threshold S/N ratio, the transmitter power is dependent on the subcarrier bandwidth. Since this is a sampled-data system, B_{sc_i} is given by:

$$B_{sc_i} = \gamma N, \quad (5)$$

where N is the total number of bits per second and γ is a factor relating the equivalent noise bandwidth to −3-dB bandwidth ($\gamma \leqq 1.08$ for most bandpass functions). N is given by:

$$N = L \, R \, f_m, \quad (6)$$

where L is the number of bits per word, R is the number of samples per hertz, and f_m is the data base-band. The transmitter power is thus:

$$P_T \geqq r \, \gamma \, L \, R \, f_m. \quad (7)$$

Since $\gamma \, L \, f_m$ is an assumed constant, m, for a given design situation:

$$P_T \geqq r\, m\, R.$$

Thus an increase in sampling rate, R, will require an increase in transmitter power. The presampling-filter characteristics are significant in reducing the sampling-rate requirements and thereby either lowering transmitter power levels or improving the transmission link performance by increasing the subcarrier predetection signal-to-noise ratio.

Filtering causes distortion

It should be noted that a presampling filter that has a sharp cutoff also exhibits nonlinear phase. Since the group (or time) delay is the derivative of the phase, it will also be nonlinear with frequency. This can be seen by a comparison of various filter functions[3] (Fig. 5).

Because sampled-data systems require linear phase and time delay, all-pass networks may be used for compensation (Fig. 5).

Analyze aliasing error by computer

Aliasing error may be analyzed by computer in the following way:

- The signal (transducer) spectral density is encoded, point by point, as input data to a program, which then operates on this spectrum with a given presampling-filter power transfer response.
- A routine numerically integrates that portion of the modified spectrum which lies beyond the Nyquist frequency. This sum represents the mean aliasing power.
- Another numerical integration, over the entire unmodified signal spectrum, results in the mean signal power.
- Finally, the routines take the square root of the ratio of these two powers and present it as the rms aliasing error.
- In addition, the sampling problem can be attacked directly, in the time domain, by use of an IBM program, ECAP (Electronic Circuit Analysis Program)* (Fig. 6).

This program computes and plots the time function at any node in a system represented by R, L, C, voltage and current source, and switch elements. This transient analysis routine is known as ECAPTR. ■ ■

*ECAP is available from the International Business Machines Corp., Greenbelt Space Flight Center, Greenbelt, Md. 20770 (contact Roger Cliff).

Acknowledgment:

This work was partially prepared under contract No. 950056 to the Jet Propulsion Laboratory and NASA.

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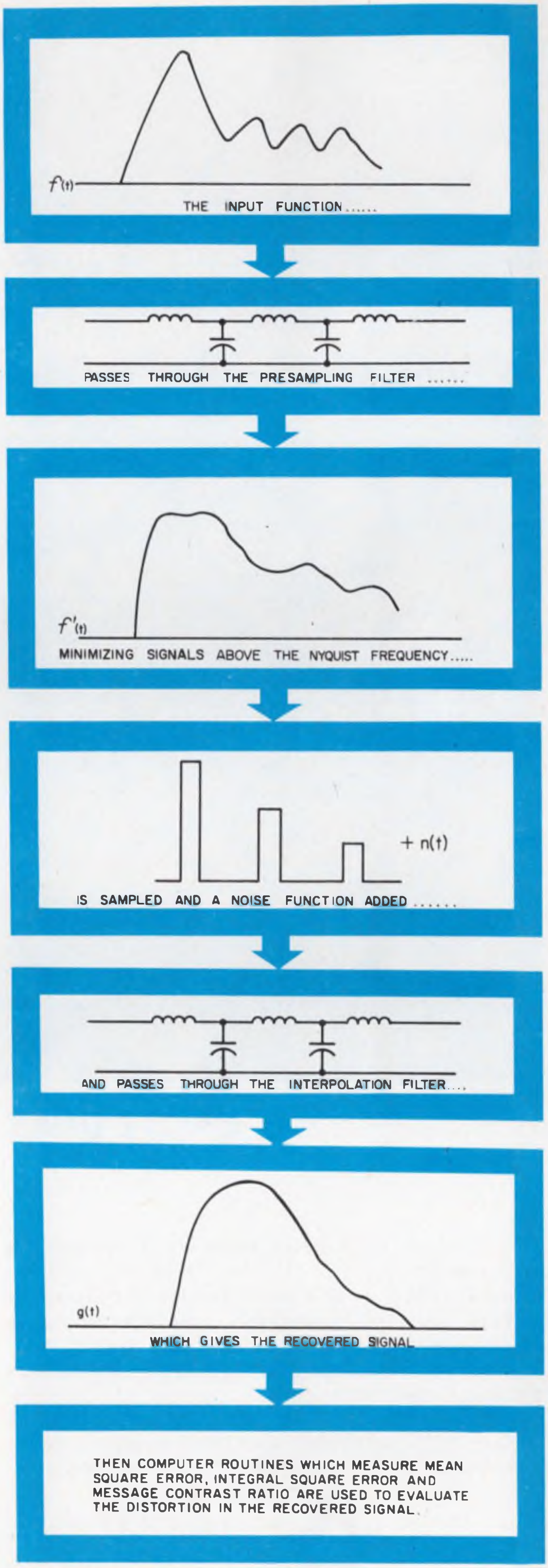
3. H. S. Black, *Modulation Theory* (Princeton, N. J.: D. Van Nostrand Co., Inc., 1953), pp. 181-233.



6. **Computer simulates multiplex link** using ECAP.

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An inexpensive character generator

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A task that frequently faces a designer is to modify or add to an existing system to meet new needs. His ability to do this with available hardware and without changing the over-all system is an important factor in holding down the cost of new devices.

In the following instance, a character generator had to be built to operate with an existing graphic display. The system already included analog sources capable of generating circles, line segments and similar geometric shapes. The focus, then, was on designing a character generator that could use analog function generators to provide a variety of character elements.

Additional requirements for the character generator were:

- Good character quality.
- Minimum bandwidth.
- High rate of character generation
- Low cost.

All the design goals were met. A comparison of this method with several other approaches showed that what at first seemed to be a constraint—the use of analog sources—proved to be an advantage. The method used was the least costly and was compatible with the rest of the system.

Compare other methods

Other methods of character generation include dot-raster schemes, straight-line-segment generators, monoscopes, and beam-shaping. These techniques are illustrated in Fig. 1.

The quality of straight-line-segment and dot-raster methods is poorer and the bandwidths they require are larger by a factor of two to three than what was selected. Beam-shaping could have been used, for its character quality is excellent, but beam-shaping CRTs run about $3000 apiece in small quantities—an excessive price. Monoscope tubes can be purchased for around $100 in small quantities, but like beam-shaping equipment require a decode matrix, which will substantially increase the cost of most character generators.

Analog methods are employed to form line segments needed for full alphanumeric display. Binary switching and timing serve to display the waveforms successively.

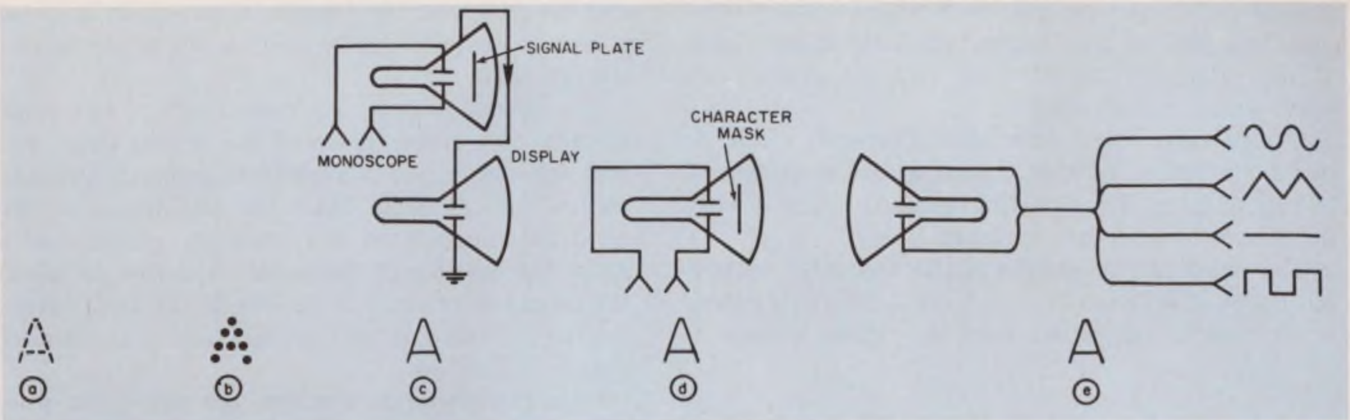
Harvey L. Morgan, Senior Systems Engineer, General Electric Co., Phoenix, Ariz.

Table: Character building waveforms

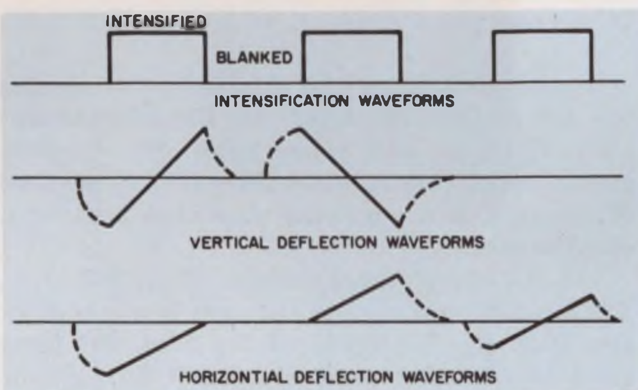
1.	Sine wave
2.	Cosine wave
3.	Sine-sawtooth
4.	Cosine-sawtooth
5.	Sine-square wave
6.	Cosine-square wave
7.	High level
8.	Zero level
9.	Low level
10.	Negative sine wave
11.	Negative sine-sawtooth
12.	Negative cosine-sawtooth
Half-amplitude waves	
13.	Positive-biased cosine wave
14.	Negative-biased negative cosine-sawtooth
15.	Positive-biased negative cosine-sawtooth
16.	Negative cosine-sawtooth
17.	Negative-biased cosine wave

The table lists the necessary waveforms. Combinations of sine waves, sawtooths, cosine waves, and constant levels are used, as well as full and half-amplitude versions of the basic waveforms, and inverted waveforms. All in all, 17 different forms are required to generate a full repertoire of characters.

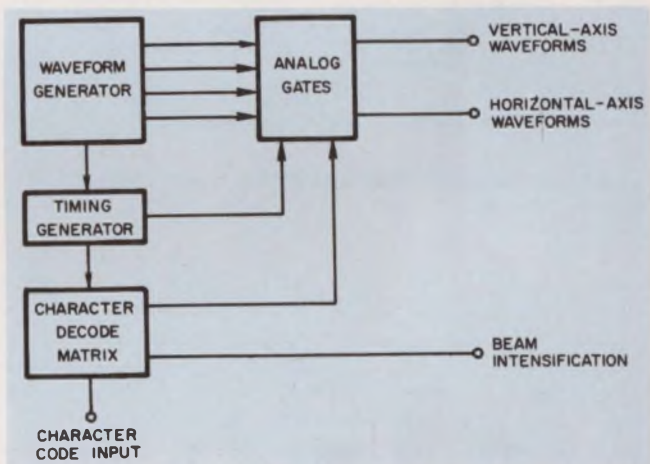
The capital letter A, for example, requires starting from the lower, left-hand corner of the alphanumeric block simultaneously with a half-amplitude cosine-sawtooth on the horizontal plates of the electrostatic deflection system and a full-amplitude cosine-sawtooth on the vertical plates. Figure 2 shows the waveforms and timing. This can be followed by negative-going sawtooths to draw the line from the top of the block to the lower, right-hand corner. The bar in the middle requires a constant (zero) voltage on the vertical axis and a half-amplitude cosine-sawtooth on the horizontal axis. Between line-drawing operat-



1. **Various approaches to forming characters for the CRT** display are possible. Straight-line-segment (a) and dot-raster (b) methods do not give good quality and require large bandwidths. Monoscope (c) and beam-shaping (d) methods include costly CRTs. (In a monoscope the characters are printed on the cathode "signal plate." The electrical TV signal is obtained by scanning the signal plate.) The selected method (e) using combinations of basic analog functions gives characters of good quality and is inexpensive.



2. **Letter A is formed** by simultaneously applying a half-amplitude cosine-sawtooth to the horizontal deflection plates and a full-amplitude cosine-sawtooth to the vertical plates. The bar in the middle requires a constant (zero) voltage on the vertical plates and a half-amplitude cosine-sawtooth on the horizontal axis. Other letters are formed in similar fashion.



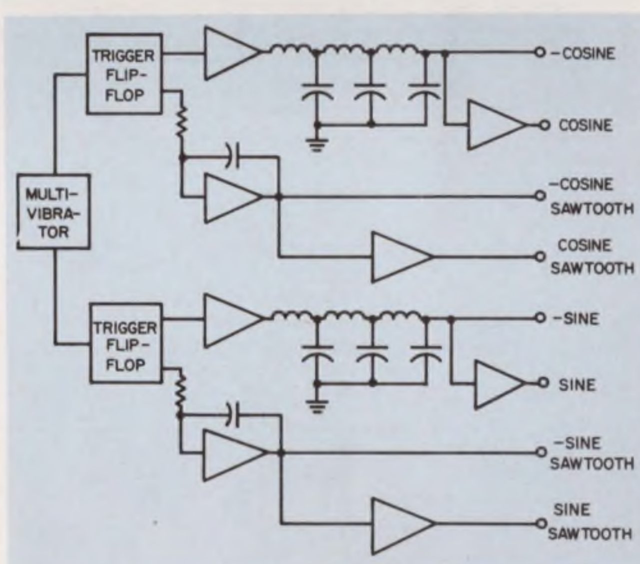
3. **Character generator block diagram** illustrates its functional simplicity. The generated waveforms are selected by the character decode matrix and applied to the display device through analog gates.

ions (when intensity is on full), blanking is required to hide the spot movements to new starting positions.

The operations illustrated for a capital A are basically the same for all the alphanumeric characters, and various other symbols. A maximum of six lines is required to delineate any character or symbol; the average is three.

How the generator works

A free-running multivibrator, followed by triggered flip-flops which are driven from opposite sides of the multivibrator (see Figs. 3 and 4), generates the signals for the various waveforms. This gives a two-phase square-wave clock. To obtain sinusoids, an LC low-pass filter with 90° phase delay is driven off each flip-flop. Sawtooths are obtained by integrating the square waves with Miller integrators (Fig. 5). Phase inverters yield positive and negative versions of both sinusoidal waves and sawtooths. Voltage dividers provide the half-amplitude waves. Clamps to

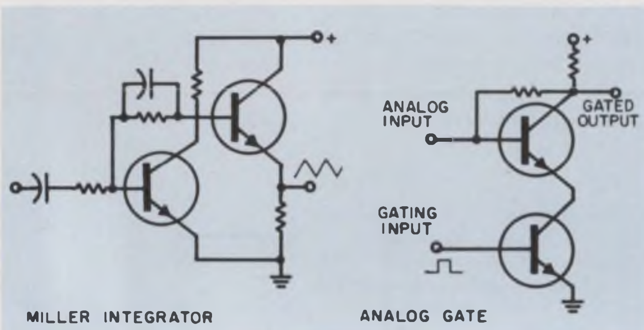


4. **Waveform generator** comprises ICs and passive pulse-shaping networks. To obtain sinusoids, an LC low-pass filter with 90° phase delay is driven off each flip-flop. See text for the component values.

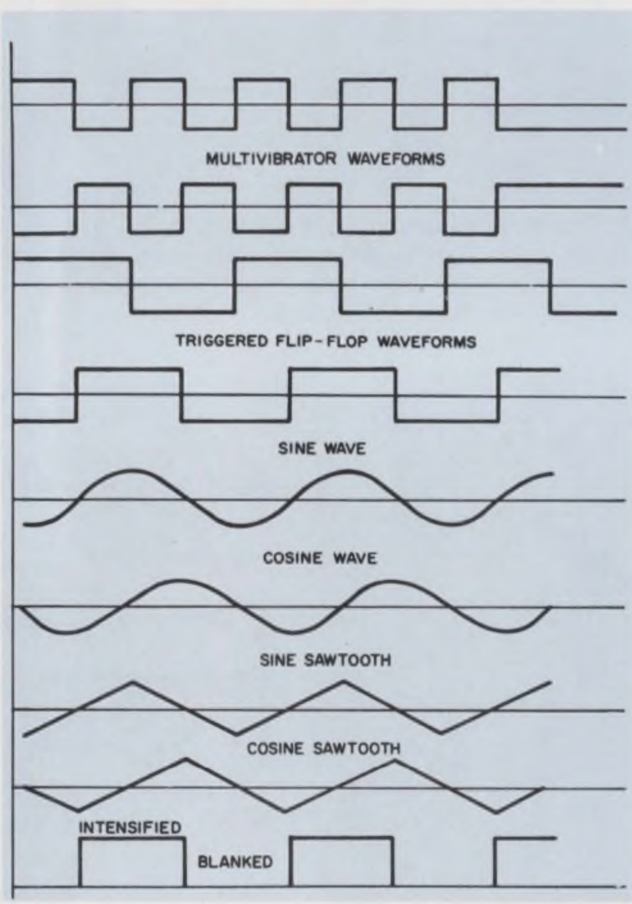
ground and plus and minus voltages supply constant voltages for lines across top, bottom, and sides of the character block. Bias voltages applied to waveforms also play a part.

Timing comes from the basic character clock. A counter wired to provide timing pulses at equal intervals of intensification and blanking is gated with waveforms to draw the characters (Fig. 6).

The heart of the system is the character decode matrix built principally with 8-input 957 AND gates. It receives timing pulses from the timing generator and the character code input. A binary six-bit code is used to enter character information from the central processor.



5. **Analog signal-shaping and gating** is accomplished with simple circuits.



6. **Waveform timing** is given by the character clock. A combination of character requirements, waveforms, timing pulses, and intensification provides the right waveforms to delineate any desired character. Only a few basic waveforms are illustrated.

The decode matrix, on recognizing a character, actuates the proper gates of the analog gate unit. Simultaneously, it determines appropriate intensification and blanking. Since the waveforms are applied continuously to the normally closed analog gates, the opening of the gates in succession allows the proper waveforms to appear at the electrostatic plates of the display unit. In this fashion the desired character is drawn.

Character decoding matrices are simplified when it is remembered that many characters have lines in common. For example, a line down the left side of the character block is used by the capital letters B, D, E, F, H, K, L, M, N, P, and R. Groupings of this type allow considerable logic simplification.

Circuit tips

In implementing the character generator, integrated circuits are employed for the multivibrator clock; flip-flops, and binary gates. For waveform gating, analog two-transistor gates (Fig. 5) are used. The signal to pass the analog waveforms is binary in either on or off.

The ICs are of the Fairchild CTμL 950 series. The multivibrator used as the clock is a pair of 952 gate packages. For triggered flip-flops, 957 power gates drive integrator and phase-shift filter circuits which not only provide sine waves but also 90° phase shifts. The transistors are 2N697 silicon units, except for the CRT deflection drivers (not shown) for character display. Character decode networks are built mostly with the 8-input 957 AND gates.

The transistor circuits use +12 volts; 4.5- and —2-volt supplies drive the logic circuits. The Miller integrator has a 1.5-kΩ collector load resistor, a 10-pF feedback capacitor, a 1.5-kΩ series base resistor, and 0.6-kΩ emitter-follower load resistor. The analog gate uses a 1.5-kΩ collector load resistor and a 90-kΩ base bias resistor.

The clock rate (multivibrator frequency) is 2 MHz. Sine-wave frequency is half that—1 MHZ. Character generation rate is one per 8 microseconds, or 125,000 characters per second. A video bandwidth of 5 MHZ is used for horizontal and vertical electrostatic deflection.

A recent look at integrated circuit prices with regard to the requirements of this generator revealed that the cost of building it is only a small fraction of the cost of buying one on the market.

All in all, this approach resulted in a simple, versatile system fully utilizing the existing hardware. In addition to its low cost, the system could be easily changed without going to some outside vendor as would be the case if any of the approaches mentioned in the beginning of the article were used. ■ ■

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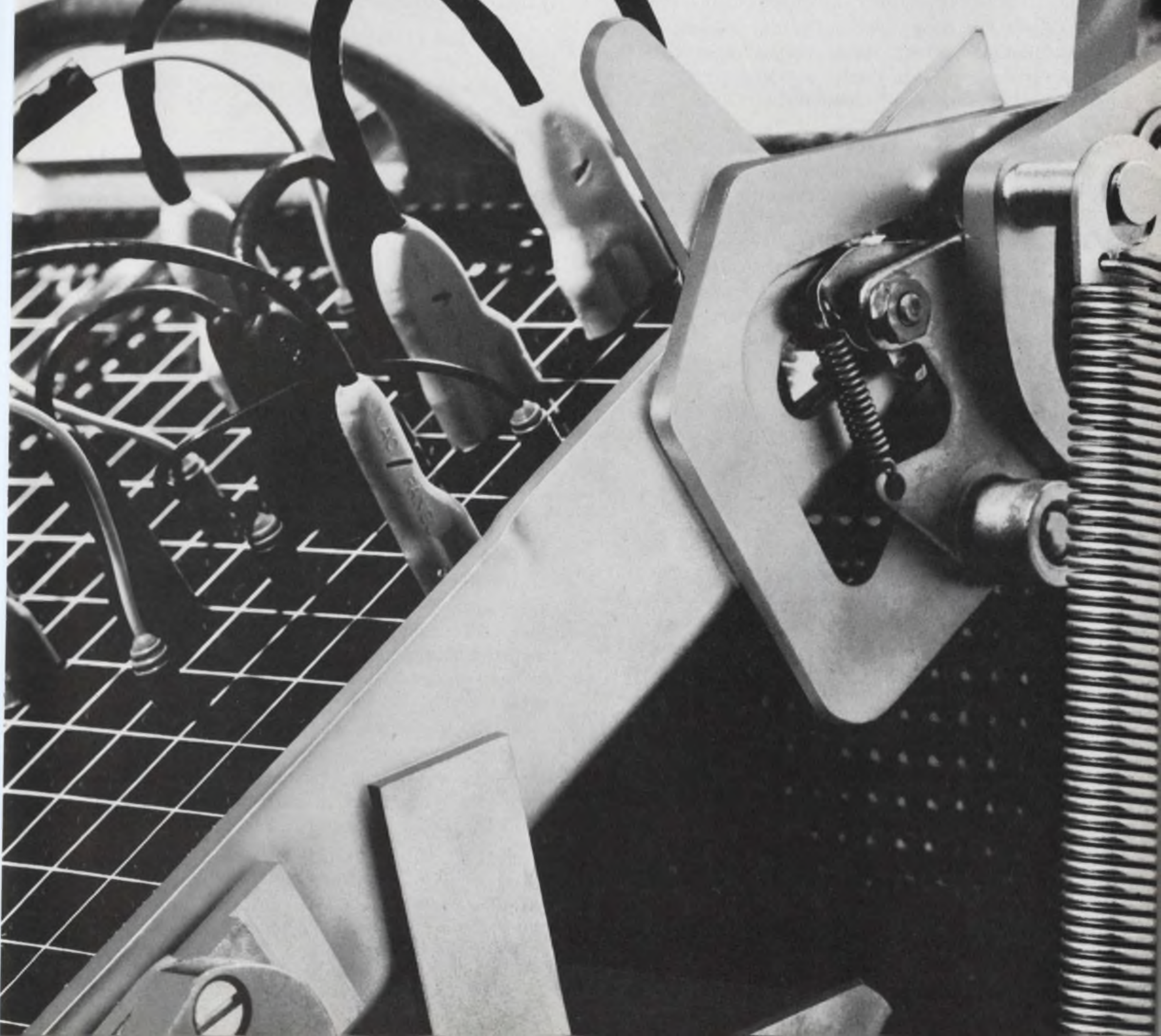


Pick plastics for high-speed circuits

by considering all properties. A low dielectric constant is only one part of the answer.

The electrical parameters and construction materials of a high-speed digital circuit influence the circuit's "speed." Theoretically it should take no time to turn a switch from off to on, or to change the voltage at some point in the circuit from, say, 0 to +3 volts. But not only do the active circuit elements cause delay, so too do the plastics used to separate, support and protect the circuit.

These plastics are important circuit-design parameters—critical factors that determine the performance of the final, packaged circuit. They affect two important elements:

- Component values.
- Heat transfer properties.

The major factor that limits the use of a particular material in high-speed circuitry is its dielectric constant. The dielectric constant alone, however, is not the sole criterion for selecting a material—even for high-speed applications. Other factors must also be taken into account. Many low-dielectric plastics have questionable insulation resistance, moisture absorption, mechanical strength, and handling and processing qualities, which make them poor choices in many applications. The logical approach to high-speed circuitry is to choose as low-dielectric a material as will satisfy all other requirements.

Mind your Ls and Cs

At present, typical propagation delays are on the order of tens of nanoseconds, but a great deal of development work is going on in the nanosecond and subnanosecond region. Here the placement of components is as critical as the components themselves. The geometry of and spacing between components become critical factors in determining the value of components. As a rule of thumb, it is convenient to remember:

- One inch of wire has an inductance of about 20 nanohenries.
- Two adjacent one-inch-long insulated wires have a capacitance of about 0.1 picofarad.

These inductances and capacitances are additional to the inductors and capacitors that are intentionally placed in a circuit (interconnecting wires, pin connections, cables, etc.). They constitute real Ls and Cs, however, which, because they must be charged and discharged, affect propagation delay.

John Piser, Staff Chemist, Systems Development Div., International Business Machines, Kingston, N. Y.

Dielectric constant affects parasitics

The material between conductors affects the parasitic capacitance between the conductors. Parasitic capacitance comprises parallel-plate capacitance and fringe capacitance (Fig. 1).

Parallel-plate capacitance is given by:

$$C = k\,\epsilon_r\,A/d, \qquad (1)$$

where:

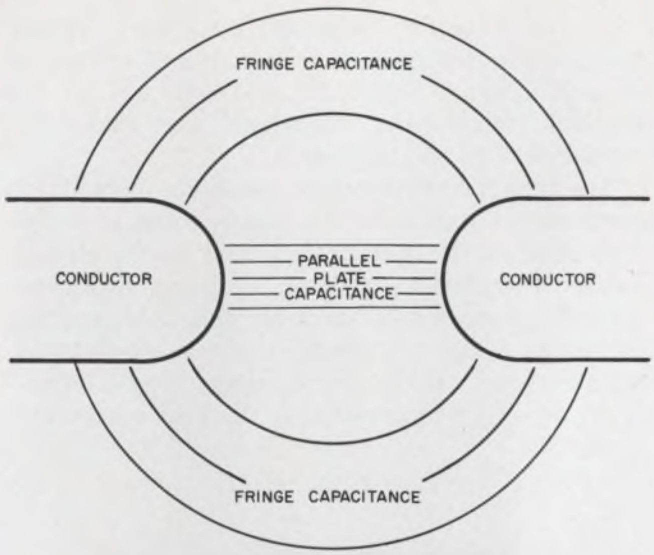
k = a constant which depends on the units of measure,
ϵ_r = relative dielectric constant,
A = plate area,
d = distance between the plates.

Fringe capacitance does not lend itself to a simple analytical expression. It is generally the dominant term in parasitic capacitance, however, since the parallel areas are usually very small. It, too, is a strong function of ϵ_r.

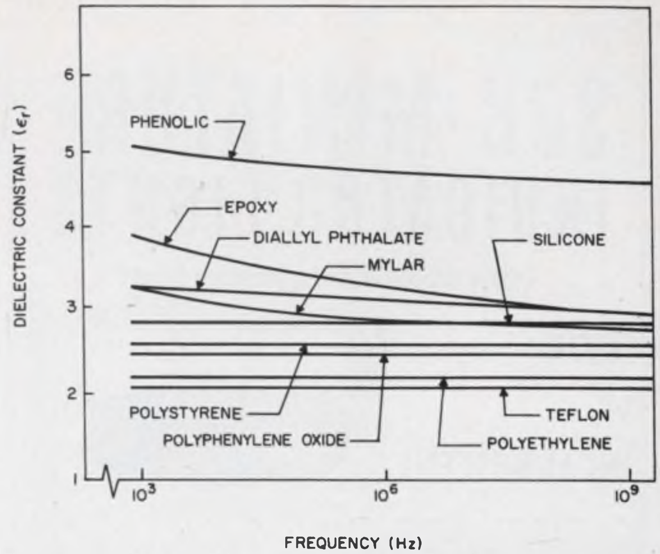
At a bare minimum, the substrate on which all the devices are mounted will increase the parasitic capacitance relative to air. If the conditions under which the circuit must operate require its encapsulation, the dielectric constant of the particular encapsulant will further increase the parasitic capacitance. Whether or not the parasitic capacitance is desirable (it might be used to cancel a stray inductance, for instance), it inevitably exists in a circuit. And plastics modify capacitances.

Another source of capacitance is the connectors and cables that join various circuits. The capacitance between adjacent wires in a cable and between pins in a connection is determined to a large extent by the insulating plastics.

The choice of the right plastic is further complicated by the fact that the relative dielectric constant of some materials is a function of frequency. Therefore, not only must the plastic itself be considered, but also the particular frequency at



1. **Parallel-plate and fringe capacitances** are inherent in any material. Both components of parasitic capacitance are strong functions of the material dielectric constant.



2. **Dielectric constant is a function of the frequency** of circuit operation. Merely choosing the lowest dielectric constant, however, is not the full answer.

which the circuit is to be operated. Figure 2 shows the frequency dependence of ϵ_r for several plastics.

Failure to consider the effect of a plastic on component values early in the breadboard phase may lead ultimately to a circuit package that has substantially less than the desired capability.

Plastics form a thermal circuit

Modification of component values is not the only problem to be considered in selecting plastics for high-speed circuits. While components may be shrunk smaller and smaller, heat dissipation will place a practical limit on packaging density.

All components dissipate heat, and this heat must eventually be transferred to the ambient environment. As higher switching speeds are achieved, the thermal power density increases, and the problem of cooling circuits becomes more critical. This is because higher switching speeds demand smaller components, placed more closely together in order to reduce propagation delay.

Reducing the power level is an obvious solution. For reliable operation, however, there is a minimum power level beyond which it is impractical to go. Therefore, as smaller components are placed closer together, the thermal power density has to increase for operation to take place at a specified power level. It is this thermal power that has to be dissipated. And, plastics play a part.

Table. Comparative properties of plastics (25° C)

	Specific gravity (dimensionless)	Heat distortion temperature (°F)	Coefficient of linear expansion (in./in. °F)	Thermal conductivity (W/°C•m)	Water absorption (% at 24 h)	Dielectric strength (V/mil)	Volume resistivity (Ω•cm)
Phenolic	1.5	350	30×10^6	0.30	0.9	350	10^{12}
Epoxy	1.5	300	30×10^6	0.17	0.04	400	10^{15}
Diallyl phthalate	1.5	310	40×10^6	0.30	0.09	450	2×10^{16}
Silicone	1.8	900	30×10^6	0.36	0.15	350	5×10^{13}
Polyphenylene oxide	1.1	375	29×10^6	0.19	0.06	450	10^{17}
Mylar*	1.4	300†	15×10^6	0.14	0.8	5000‡	10^{18}
Polyethylene	0.94	110	100×10^6	0.35	0.01	500	10^{16}
Polystyrene	1.1	170	40×10^6	0.12	0.04	500	10^{17}
Teflon*	2.1	132	55×10^6	0.25	0.01	500	10^{17}

NOTES:
* DuPont trademark
† Maximum service temperature
‡ 1-mil film

As in the case of component-value modification, the plastics used in high-speed circuitry affect its thermal characteristics. They form part of the thermal circuit that transfers heat from the components to the ambience.

The exact relationship between component temperature and ambient temperature is highly dependent on the specific geometry of the circuit. Proper thermal analysis of a circuit ordinarily requires experimental data as well as theoretical calculation. The temperature difference between ambience and a particular component will, however, be directly proportional to the heat conductivity:

$$\theta_A - \theta_C = k\,P_T/\lambda, \qquad (2)$$

where:

θ_A = ambient temperature,
θ_C = components temperature,
k = a constant which depends on the particular geometry,
P_T = thermal power,
λ = heat conductivity of the intervening material.

Since the component temperature may approach 200°C, the heat conductivity of the particular plastics used is important for the efficient transfer of heat to the external environment.

Thus at each stage of the final packaging of a typical high-speed digital circuit, the electrical and thermal properties of the plastics must be taken into consideration since they help to determine the performance of the final system.

The table indicates important electrical, thermal, and physical properties of plastics which lend themselves to use in high-speed circuits. Depending on the particular application and environment, trade-offs have to be made between desirable characteristics. For example, Teflon has the lowest dielectric constant. However, if the dielectric constant of polyphenylene oxide can be tolerated, it has excellent mechanical and thermal properties. One other parameter not listed has also to be considered: the cost of the material selected.

This article has been confined to high-speed digital circuits, but its findings apply similarly to high-frequency linear circuits. ■ ■

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Choose metals for compatibility

in packaged circuits to avoid RFI, poor grounds, ground loops and stray coupling.

A little knowledge of metallurgy is a useful adjunct for the designer who is packaging his electronics in a metal chassis. An ill-chosen finish for a package can lead to poor grounds, ground loops, stray coupling and RFI. The wrong protective coating for this finish can introduce noise. Metal hardware performing interconnection, support, readout and read-in functions must be selected with care. And in general, the smaller a package of linear or nonlinear circuitry, the greater the problems of metal compatibility tend to become. Only the proper choice of compatible hardware, materials and finishes can alleviate these problems. Here then are some hints on how to achieve this end.

Metallic materials must be galvanically similar

For much of today's equipment, an aluminum alloy is used as the chassis material. When this is the case, feed-through insulators and similar hardware that is in contact with the chassis should be plated with finishes that do not form galvanic couples with aluminum. As the table shows, these finishes would need to be of zinc, cadmium, tin or stainless steel.

If the designer were to choose hardware that was nickel-plated, for example, undesirable contacts between dissimilar metals could occur. Many oxides and sulfides that might result are semiconductors and could form nonlinear ground paths or loops in which a nonlinear element is present. This could lead to faulty rectification and reradiation.

William A. Melanson, Vice President, Cambridge Thermionic Corp., Cambridge, Mass.

The table, taken from MIL-Std-454A, groups together metals that are considered galvanically similar. Any metal within a group may be used in intimate contact with any other metal in the same group. All the metals listed are for surface application and can be an electrodeposited plate, hot dip or spray.

Extra protective coatings are added to many finishes to increase corrosion resistance. These coatings can be in the form of organic dips, chromate conversion coatings or anodizes. If care is not taken, these coatings can interfere with good grounding and bonding, thus introducing noise. If the coatings are used in structural hardware or as grounding hardware, devices such as lock washers or bonded jumpers should be used to ensure that the surface film is broken and metal-to-metal contact is made. One useful rule of thumb is that the resistance of chromate conversion coatings increases in direct proportion to the depth of the color of the coating.

Electronic hardware is commonly made of a copper alloy base metal, which is either electroplated or coated with another metal, both to give the character-

Table: Galvanically similar metals

Group I	Group II	Group III	Group IV
Magnesium alloys (all)	Aluminum	Zinc	Copper
Aluminum alloys 5052, 5056, 5356, 6061 and 6063	Aluminum alloys (all)	Cadmium	Copper alloys (all)
Tin	Zinc	Steel	Nickel
	Cadmium	Lead	Nickel alloys (all)
	Tin	Tin	Chromium
	Stainless steel	Stainless steel	Stainless steel
	Tin-lead (solder)	Nickel	Gold
		Nickel alloys (all)	Silver
		Tin-lead (solder)	

istics desired for the end use and to provide greater corrosion protection. Unfortunately, there exists no universal finish for all electronic hardware that will satisfy all requirements for solderability, weldability, appearance, corrosion resistance and conductivity. Here's a rundown of the more commonly used metal finishes.

Many trade-offs in choosing a finish

Silver-plate finishes are best for hard-wiring and soldering. Silver is an excellent conductor and does not amalgamate so readily with commonly used base metals as some other finishes. Unprotected silver, however, tarnishes rapidly in the presence of sulphur contaminates and may migrate under appropriate conditions of moisture, heat and voltage. Like all other finishes, it will suffer surface contamination by atmospheric pollutants. This surface contamination may be delayed by a protective coating of a chromate or lacquer.

Gold plate is widely used for hand-soldered terminals and hardware as well as for connectors. Gold has a very high resistance to corrosion in relation to film thickness. Even gold, however, requires to be at least 0.0001 inch thick in order to withstand a 100-hour salt-spray test when plated over free-machining brass. Obviously, gold platings this thick can be expensive. Precautions may be necessary when wave-soldering gold or silver to prevent contamination and/or scavenging of the solder bath.

Electro-tin, electro-tin alloy and centrifuge coatings are extensively used for hardware that is to be wave-soldered. For these finishes, stearic acid coatings should be used for protection against atmospheric contaminates. In addition, zinc migration and consequent amalgamation have to be prevented when tin coatings are used on such zinc-bearing alloys as brass. This amalgamation will produce an unsolderable finish. Normally, an intermediate barrier plate is used to guard against migration and amalgamation.

Cadmium plating is used on both ferrous and nonferrous material. Cadmium as a protective finish is sacrificial; that is, its own corrosion products protect the base metal. To prevent eventual exposure of the base metal, the cadmium corrosion can be retarded with surface chromate conversion coatings. For example, 0.0003 inch of cadmium on brass with colored-chromate treatment will withstand 100 hours' salt spray. Cadmium is highly suitable for interior hardware applications.

Finally, many finishes on electronic hardware are used for their appearance as well as to prevent corrosion. These include nickel plate, chromium plating, black oxide treatments, and anodizing treatments for aluminum. ■ ■

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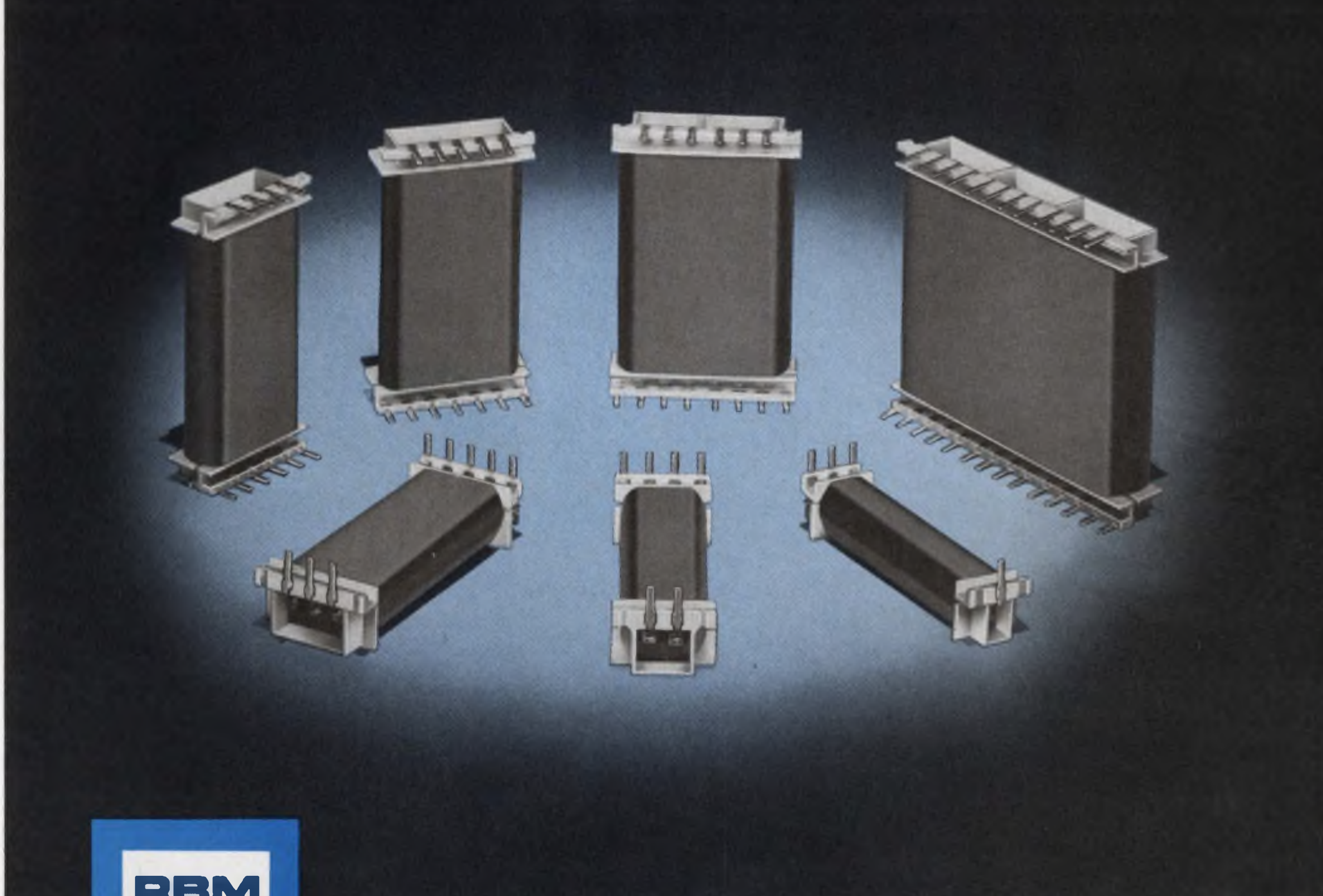

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Use the signal flow graph technique

without the tedious flow graph reduction step to analyze active and passive networks.

The solution to network problems is usually obtained by writing down the set of simultaneous equations that describe the network and solving them by substitution or by the matrix method. The flow graph method, first introduced by S. J. Mason,[1] however, can often significantly reduce the work involved. Many problems that might not even be attempted by lengthy equations are often solved with ease by the signal flow graph method.

Moreover, the signal flow method itself can be further simplified if the graph reduction step normally required is omitted.

What is a signal flow graph?

The signal flow graph method is a transformation from the matrix method to a topological method when a set of simultaneous equations is under consideration. The flow graph illustrates the passage of a signal through a network and indicates feedback paths present in the network. Once the flow graph has been constructed, the network solution can be obtained either by the rules of reduction or with Mason's general-gain equation.[2] Applying reduction rules to a flow graph generally cuts down the number of dependent variables associated with a set of simultaneous equations but is not necessary when the general gain equation is used.

A signal flow graph consists of junction points called nodes which represent network variables. The nodes are connected by paths which are called branches. The branches have direction with a signal traveling along a branch in the direction of the arrow. The flow graph for the expression:

$$x_2 = T_1 x_1 \quad (1)$$

is shown in Fig. 1a. Nodes x_1 and x_2 represent variables and the branch direction shows the dependence of x_2 on x_1. The coefficient T_1 is called the transmittance.

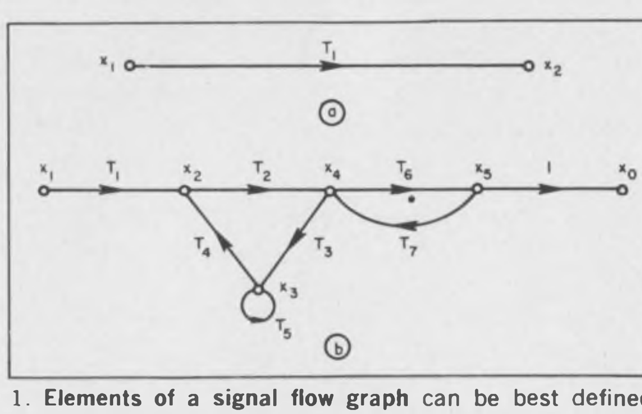
At this point it is well to define the terms illustrated in Fig. 1b:

Glenn B. De Bella, Project Engineer, Hewlett-Packard Co., Palo Alto, Calif.

Input node	A node with only outgoing branches (e.g., node x_1).
Output node	A node with only incoming branches. When this condition is not met, an additional branch of unity transmittance and an additional variable (e.g., node x_0) are introduced.
Path	A continuous succession of branches.
Forward path	A path connecting the input node to the output node where no node is encountered more than once (e.g., x_1, x_2, x_4, x_5, x_o). A flow graph may have more than one forward step.
Feedback loop	A path originating and terminating on the same node where no node is encountered more than once (e.g., x_2, x_4, x_3, x_2 or x_4, x_3, x_4).
Self loop	A branch originating and terminating on the same model (e.g., x_3, x_3 through T_5).
Path gain	The product of transmittances encountered along the path.
Loop gain	The product of transmittances of the branches forming the loop.

How to write network equations

There are many ways of writing a set of independent equations describing a network. With the



1. **Elements of a signal flow graph** can be best defined through a sketch. A flow graph for one branch (a) has an input node, x_1, transmission path, T_1, and an output node, x_2. Other elements appear in (b).

signal flow graph method, it is unnecessary to minimize the number of equations. It is advisable, however, to follow a systematic procedure for writing the network equations such as the following:

1. Define the variables. Except for situations where a network output is desired for many independent driving sources, there is one independent variable and n dependent variables.

2. For $(n+1)$ variables, use n independent equations.

3. Do NOT write an equation for the independent variable.

4. Write one equation for each dependent variable. This results in at least one branch entering every dependent node.

Once the signal flow graph has been constructed from the network equations, the solution T (the ratio of output variable to input variable) can be written down by inspection through use of Mason's general gain equation. This equation is:

$$T = \Sigma_k T_k \Delta_k / \Delta, \tag{2}$$

where:

T_k = path gain of the k^{th} forward path,

Δ = 1 − *sum of all individual loop gains + sum of the loop gain products of all possible combinations of two nontouching loops—sum of the loop gain products of all possible combinations of three nontouching loops + ...*

Δ_k = value of Δ not touching the k^{th} forward path.

Note that two loops are considered nontouching when they have no common nodes.

Ladder network analyzed

Consider the problem of finding the voltage transfer ratio, v_0/v_1, for the ladder network in Fig. 2a. In this figure v_1 is the independent variable and i_1, v_2, i_2, v_3, i_3, v_4, v_0 are the dependent variables. The network equations are:

$$\left.\begin{aligned} i_1 &= (v_1 - v_2)/Z_1, \\ v_2 &= Z_2(i_1 - i_2), \\ i_2 &= (v_2 - v_3)/Z_3, \\ v_3 &= Z_4(i_2 - i_3), \\ i_3 &= (v_3 - v_4)/Z_5, \\ v_4 &= Z_6 i_3, \\ v_0 &= v_4. \end{aligned}\right\} \tag{3}$$

From Eqs. 3 the signal flow graph can be constructed, as shown in Fig. 2b. The only forward path has a path gain:

$$T_1 = Z_2Z_4Z_6/Z_1Z_3Z_5. \tag{4}$$

The individual loop gains are:

$$-(Z_2/Z_1),\ -(Z_2/Z_3),\ -(Z_4/Z_3),\ -(Z_4/Z_5),\ -(Z_6/Z_5). \tag{5}$$

The loop gain products of all possible combinations of two nontouching loops are:

$$Z_2Z_4/Z_1Z_3,\ Z_2Z_4/Z_1Z_5,\ Z_2Z_6/Z_1Z_5,\ Z_2Z_4/Z_3Z_5,\ Z_2Z_6/Z_3Z_5,\ Z_4Z_6/Z_3Z_5. \tag{6}$$

The loop gain product of the only possible combination of three nontouching loops is:

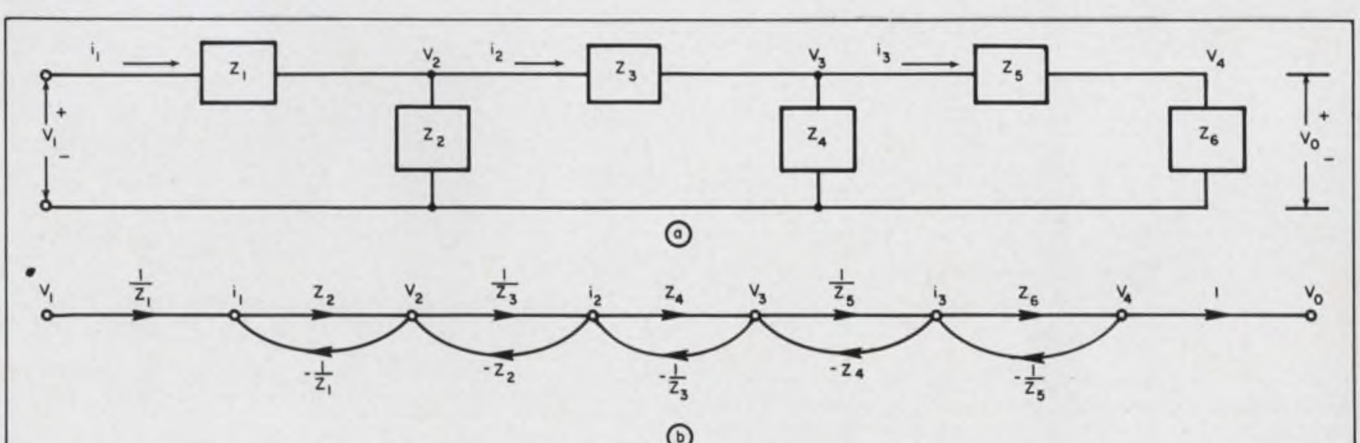
$$-(Z_2Z_4Z_6/Z_1Z_3Z_5). \tag{7}$$

Now, substituting Eqs. 4 through 7 into Mason's general gain equation (Eq. 2) yields a voltage transfer ratio:

$$v_0/v_1 = \frac{Z_2Z_4Z_6/Z_1Z_3Z_5}{\left\{\begin{aligned} &1 + Z_2/Z_1 + Z_2/Z_3 + Z_4/Z_3 + Z_4/Z_5 \\ &+ Z_6/Z_5 + Z_2Z_4/Z_1Z_3 + Z_2Z_4/Z_1Z_5 \\ &+ Z_2Z_6/Z_1Z_5 + Z_2Z_4/Z_3Z_5 \\ &+ Z_2Z_6/Z_3Z_5 + Z_4Z_6/Z_3Z_5 \\ &+ Z_2Z_4Z_6/Z_1Z_3Z_5 \end{aligned}\right\}}, \tag{8}$$

which could be rearranged to give a more pleasing form.

If, for example, the input impedance to the ladder network were desired, i_1 would be the independent variable, resulting in little change in the signal flow graph shown.



2. **A ladder network (a) and its flow graph** (b) demonstrate how voltage transfer ratio, v_0/v_1, can be determined.

Finding the voltage transfer ratio of an amplifier

As another example, consider the common-emitter transistor amplifier in Fig. 3a. The voltage transfer ratio, $v_0(s)/v_1(s)$ has to be found. From the small-signal equivalent circuit in Fig. 3b,[3] it is seen that v_1 is the independent variable and i_1, $v_{b'e}$, i_2, v_2, v_0 are the dependent variables.

The network equations are:

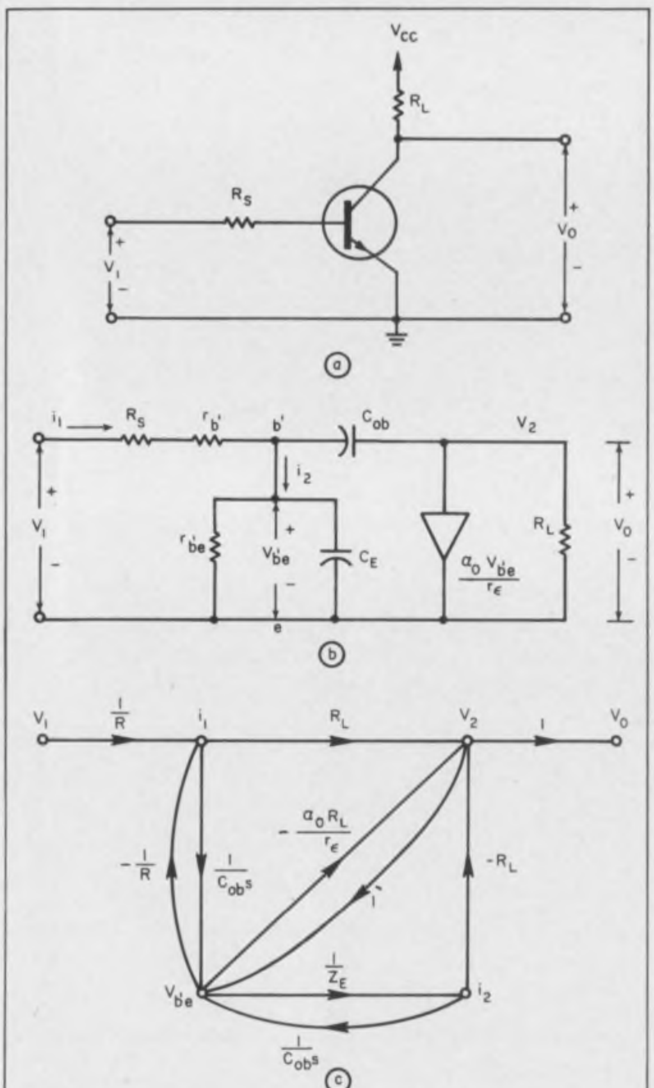
$$\left.\begin{aligned} i_1 &= (v_1 - v_{b'e})/R, \\ v_{b'e} &= [(i_1 - i_2)/C_{ob}s] + v_2, \\ i_2 &= v_{b'e}/Z_E, \\ v_2 &= [(i_1 - i_2)/R_L] - [\alpha_o R_L v_{b'e}/r_\epsilon], \\ v_0 &= v_2, \end{aligned}\right\} \quad (9)$$

where:

$$R = R_s + r_{b'}$$

and:

$$Z_E = r_{b'e}/(r_{b'e} C_E s + 1).$$



3. **A common emitter amplifier** (a) is first redrawn in its equivalent form (b) and the flow graph is then prepared (c). Determination of its voltage transfer ratio, v_0/v_1 is now a simple matter.

From Eq. 9, the signal flow graph is constructed as in Fig. 3c. There are three forward paths; their respective path gains are:

$$\left.\begin{aligned} T_1 &= R_L/R, \\ T_2 &= -\alpha_o R_L/R\, r_\epsilon C_{ob} s, \\ T_3 &= -R_L/R\, C_{ob} s Z_E. \end{aligned}\right\} \quad (10)$$

The individual loop gains are:

$$-(\alpha_o R_L/r_\epsilon),\ -(1/R C_{ob} s),$$
$$-(1/Z_E C_{ob} s),\ -(R_L/Z_E),\ -(R_L/R). \quad (11)$$

There are no nontouching loops. The loop with gain $-(1/Z_E C_{ob} s)$ does not touch the forward path given by T_1 in Eqs. 10.

The voltage transfer ratio is found by substituting Eqs. 10 and 11 into Mason's general gain equation:

$$\frac{v_0(s)}{v_1(s)} = \frac{\frac{R_L}{R}\left[1 + \frac{1}{Z_E C_{ob} s}\right] - \frac{\alpha_o R_L}{R r_\epsilon C_{ob} s} - \frac{R_L}{R C_{ob} s Z_E}}{1 + \frac{\alpha_o R_L}{r_\epsilon} + \frac{1}{R C_{ob} s} + \frac{1}{Z_E C_{ob} s} + \frac{R_L}{Z_E} + \frac{R_L}{R}} \quad (12)$$

Note that $\alpha_o = \beta_o/(\beta_o + 1)$ and $r_{b'e} = (\beta_o + 1) r_\epsilon$. Then substituting for Z_E enables Eq. 12 to be rearranged to give the more familiar:

$$\frac{v_0(s)}{v_1(s)} = \frac{-\frac{\beta_o R_L}{R + r_{b'e}}\left[1 - \frac{C_{ob} r_\epsilon}{\alpha_o} s\right]}{s^2\left[\frac{R r_{b'e}}{R + r_{b'e}} R_L C_{ob} C_E\right] + s\left[\frac{R r_{b'e}}{R + r_{b'e}}\left\langle C_{ob}\left(1 + \frac{\alpha_o R_L}{r_\epsilon}\right) + C_E\right\rangle + R_L C_{ob}\right] + 1} \quad (13)$$

In this example, as in the previous one, the network equations and the path and loop gains were written out before the general gain equation was applied. It is not unreasonable to expect, however, that with a little practice it would be possible to construct the flow graph directly from the network and to obtain the solution by inspection through use of Mason's general gain equation. ■ ■

References:

1. Mason, "Feedback Theory: Some Properties of Signal Flow Graphs," *Proc. IRE*, XLI, No. 9 (Sept., 1953), 1144-1156.

2. ———, "Feedback Theory: Further Properties of Signal Flow Graphs," *ibid*, XLIV, No. 7 (July, 1956), 920-926.

3. G. B. DeBella, "Stability of Capacitively Loaded Emitter-Followers: A Simplified Approach," *Hewlett-Packard Jour.*, XVII, No. 8 (April, 1966), 15-16.

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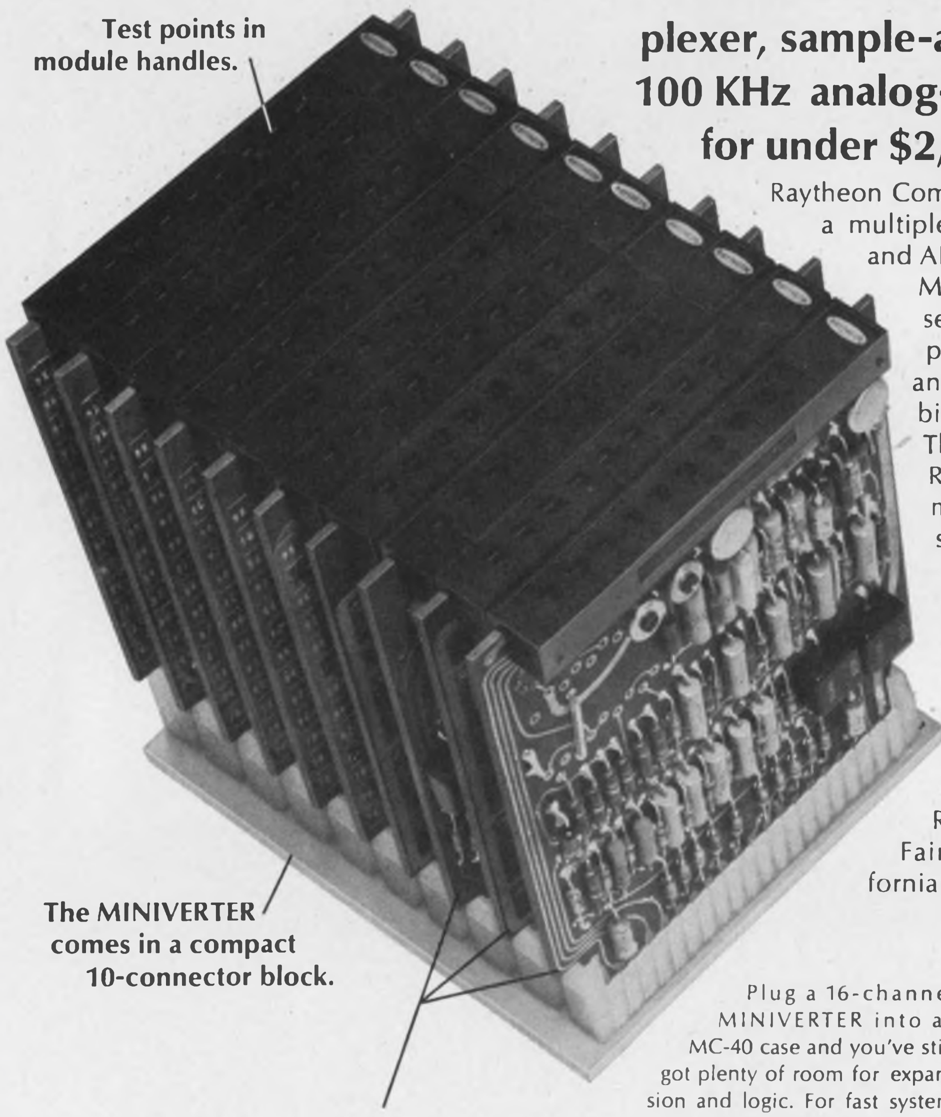

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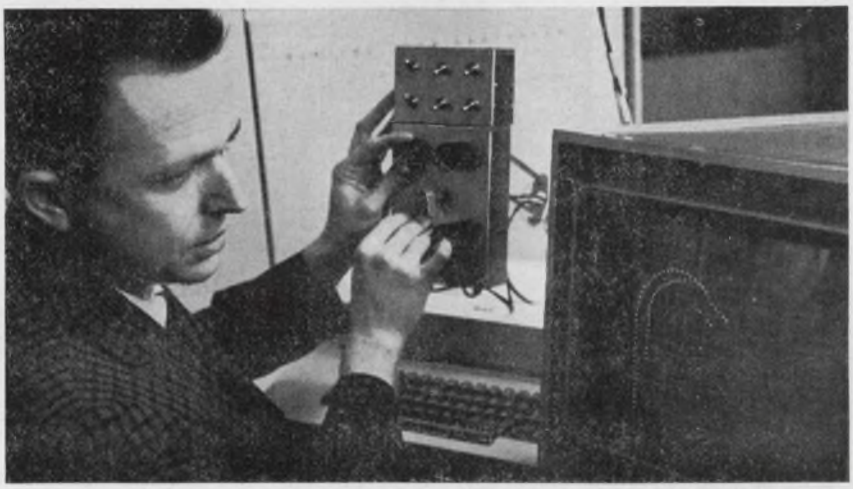
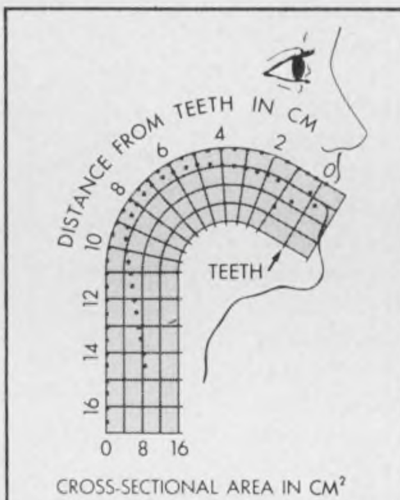
ON READER-SERVICE CARD CIRCLE 201

Report from
BELL LABORATORIES

See a computer talk

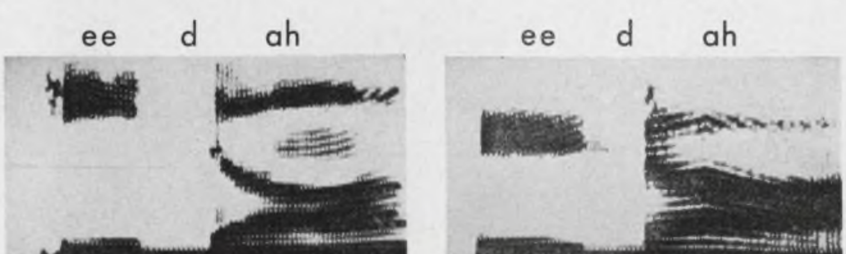


C. H. Coker adjusts controls which change the outline of the "vocal tract" simulated on the oscilloscope. At the same time, he hears the sound corresponding to the displayed shape. Desired vocal-tract shapes (representing sounds) can be stored in the computer memory.



Bell Laboratories' computerized vocal-tract model. (Head outline added.) The various parts can be positioned to imitate any speech sound. The model displays tract length versus cross-sectional area. It is based on anatomical measurements of the vocal tract made by a number of acousticians.

A feature of the model is that it reproduces the transition sounds between word fragments. The nonsense word eedah, for example, consists of ee plus d plus ah. But the d is not the same as in, say, eedee. That is, the d is noticeably affected by context. Coker handles this by storing dynamic properties of the vocal articulators (the tongue, lips and jaw). The program automatically incorporates these properties in assembling word fragments.



Comparison of nonsense word "eedah," pronounced by a human (left) and by Coker's program. These speech spectrographic patterns represent time (horizontal scale), frequency (vertical), and intensity (line density). The dark bars are called "formants" and are characteristic of speech sounds. The technique for making these diagrams was conceived and developed in the early 40's at Bell Telephone Laboratories.

Speech, one of the most complex of human activities, is studied as part of the continuing communications research at Bell Telephone Laboratories. But the speech mechanism has always been difficult to analyze: vocal-tract movements—crucial to the formation of meaningful acoustic signals—are mostly obscured from sight and are not easily measured. Now our understanding of speech is being advanced through a computerized simulation of the vocal tract devised by Cecil H. Coker of Bell Laboratories and Osamu Fujimura of the University of Tokyo, who worked at Bell Labs as a consultant.

The model (displayed on an oscilloscope, left) resembles the actual vocal tract and shows its principal parts. The parts can be moved either automatically by the computer program or by manual controls on the computer panel. The program calculates speech data corresponding to the displayed vocal-tract shape and delivers these data to an electronic speech synthesizer, designed by Coker. The synthesizer then generates a sound corresponding to the tract shape. Hence the researcher can hear the synthetic output at the same time he sees the tract motion.

The model accurately reproduces not only individual speech sounds but, for the first time, the subtle transitions that connect these sounds. It also demonstrates that these transitions are vital to clarity and realism.

The system produces patterns of frequency and energy (spectrograms) very like a human's (left). And it passes a more difficult test: pronouncing speech sounds which are understandable even when taken out of context.

Bell Telephone Laboratories
Research and Development Unit of the Bell System

CRT displays antenna patterns

directly with the aid of a simple test setup. Picking the best pattern is then child's play.

A new type of antenna pattern recorder, which can be built with components readily available in most laboratories, shows the pattern in polar form on a cathode-ray oscilloscope.

Besides giving a better "feel" for the pattern shape through the polar coordinates, the device eliminates the need for paper recording. For permanent recordings, a scope camera can be used, thus reducing storage space: instead of piles of paper, the selected patterns are photographed and filed away in a 4-inch-by-4-inch cabinet.

The basic form of the recording system is shown in Fig. 1. The antenna pedestal drive can be any variable speed drive. The antenna under test is attached to the antenna mast.

The signal received by the antenna under test is detected conventionally, and routed to the antenna recorder for display on a conventional pattern recorder.

The present system differs from the usual method, however, in that a synchrotransmitter is attached to the antenna mast in a 1:1 drive arrangement—that is, one revolution of the antenna mast produces one revolution of the synchrotransmitter shaft. The output of the synchrotransmitter is fed to a synchrofollower, located in the antenna pattern facility. The synchrofollower, in turn, drives a two-phase resolver on a 1:1 basis. The detected signal is fed into the rotor winding of this resolver. The two stator windings channel the components of the resolved signal into the plates of the cathode-ray tube, where they are recombined. Thus, assuming linear detection and amplification, the displayed pattern on the CRT will be a replica of the antenna pattern. A typical polar display (Fig. 2a) gives a much better and quicker understanding of a radiated pattern than a flat version (Fig. 2b).

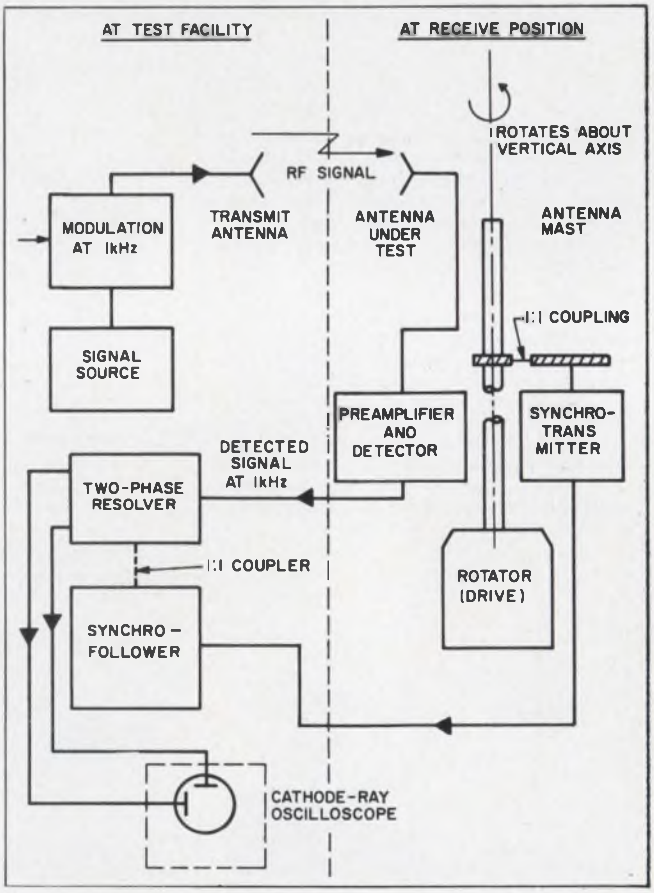
The only unit that is not standard in Fig. 1 is the detector preamplifier.[1] The preamplifier (see Fig. 3) offers voltage gain of about 74 dB—a useful value in view of the fact that most crystal detectors have a linear dynamic range only on the order of 30 dB. The bandwidth of the preamplifier is limited on the low side by C_5 and on the high side by C_2. With the components specified in Fig. 2, for example, the bandwidth is from 2.5 to 250 Hz. If C_2 is removed, the range extends up to 7 kHz.

To record antenna patterns at different frequencies, the frequency setting on signal generator has only to be changed. Thus, a swept-frequency source makes octave-bandwidth testing possible. ■ ■

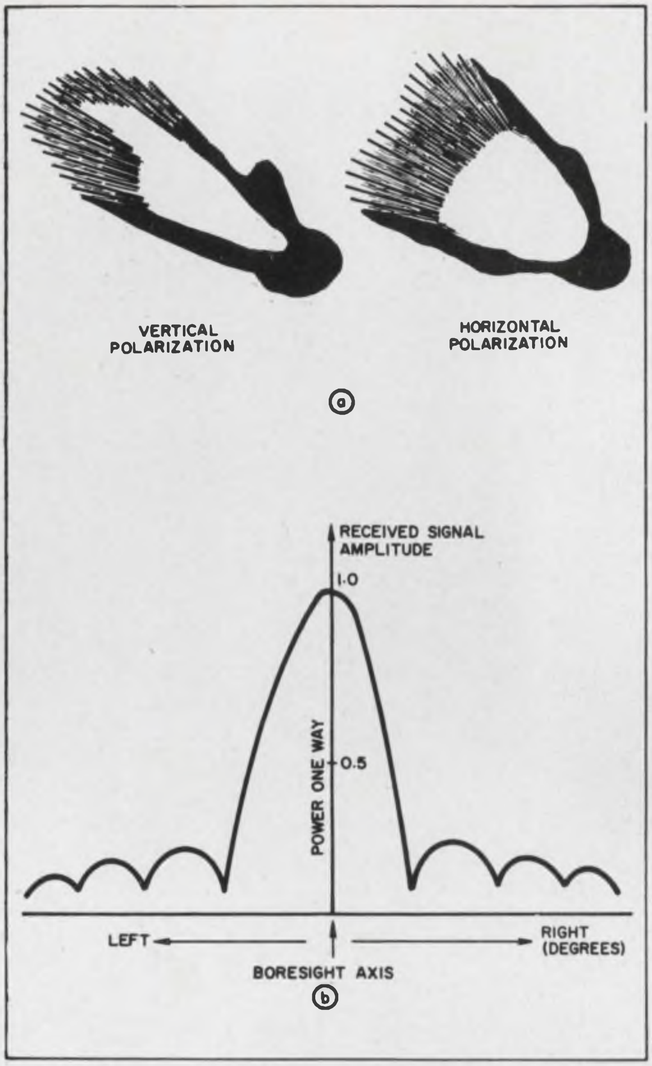
George J. Monser, Head, ECM Antenna Section, Raytheon Co., Goleta, Calif., and **Joseph Miller,** Engineering Specialist, American Electronic Laboratories, Inc., Colmar, Pa.

Reference:

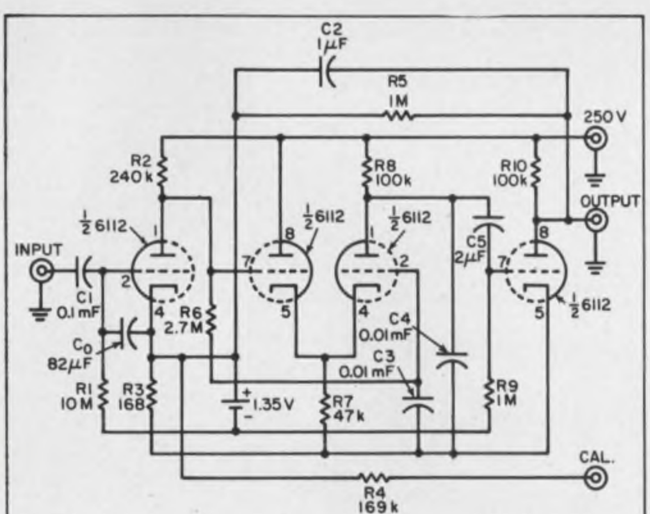
1. Nathan Buitenkant, "Infrared System Preamplifier Design," *EDN*, III, No. 8 (August, 1958), 36-45.



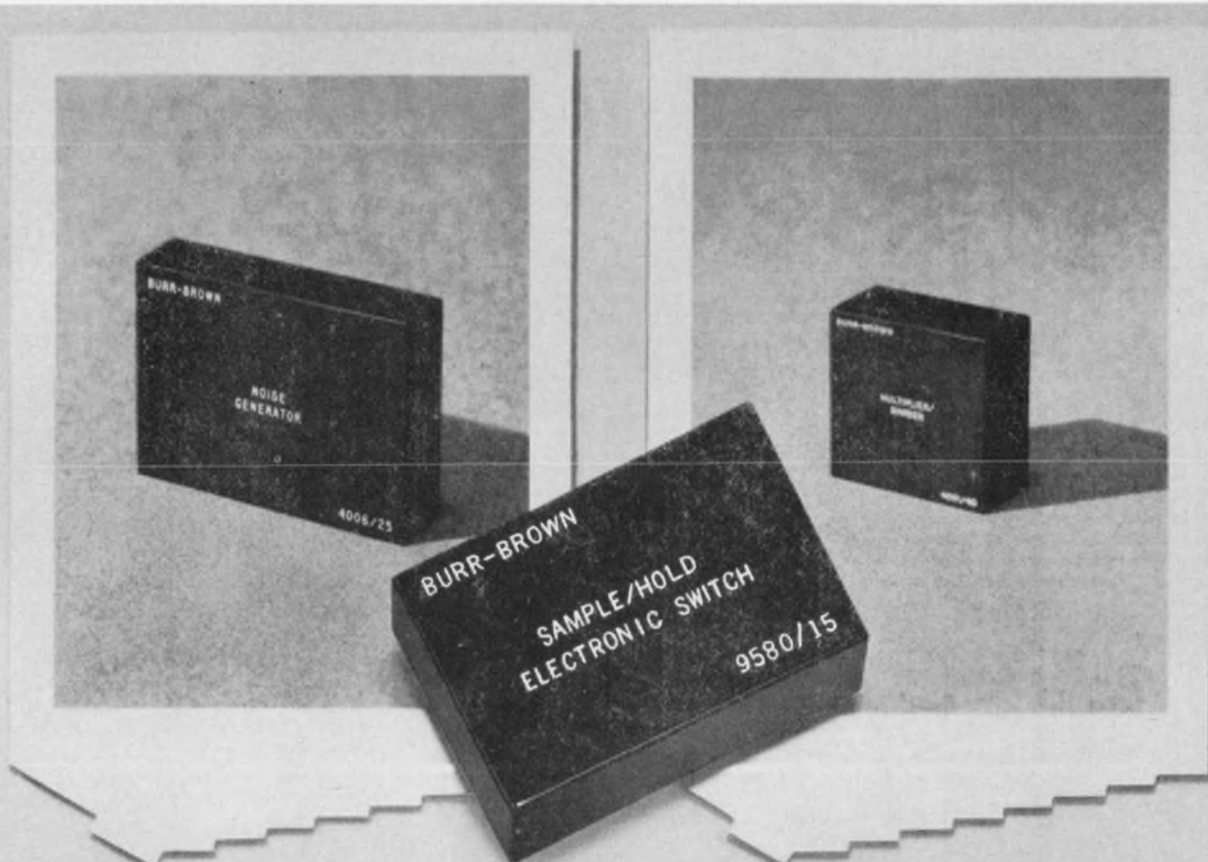
1. **Antenna-pattern display** uses a cathode-ray tube to show the actual polar pattern. Instead of storing the paper recording of conventional setups, the photos of the appropriate patterns can be put away in a 4-by-4-in. file cabinet.



2. **Typical polar pattern** immediately shows the directivity of the antenna and the relative energy radiated through the side-lobes (a). Strip-chart recording of the same pattern (b) is less clear.



3. **Only nonstandard circuit is the detector preamplifier,** which offers a gain of about 74 dB. Its bandwidth is limited by C5 at the lower end and by C2 at the upper. With the given components, the circuit has a bandwidth from 2.5 to 250 Hz. Removal of C2 ups the range to 7 kHz.



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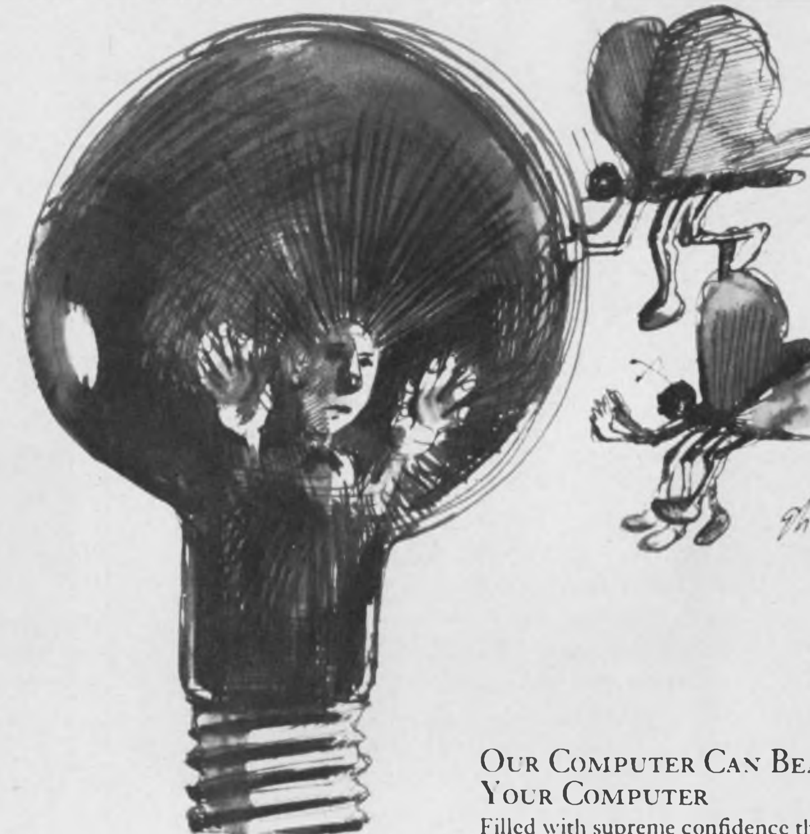
ON READER-SERVICE CARD CIRCLE 209

Chapter II. The Word from GENISCO.



Let There Be Light or Tell me about the Free $50 Switch

It's yours absolutely, unconditionally free. All we ask is that you give us $50 for it. Why do we call it "free" when we are earnest about getting paid for it? Two reasons:
First of all, when you throw the mechanical switch on, nothing happens until a teeny solid-state device senses that the voltage passes through zero. Then the switch turns the circuit on. When you throw the mechanical switch off and the current passes through zero, the circuit is turned off. That means that the on-off switching is done at the point of minimum energy. And that means no step function voltage to generate high-frequency components. And that means that the switch is *free* from radio frequency interference. *Quad est demonstradum.*

The second reason we call it "free" is we thought that if you thought you could get a $50 switch for nothing you'd probably be greedy enough to read this ad. There appears to be some justification for this assumption.

Circle reader service # 831

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For example, our new, compact FM Discriminator for playback in FM/FM telemetry systems. The pulse average design has 0.1% linearity. The Model 71-282 operates on all IRIG channels, 1-21, and A through H, with an input sensitivity of 20 mV. Accommodates any center frequency from 300 Hz to 300 KHz. Each one weighs less than a pound. Disgustingly inexpensive, too.

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How We Invented the Sandwich

To make the ruggedest possible field portable tape recorder we suspended the entire tape transport mechanism between two parallel flat plates. This gives double support to all members, and as the tape contacts only the primary drive mechanism, reel hubs, two turn rollers and the head surfaces, its oxide coating gets maximum protection.

As you know, the flanges on tape reels are cantilevered members which can be supported against extreme shock and vibration only at the cost of a substantial increase in the rotational inertia of a system. So we got rid of them. The tape can't slip off the reel because hoop tension forces resulting from normal pulling of the tape provide great compressive forces within the reel stack. It would take in excess of 300 g's for slippage to occur.

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Our Rate-of-Turn Table Laughs At Abuse

Our new Model 1147 maintains high precision performance regardless of rough handling and transportation. (One reason it's used as the AGE gyro test table for F-111 Aircraft System.) Hydrostatic bearings give precise dimensional stability, excellent alignment, low runout and eccentricity, low mechanical noise and long life. The bearing is capable of smooth rotation at less than siderial rates (.004°/sec.). And up to 1500°/sec.

The Model 1147's compactness makes it ideal for field or bench checking. Its ruggedness makes it ideal in case you just happen to feel like kicking hell out of a fine piece of equipment.

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Our Computer Can Beat Up Your Computer

Filled with supreme confidence the engineer plugs in his newly designed gem of a system. Then discovers that it's too noisy. So off to the supplier for a custom filter. It's expensive and its weird configuration makes it almost impossible to maintain a hermetic seal under the stresses of high pressures and extreme temperature variations.

We can help you avoid the what-me-need-a-filter syndrome. Give us a work statement. For free, we'll crank the system parameters into our computer and it will design the Perfect Filter. It will do the job right, and cost you about 40% less than one that must be produced downstream.

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Circle reader service # 835

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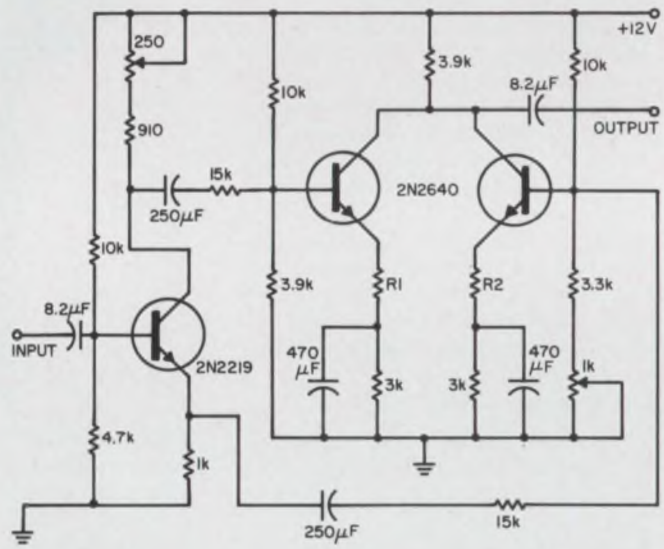
Matched bipolars replace FETs in a simple squaring circuit

The squaring circuit shown in the figure is very similar to that described by Theodore F. Bogart, Jr., in ELECTRONC DESIGN.* The main difference is the use of a matched pair of transistors instead of FETs. The transistors are forced to assume square-law characteristics by the use of small unbypassed resistors *R1* and *R2* in the emitter circuits. These resistors not only shape the square-law function but, in addition, by slightly unbalancing them, they can compensate for phase errors at low frequency, such as that due to insufficient or unbalanced emitter-bypass capacity. In this manner the frequency response may be extended downward. If high-frequency response is not important, *R1* and *R2* may be replaced by potentiometers.

To adjust this circuit, an input signal of 1000 Hz is used. The 250-ohm potentiometer is adjusted so that the outputs as measured at the collector and emitter of the 2N2219 are equal. Then the 1000-ohm potentiometer is adjusted so that the inputs at the two bases of the 2N2640 are equal. Looking at the output on an oscilloscope at nearly maximum output level, a 2-kHz signal should be seen with unequal successive peaks. The 250-ohm and 1000-ohm potentiometer are now alternately adjusted, with the output signal first at maximum level and then at minimum readable level, to equalize the peaks so that a pure 2-kHz sine wave is seen on the scope at all levels.



True square-law response is obtained with the circuit shown. R1 and R2 are approximately 22 ohms and can be potentiometers if high-frequency operation is not required.

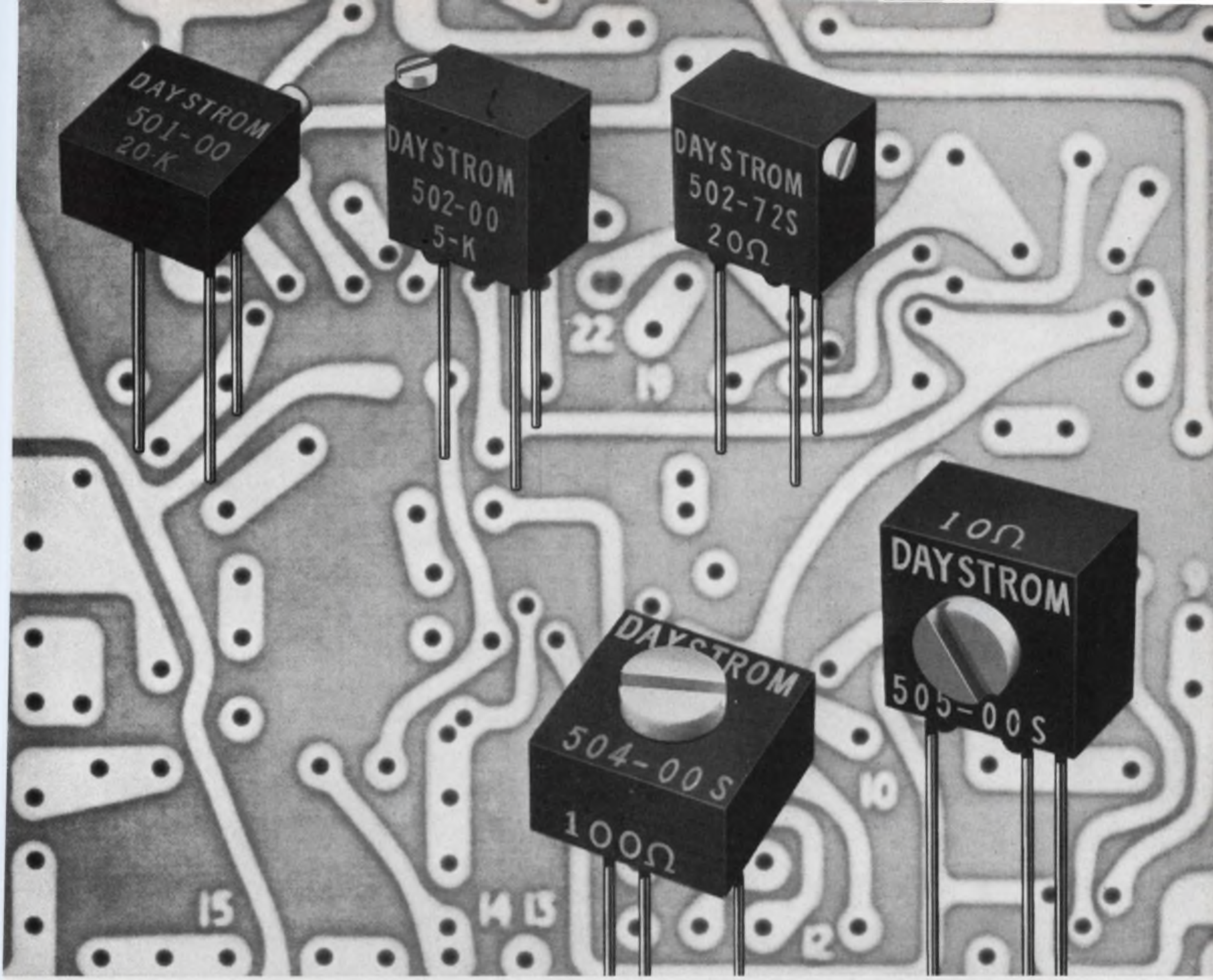
After this is done, record the maximum and minimum input and output levels to see if the circuit truly has the square-law characteristics. If not, readjust *R1* and *R2* until it is obtained. In this circuit, 22 ohms was found to be satisfactory with several transistors tried.

If low-frequency operation is required, readjust either *R1* or *R2* at the desired low frequency until a perfect sine wave is obtained at the lowest expected level of operation. This should have only a second-order effect on the square-law characteristic.

The circuit will operate with an open-circuit output of about 10 volts peak to peak and has a range of almost 60 dB.

It has not been thoroughly investigated espe-

*"Matched Transistors Passé for FET Squarer," *op. cit.*, XIII, No. 23 (Nov. 8, 1965), 36-41.



Savings across the board just took a new turn

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Daystrom *potentiometers are another product of:*

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WESTON® *prime source for precision . . . since 1888* cially with respect to temperature. It does demonstrate, however, that a square-law characteristic can be obtained practically with transistors. When four different 2N2640 transistors were successively inserted in this circuit, only a slight readjustment of the two potentiometers was necessary. This circuit may also be used as a low-distortion, low-frequency doubler with or without *R1* and *R2* in the circuit

(This work was performed for the Quality Control Laboratory at Marshall Space Flight Center, Huntsville, Ala.)

Richard L. Phares, Project Engineer, Spaco, Inc., Huntsville, Ala.

VOTE FOR 110

Foolproof dc regulator uses minimum of components

During normal operation diode *D2* in Fig. 1 is kept in conduction by the current flow in *R1*, so that changes in the output voltage arrive unattenuated at emitter of *Q2*. This compares the output with the Zener voltage of *D1* and amplifies the difference. The difference signal is used to make series transistor *Q1* a constant-voltage source.

When the output current increases, transistor *Q2* has to deliver more current to *Q1*. On overload, the current in *Q2* will make the voltage drop across *R1* so large that *D2* is cut off. Now the feedback loop is broken, and *Q2* becomes a constant-current source. Hence the output current remains constant.

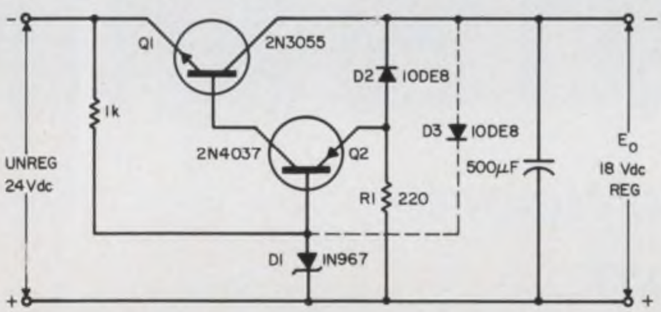
Excessive dissipation in *Q1* during overload can be prevented by adding diode *D3*. Normally *D3* is biased off. But when E_o drops below the Zener reference voltage, *D3* conducts and shorts Zener diode *D1*. This causes a drop in the emitter current of *Q2* and a consequent decrease of the output current.

The value of resistor *R1* determines the output current, I_o, at which diode *D2* turns off. It can be calculated as follows, if the β of *Q1* at I_o is known:

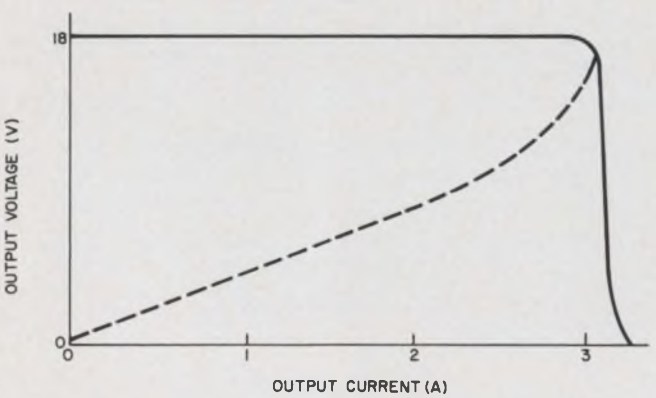
$$R1 = \beta(E_o - 0.5)/I_o.$$

H. L. Han, Staff Member, Technological University, Delft, Netherlands.

VOTE FOR 111



(a)



(b)

Output current remains constant (b) by the action of D2 (a). D3 keeps Q1 "cool" during a short.

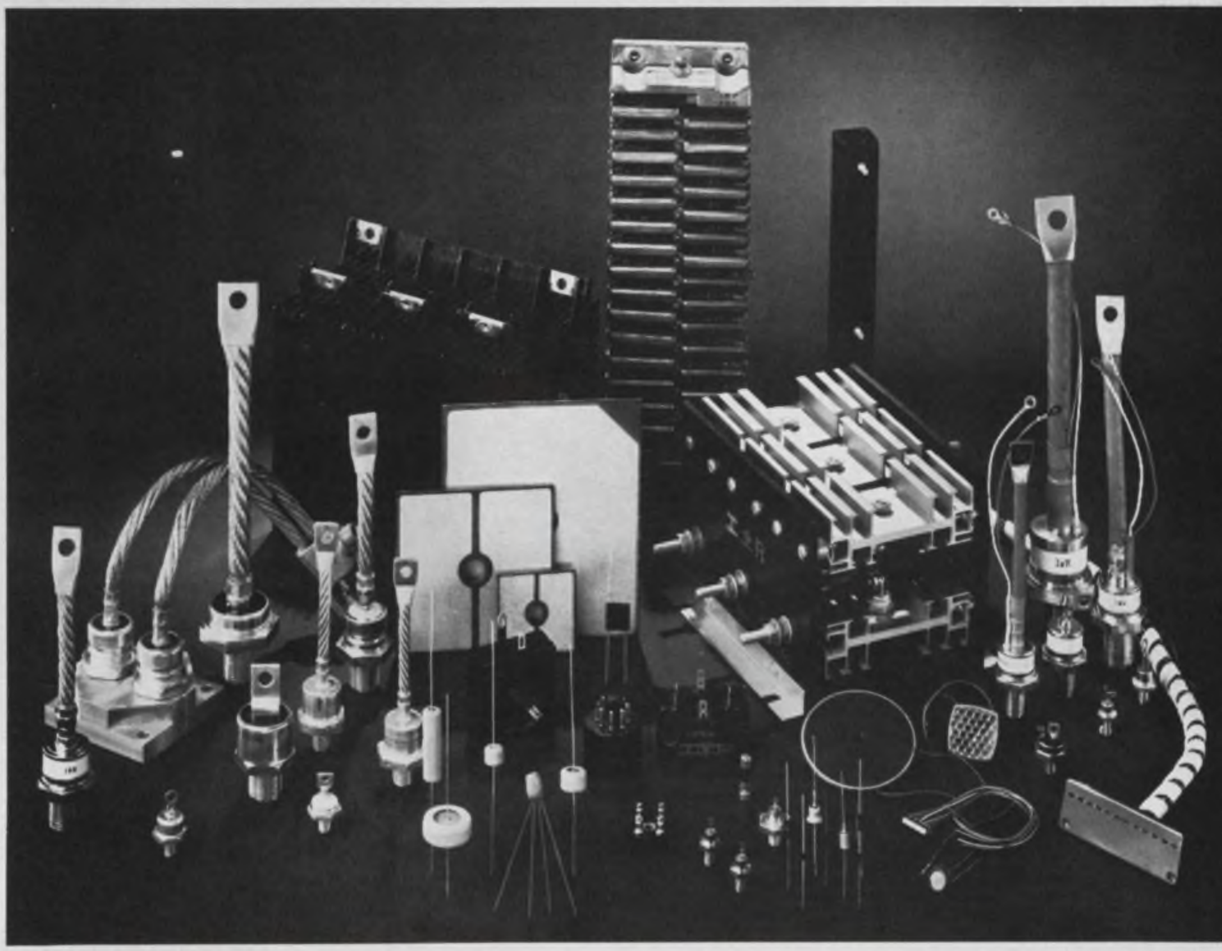
Electronic bailing circuit is all solid state

This design for an electronic bailing circuit requires only two interconnecting leads between selector circuits, and selector circuits are not restricted in location with respect to each other.

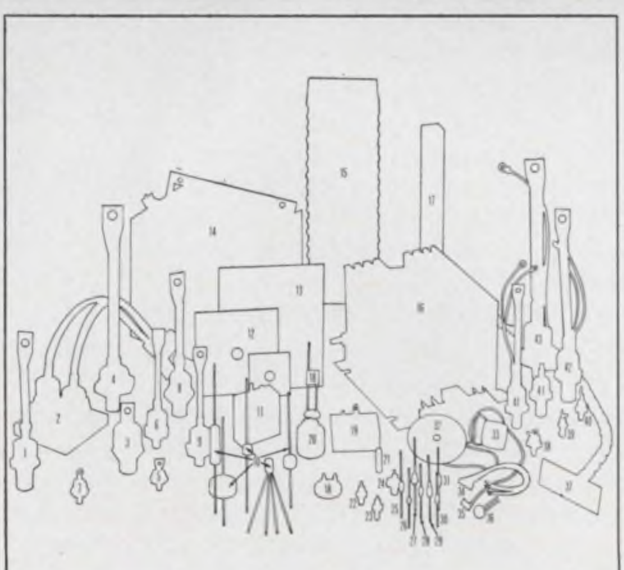
Bailing circuits are used in electronic equipment where there is a need to select one of several circuits at a time. When a circuit is selected, any previously selected circuit is automatically turned off. The most usual bailing methods utilize mechanical devices or multicontact switches or relays to perform the bailing function. Multicontact methods require several interconnecting leads between selector switches. Mechanical methods require that the individual selector switches be located in the same assembly.

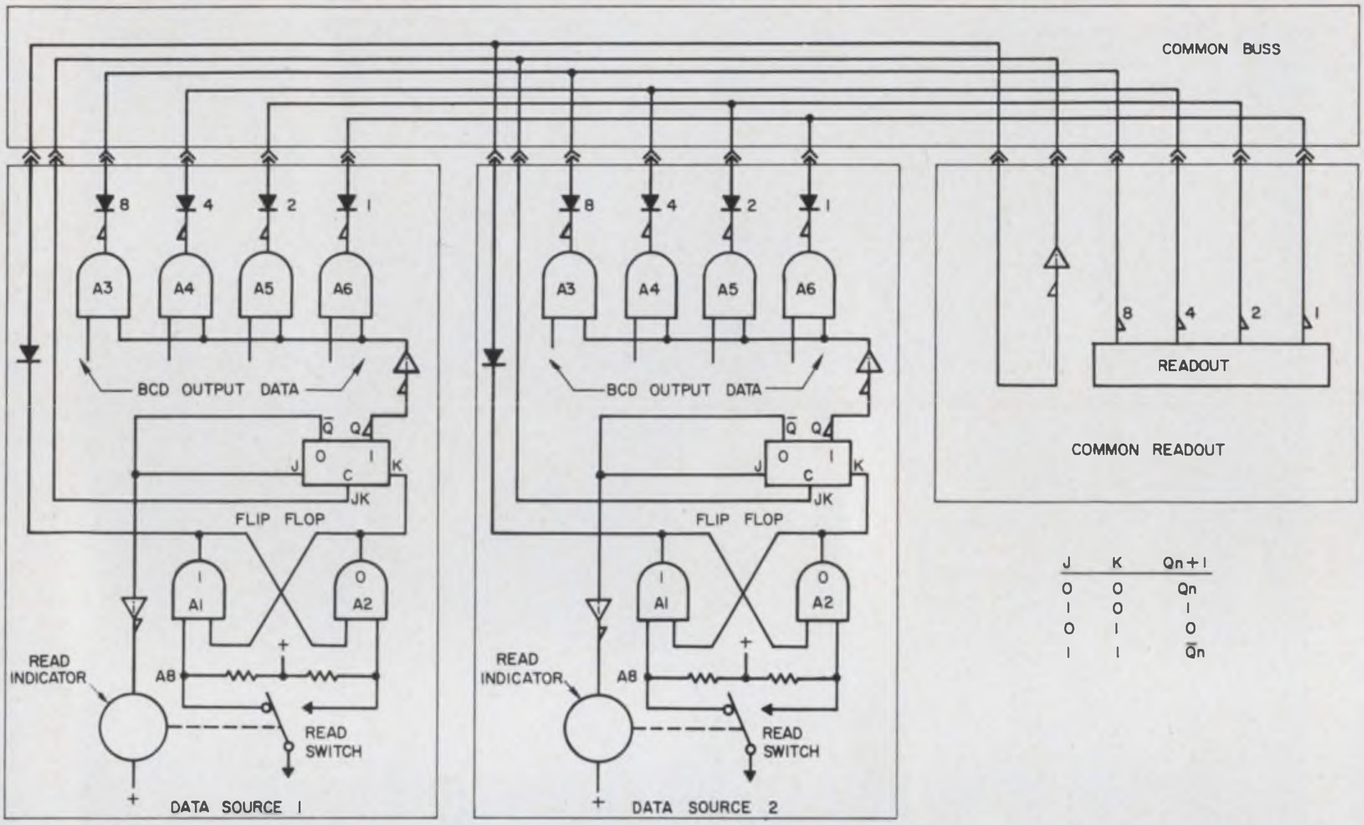
A typical application of the electronic bailing circuit is shown in Fig. 1. The circuit is used to gate on or off the output of two binary-coded-data (BCD) sources to a common read-out and ensures that only one of the two data sources is connected to the common read-out at a time. Although only two data sources are shown, additional data sources could be added in parallel with them.

The main element of the circuit is a J-K flip-flop in each data source. This device changes state on the leading edge of a positive-going signal at the clock (*C*) input. The *J* input is activated only when *J* is logical *1*; likewise, the *K* input only when *K* is logical *1*. A truth table for the *J* and *K* input is shown in Fig. 1. Data source gates *A1* and



The great IR family portrait





J	K	Qn+1
0	0	Qn
1	0	1
0	1	0
1	1	$\overline{Q}$n

Exclusively selective solid-state switching circuit (so-called bailing circuit) uses J-K flip-flops and several gates to connect data from any desired source to the common read-out, simultaneously disconnecting other sources. While only two data sources are shown, additional sources can be added in parallel.

A2 eliminate the effects of the contact bounce of the *READ* switch. Gates *A3* through *A6* gate the data source output, through the common bus, to the common read-out.

When the *READ* switch/indicator unit of data source 1 is operated, the output at gate *A2* goes to a logical *1* and the output at gate *A1* goes to a logical *0*. At this instant, the *K* input of the flip-flop is a logical *1* and the *J* input is a logical *0*. The negative or zero-going pulse at gate *A1* is inverted by the current amplifier of the common read-out and the positive-going output of this current amplifier is connected back to the clock input of the flip-flop. These input conditions will result in point *Q* of the flip-flop changing to a *0* level, its active state.

The positive-going output of the data-source current amplifier is also connected to the clock input of the flip-flop in data source 2. But since both the *J* and *K* inputs of this flip-flop are at *0* the flip-flop will not change state. With point *Q* of the flip-flop in data source 1 at a *0* level, the BCD output gates that connect data from data source 1 to the read-out are activated. Point *Q* of the flip-flop is also at a *1* level, which, when inverted at current amplifier *A8*, will result in the *READ* switch/indicator being lighted. When the *READ* switch/indicator is released, the level at gate *A2* returns to a logic 0 and gate *A1* returns to a logic *1*. At this instant, the *K* input of the flip-flop is a logic *0*, and because the flip-flop is now in the active state ($\overline{Q} = 1$), the *J* input is then a logic *1*.

The positive-going pulse at gate *A1* is inverted at the read-out–module current amplifier, resulting in a negative-going signal at the flip-flop clock input. Since the flip-flop changes state only on a positive-going signal, the flip-flop remains in the active state until either the *READ* switch/indicator of data source 1 is operated again or until the *READ* switch/indicator of data source 2 is operated.

With the flip-flop of data source 1 in its active state and the *READ* switch/indicator released, the *K* input of the flip-flop is a logic *0* and the *J* input is a logic *1*. If the *READ* switch/indicator of data source 2 is then operated, data source 2 output data will be gated to the common read-out in the same manner as for data source 1. In addition, the positive-going output of the common-read-out current amplifier will cause the flip-flop of data source 1 to change from the active to the inactive state.

If a data source is connected to the common

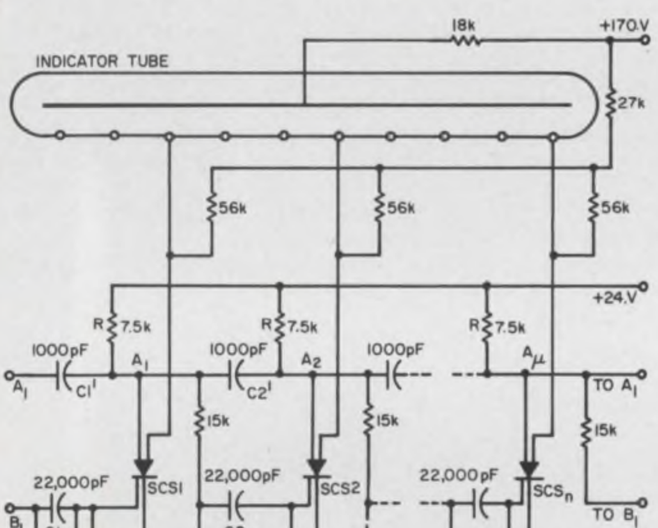
read-out, it can be disconnected simply by actuating its *READ* switch/indicator. When the switch/indicator is actuated, both the *J* and *K* inputs of the flip-flop are a logic *1*. The positive-going pulse from the common-read-out current amplifier will cause the flip-flop to change its state.

D. R. Deatherage, Product Tester Design Div., Sandia Corp., Albuquerque, N. M.

VOTE FOR 112

Ring counter uses SCSs and neon tubes

Counters to any base can be built very simply with silicon-controlled switches (SCSs) and neon display tubes, such as Nixies. In addition to their versatility, SCSs can drive the display tubes directly. Such counters are widely useful because of their low cost and high noise immunity, particularly in digital clocks requiring counters to the bases of six and ten.



SCS=3N83, Q=2N3704 DIODES = OA-200 PHILIPS

Ring counter to any base can be built with an appropriate number of switching blocks and neon display tubes. The speed of this counter is limited by the value of RC and the response of the Nixie tube.

Here is how the counter works. Assume *SCS1* is on and *SCS2*, · · · SCS_n are off. On the arrival of a positive-going square pulse, only diode *D2* is forward-biased, since points A_2, · · · , A_n are at the supply voltage. Diodes *D1*, *D3*, · · · , D_n do not conduct. The input pulse reaches gate 1 of *SCS2* through the differentiating network *C2R2* and turns it on.

This causes the voltage at point A_1 to fall to −24 volts. The current previously passing through *SCS1* is diverted to charge capacitor *C2*. The voltage at point A_1 will reach zero after time $t = 0.69\ R\ C2'$.

The turn-off time of *SCS1* is less than *t* and the *SCS1* will be turned off.

Paolo Redi, Engineer, Officine Galileo, Florence, Italy.

VOTE FOR 113

Explosive motor characteristics are measured without difficulty

Here is how a test set to obtain force and displacement curves for the piston travel of an explosively actuated linear motor was designed. The rate of travel of the motor piston is approximately 2 inches per millisecond. The output of the test set is an oscilloscope photograph, recording the force-vs-displacement curves as a function of time.

In Fig. 1a, the dynamic load is the weight of the load piston, which is easily changed, making variable loads possible. The static load is a result of air pressure. The load piston, lamp and photocell are all encased in an airtight housing. This housing is pressurized and only the load piston is affected by the differential pressure. If the surface area of the end of the load piston is known, any static load may be obtained by application of the proper air pressure.

A light is directed through slots in a cylinder onto a photodiode. A load piston, driven by the piston of the motor under test, cuts off the light as the piston is displaced up the cylinder. The schematic drawing illustrates the electrical simplicity of the device.

The linearity of the displacement curve depends on a uniform intensity of light across the slot. The lamp filament is a concentration or hot spot of light. A means is needed to spread the image of the filament across the slot. A cylindrical lens made simply from a glass rod of a diameter larger than the slot length yields good results.

The photocell is the EG&G SD100 photodiode. This device, mounted in a TO-5 can, has a turn-off time of approximately 15 nanoseconds.

Calibration of the distance-vs-time signature is

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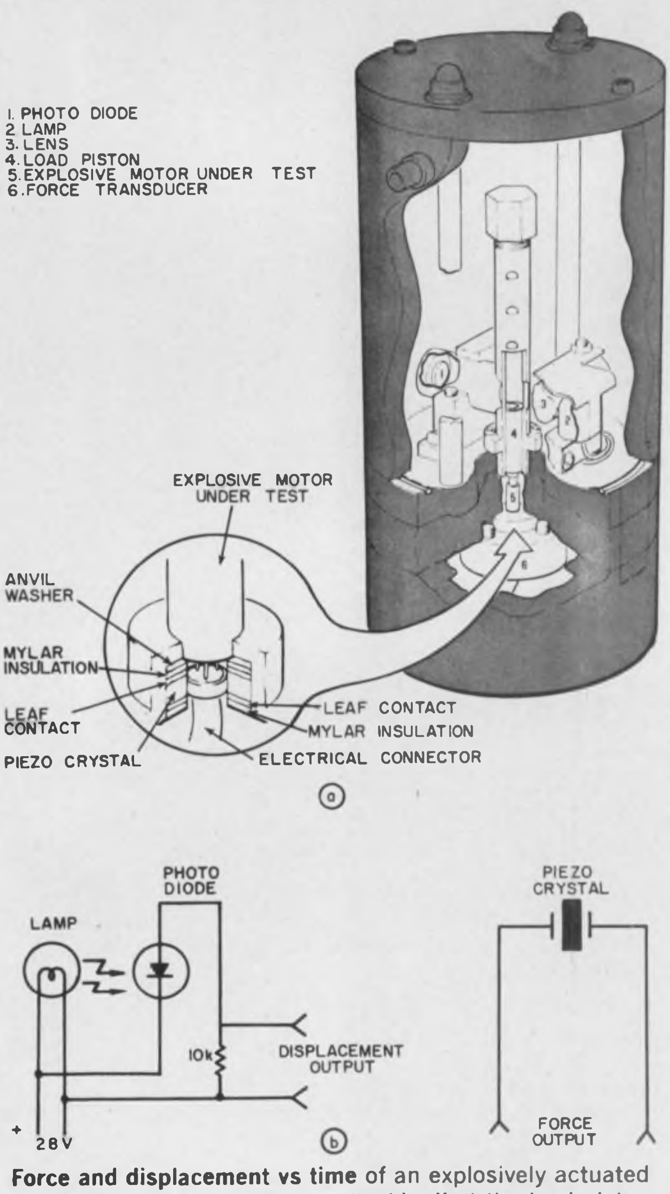
The greatest time resolution on the oscilloscope can be obtained if it is triggered by the bridge-wire-to-case ionization of the explosive motor. Triggering is done with 200 volts dc and a 0.22-μF capacitor. The scope is set for 0.2 ms/cm sweep with the vertical sweep set to give the maximum display of 1-volt pk-pk signal. It is of interest to note that the completion of motor piston travel can be seen on the displacement trace as a discontinuity. This is the point of separation of the motor and load pistons. This point can also be detected on the force trace.



Force and displacement vs time of an explosively actuated linear motor are measured by "looking" at the load piston with the photocell and by measuring the reaction force of the motor with the piezoelectric washer (a). The test circuit is simple (b).

The force-vs-time output is obtained with a ceramic piezoelectric washer, 0.625 inch in diameter and 0.035 inch thick, with a 0.321-inch hole in the center. A "sandwich" is made with the crystal, contact leaves on either side of the crystal, mylar insulators, and a steel anvil washer. The bottom of the explosive motor sits on the anvil washer. When the piston is fired up the cylinder, the reaction force is transduced by the crystal and displayed on the scope.

The crystal can be calibrated with a static load and an electrometer, voltmeter or charge amplifier. Calibration can also be accomplished with a dynamic force such as that generated with a pendulum. The force is then easily calculated.

The output of the crystal is not linear; but with proper calibration, this is no problem. The force on the crystal may be as high as 600 pounds with a corresponding output of over 300 volts. There is some attrition due to breakage, but crystals are easily changed and are made to such tolerances that recalibration is unnecessary.

J. M. Phillips, J. K. Shane, R. M. Bleakney, Component Test Equipment, Development Div., Sandia Corp., Albuquerque, N. M.

VOTE FOR 114

FET buffers output of voltmeter or counter

A field-effect transistor (FET) may be used as an impedance buffer and level inverter between four-line binary-coded-decimal (BCD) printer output and negative-potential diode-transistor logic.

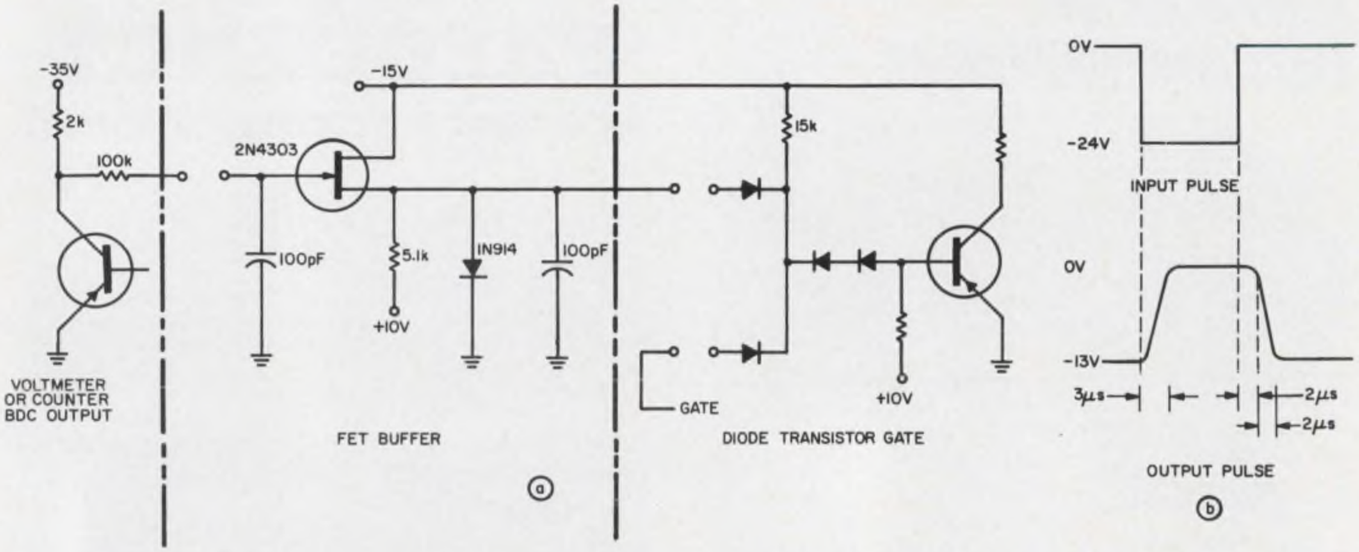
A specific problem was to gate the four-line BCD printer output of a Dymec 2401C voltmeter. The logical *1* level consisted of a 0- to −5-volt dc level; the logical *0* level of a level of −24 to −35 volts dc. These voltages are isolated by a 100-kΩ resistor.

The FET buffer circuit of Fig. 1a solved the problem. The 2N4303 is an n-type industrial-grade FET. The main characteristics exploited here are:

Min saturation current (I_{DDS})	4 mA
Max pinch-off voltage (V_p)	6 V

The 4-mA minimum saturation current provides an output voltage of about −10 volts dc for a 0-to-−5-volt dc input (logical *1*).

The 6-volt maximum pinch-off voltage guaran-



FET impedance buffer and level converter solves the problem of coupling output of a digital voltmeter to a DTL AND gate (a). Input-output waveforms are shown in (b) together with the two-input DTL gate.

tees turnoff of the FET for a 24-volt (logical *0*) input.

The logic inversion is such that the buffer circuit will work directly into a negative-potential diode-transistor-logic (DTL) two-input AND gate, which in this case was the desired end result.

Sketches of turn-off and turn-on time are shown in Fig. 1b. For an input of a −24-volt pulse with 30-nanosecond rise and fall times, the output pulse had about a three-microsecond rise time (FET turn-off) and a two-microsecond delay plus two-microsecond fall time (FET turn-on). In the breadboard circuit, a 100-pF capacitor was added at the input and output to simulate wiring capacitance.

J. H. Smelser and D. M. Morrison, Product Tester Design Div., Sandia Corp., Albuquerque, N. M.

VOTE FOR 115

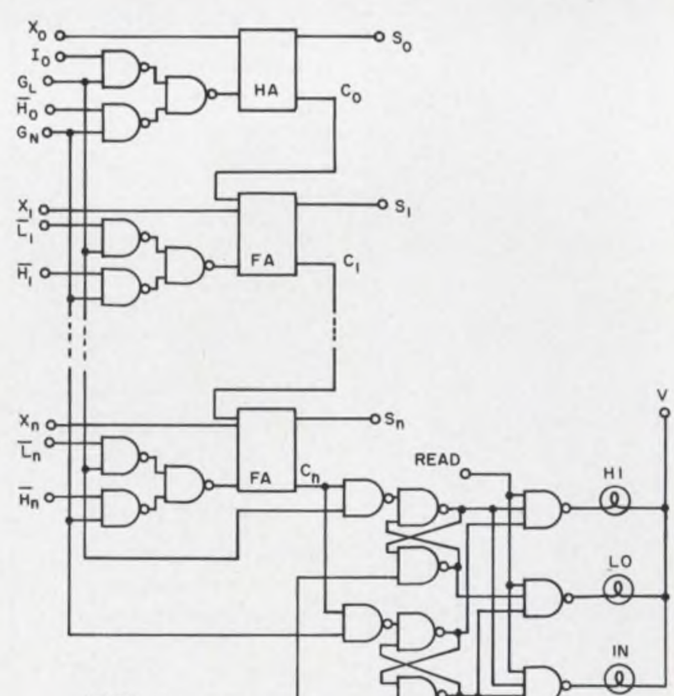
Go-no-go digital comparator uses complementary addition

Two binary numbers can be compared by subtraction. This may be performed and more easily implemented by complementary addition.

In general, when any two numbers in the same binary form (straight binary, excess three, Gray, and any form of BCD.) are compared by complementary addition, the final carry term will be a *1* if the unknown is greater than the limit, and a *0* if the unknown is less than or equal to the limit.

Determining whether a binary number, X, lies between two limits, H (high) and L (low), requires two comparisons. When X is compared with H, the carry term should be *0*; when X is compared with L, the carry term should be *1*. Therefore, by making two comparisons and storing the resulting carry terms, a below-limits, in-limits, or above-limits condition can be recognized.

The schematic for an n-bit, dual-limit comparator is shown in the figure. Standard half-adder and full-adder circuits compare first digits X_o - X_n with digits L_o - L_n (low limit), and then X_o - X_n with H_o - H_n (high limit). Each resulting final



Comparator stores the final carry from the separate high and low limit checks. The two carries are decoded to give in- or out-of-limits signals.

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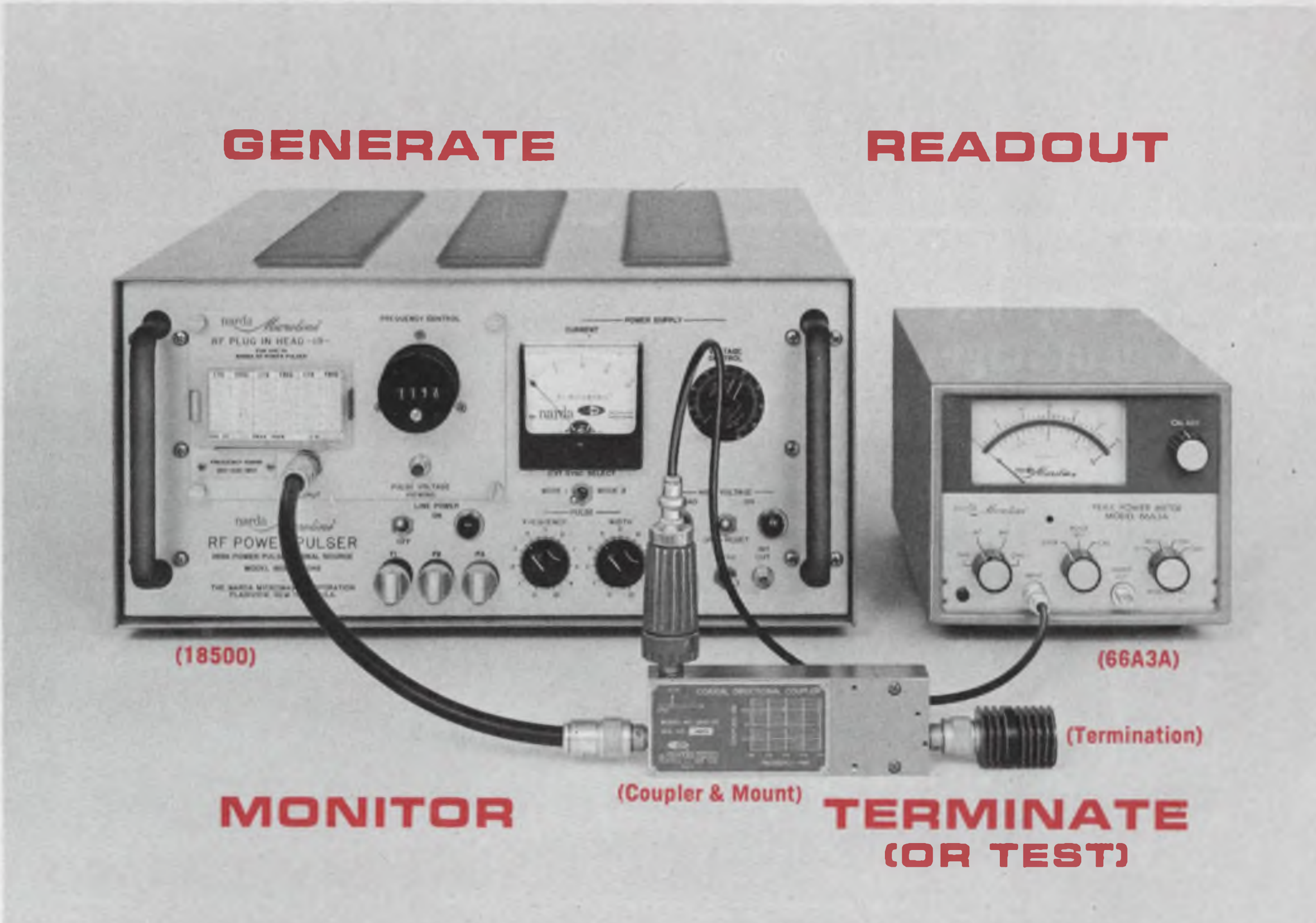

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carry term, C_n, is stored and appropriate logic circuits provide an output as shown in the truth table.

The main feature of this comparator is that it is a universal-decision element, providing automatic accept-reject information on any parameter which can be digitized. Digital comparison accuracy is absolute so that total system accuracy depends only on the analog-to-digital converter used in the measuring equipment, which is commonly ±0.1%.

J. Lopper and R. Stinson, Engineering Research Center, Western Electric Co., New York.

VOTE FOR 116

Mini-noise amplifier has FET input stage

This device can be used where noise, temperature stability, dynamic range, gain requirements, and physical size are critical.

The circuit (see figure) is basically a two-stage FET amplifier with a Darlington output stage. The advantages of using FETs are twofold: they give an internal noise threshold of −112 dBV over a bandwidth from 60 Hz to 24 kHz, and they provide the high input impedance. In addition, the current drain in the stand-by mode is very small which is important in any battery-operated equipment.

Each amplifier stage provides 20-dB gain for an over-all gain of 40 dB. The first stage is operated in the self-biased mode to provide greater stability.

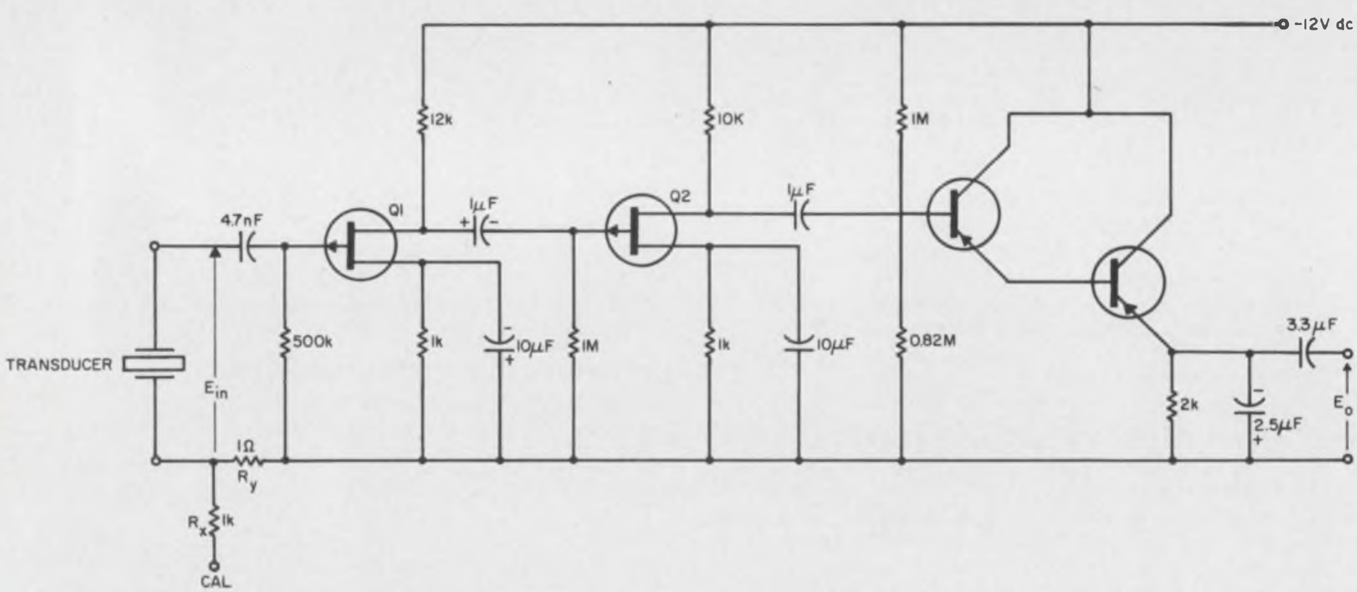
It has been found that the signal variation is ±1 dB over the frequency range. Negative feedback can be added to improve stability with a corresponding increase in noise level.

The Darlington output stage reduces the effective output impedance to 40 ohms in order to operate into low-impedance cables.

The use of tantalum capacitors and metal-oxide-film resistors makes for a small package which can easily be encapsulated along with its battery supply. The addition of resistors R_x and R_y allows for the calibration of the entire system.

William Martin Keane, Electronics Engineer, U. S. Navy, Office of Naval Research, Bermuda.

VOTE FOR 117



Low-noise amplifier with high input impedance uses two FET input stages. The output of the amplifier is flat within ±1 dB from 60 Hz to 24 KHz. A Darlington pair at the output gives 40 ohms' output impedance.

IFD Winner for May 10, 1967

Les Toth, Project Engineer, Diamond Electronics, Lancaster, Ohio.

His Idea, "IC and four resistors compose inexpensive voltage regulator," has been voted the $50 Most Valuable of Issue Award.

Cast Your Vote for the Best Idea in this Issue.

Solid-state converter combines two functions

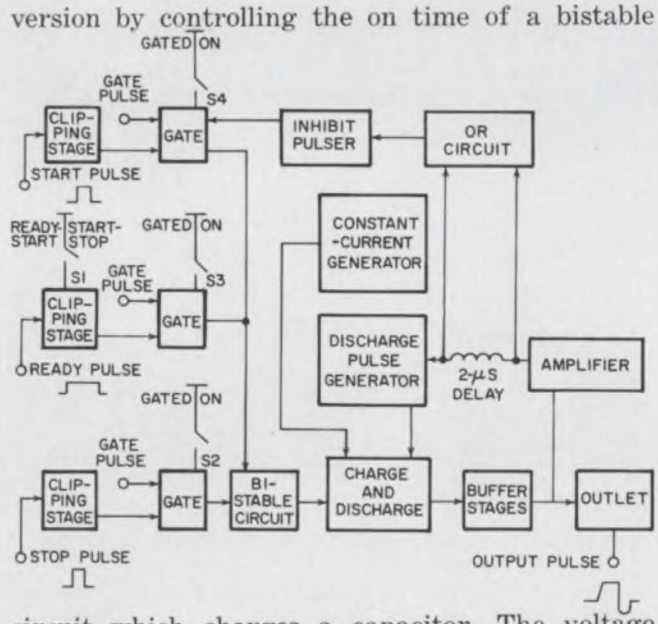
Problem: Design a circuit capable of producing an output pulse with an amplitude directly proportional to the time interval between two input pulses. A single circuit must be capable of operating under two separate and distinctly different input conditions:

- It must measure the time interval between two pulses which occur in very rapid succession. This time interval is generally of shorter duration than that of the pulse lengths themselves.
- It must measure the time interval between the starting point and the end point of a continuous "beam"-type pulse. The circuit in this instance receives not two pulses, but one in the form of burst energy.

Usual methods of obtaining time-to-pulse-height conversion require that separate circuits be used for each type of input condition.

Solution: Incorporate selected circuit options into one solid-state circuit, to achieve variable mode operation. A tunnel diode, used as a bistable element, controls the charging time of a capacitor in proportion to the time interval being measured for either randomly or periodically occurring pulses.

The device achieves time-to-pulse-height conversion by controlling the on time of a bistable



circuit which charges a capacitor. The voltage developed across the capacitor is thus proportional to the time interval. After a short time interval, the capacitor is discharged so that the circuit is ready for a new conversion. The conversion is accomplished by five basic circuit functions:

- Wave-shaping circuits and gates.
- Converter circuits.
- Capacitor discharge circuit.
- Start pulse inhibit circuit.

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- Isolating and output stages.

The system permits two modes of operation: ready-start and start-stop.

The ready-start mode measures the time interval between two pulses occurring at a random rate. By switching *S1* in the ready-start position, the circuit turns on the bistable element whenever a start pulse appears coincidentally with a ready pulse. The ready pulse, of a duration fixed by a delay cable, switches the bistable element off.

With *S1* in the start-stop position, a ready current is always present at the bistable circuit, and the bistable circuit is turned on by a start pulse. The circuit remains on until either a stop pulse or a negative ready pulse is applied. This mode of operation is used for experiments where one pulse occurs at a periodic rate, i.e., pulsed-beam experiments.

The wave-shaping circuits and gates first shape the input pulses (start, ready, and stop) in size and duration. The start and stop pulses, which must be positive, are clipped to a duration of 7 μs. The ready pulse is clipped to a time longer than the true interval of interest. The start pulse is delayed so that for isochronous pulses it arrives later than the start of the ready pulse.

The capacitor discharge is controlled by the pulse generator and the charge and discharge circuitry. A normally cut-off transistor amplifier is brought into conduction and discharges the capacitor after a 2-μs delay. The discharge current of the capacitor produces an output pulse of an amplitude that is directly proportional to the time interval between input pulses.

The OR and inhibit pulser circuits close the gate to the start pulse regardless of the position of *S4*. This is to ensure that a new start pulse will not enter when a cycle is in progress. A 2-μs delay line between the discharge pulse generator and the OR circuit provides a flat-topped pulse suitable for use with a multichannel pulse-height analyzer.

The isolation and output section uses three cascaded emitter-followers to present a very high impedance to the charging capacitor, thus minimizing capacitor leakage current and maintaining system accuracy.

The input pulses must have a rise time of less than 10 ns and an amplitude of at least 1.5 volts.

Ready pulses appearing at the input of the device must have a time duration greater than the time lag between the pulses under observation. This is to ensure that clipping of the ready pulse at the ready clipping line will not impair the complete coincidence condition which must occur between ready and start pulses.

Inquiries concerning this innovation may be directed to: Office of Industrial Cooperation, Argonne National Laboratory, 9700 South Cass Avenue, Argonne, Ill. 60439 (B67-10053).

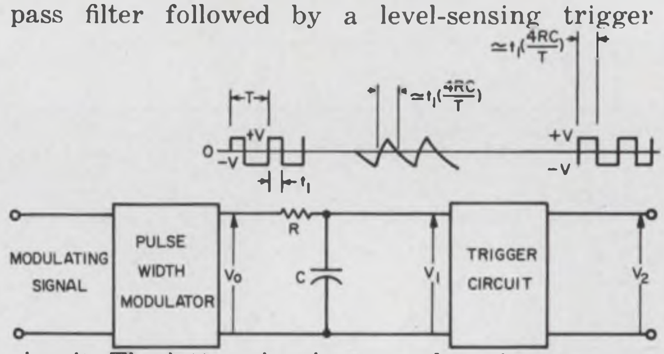
Inquiries about obtaining rights for commercial use of this innovation may be made to: Mr. George H. Lee, Chief Chicago Patent Group, U.S. Atomic Energy Commission, Chicago Operations Office, 9800 South Cass Avenue, Argonne, Ill. 60439.

Multiply width of pulse in two easy steps

Problem: Provide a simple means to multiply the width modulation of a pulse train by some constant factor.

Solution: A modulation multiplier that operates directly on a pulse-width-modulated input signal, to generate an output pulse train that has a greater degree of width modulation than the input signal.

Pulses from the pulse-width modulator are applied to the input of the modulation multiplier. The modulation multiplier consists of an RC low-pass filter followed by a level-sensing trigger



circuit. The latter circuit responds to its exponential sawtooth input voltage, V_1, by switching to output level $+V$ when V_1 is positive, and to $-V$ when V_1 is negative. In this way the circuit generates the pulse-width-modulated output, V_2.

When the *RC* time constant is equal to or greater than the period *T* of the pulses V_0 (the input to the modulation multiplier), the multiplication is linear (within 2 per cent when *RC* is equal to the input pulse period, and better as the *RC* time constant increases) over the whole range of operation. The output modulation is greater than the input modulation by approximately $4RC/T$.

The modulation multiplication method also applies to input-pulse switching between $+V_0$ and 0 volts. However, the level at which the trigger circuit changes state must be adjusted to compensate for the additional dc level of the input pulse.

Inquiries concerning this invention may be directed to: Technology Utilization Officer, Headquarters, National Aeronautics and Space Administration, Washington, D. C. 20546 (B67-10055). Inquiries about rights for the commercial use of this invention may be made to NASA, Code GP, Washington, D. C. 20546.

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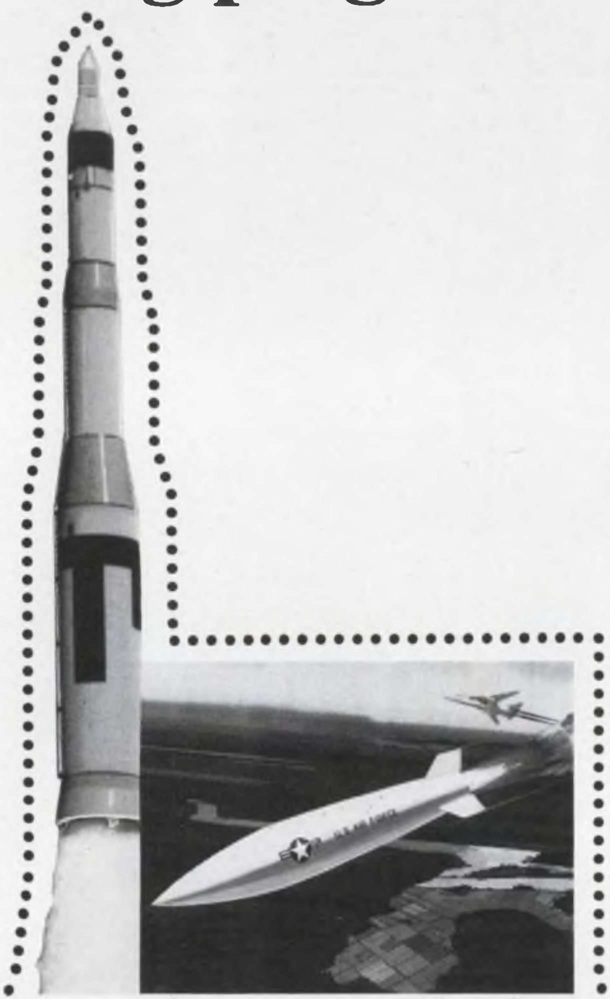

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Additional Seattle openings exist in developmental design and electronic packaging. Design assignments are in airborne control systems, ground system electrical power systems, and environmental control, and require a B.S. degree in an applicable discipline plus related experience. Electronic packaging qualifications include a B.S. in electrical engineering plus applicable experience.

A number of openings also exist on the Apollo/Saturn V program. At Huntsville, assignments in flight mechanics and flight evaluation include operational trajectories, mission analysis, trajectory analysis, post-flight trajectories, flight simulation development, and flight dynamics. Qualifications include a B.S., M.S. or Ph.D. in electrical engineering. Openings also exist for electrical/electronic engineers at Kennedy Space Center.

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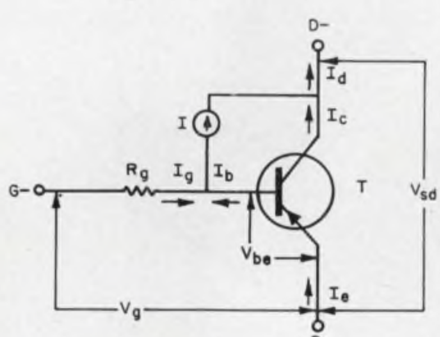
A FET model for computer design

Problem: Provide a computer simulation for a field-effect transistor (FET). Existing computer programs for automated electrical-circuit analyses and syntheses are only able to simulate resistors, voltage and current sources, diodes, capacitors, inductors, and conventional transistors.

Solution: Form an equivalent circuit for the field-effect transistor with circuit elements that can be simulated by existing computer programs.

The equivalent circuit of a FET consists of a conventional transistor (*T*), a resistor (R_g), and a constant-current source (*I*). The terminals *S*, *G* and *D* correspond to the source, gate and drain terminals of the FET.



The value of R_g is equal to the gate input resistance. The value of *I* must be calculated from the electrical characteristics of the FET.

Transistor *T* will be a pnp type for a p-type channel FET, and an npn type for a n-type channel. Because computer programs simulate transistors by the I_c-vs-V_{be} characteristic curve, the values for I_v, V_{be} and β must be calculated for the transistor.

Depending on the accuracy required by the application, the model may be improved by including some or all of the factors that influence performance characteristics of the field-effect transistor. For example:

- Adjust the characteristics of the base-collector junction to improve the drain current curve in the pinch-off region.
- Vary the value of R_g with variation in V_g to cause the slope of the drain current curve to vary with gate voltage.
- Vary both R_g and β with temperature.
- Vary β with drain current.

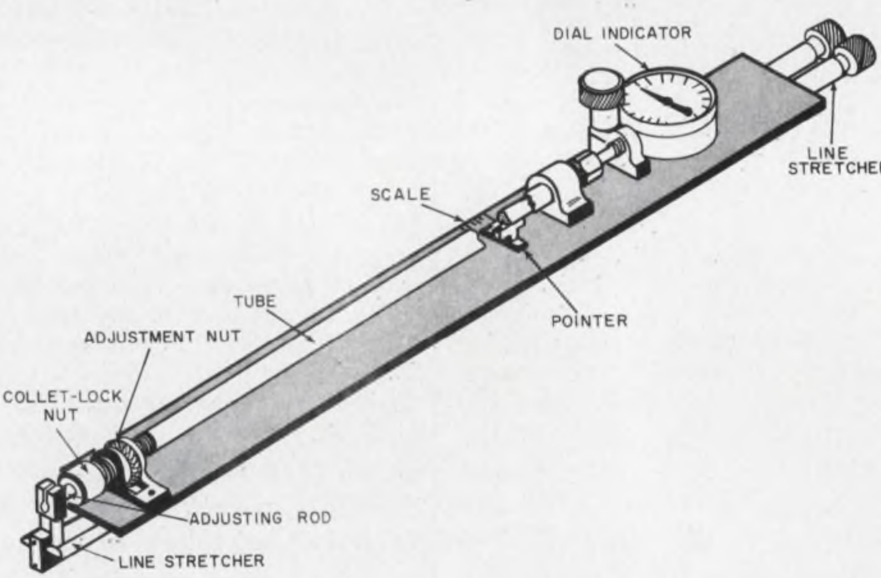
These factors may also be described by curves in the computer program instead of by fixed parameters.

For further information, contact: Technology Utilization Officer, Marshall Space Flight Center, Huntsville, Ala. 35812 (B66-10690).

Dual-range device measures RF phase

Problem: Devise a mechanical instrument to help measure RF phase differences in either vhf or uhf ranges accurately.

Solution: Build a dual-range, linear measurement device with a coarse range, extending to 30 cm, readable to 1 mm and any fine-range portion of 2.5 cm readable to 0.01 mm.



With the collet-lock nut released, the RF line stretcher can be adjusted to different lengths by sliding the coarse adjusting rod, with an attached pointer, within the tube and then reading the change in adjustment in millimeters on the scale.

With the collet-lock nut tightened, the line stretcher and rod are made integral with the tube, which impinges against the dial indicator. By turning the fine adjustment nut, the line stretcher can be adjusted in length within the limits of the dial indicator, with the change in adjustment readable to 0.01 mm on the dial indicator.

The device can measure the phase differences of radio frequency outputs of power dividers or hybrid junctions.

For further information, contact Technology Utilization Officer, Marshall Space Flight Center, Huntsville, Ala. 35812 (B66-10694).

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Book Reviews

Practical logic circuit design

Switching Circuits for Engineers, Mitchell P. Marcus (Prentice-Hall, Inc., Englewood Cliffs, N. J.), 338 pp. $12.00.

Here is a designer's handbook that is filled with practical information from beginning to end. Although the result of this compression is an often staccato presentation, the practicing logic designer will find this a valuable reference.

As might be expected from an author actively engaged in the computer industry, much of the emphasis is on the design of sequential circuits. One result is that coding and error detection and correction are well treated but code conversion, surprisingly, is omitted.

In this second edition the author has taken the opportunity to add further problems and some solutions. These together with an extensive bibliography should increase the book's usefulness for the student.

Jeffrey N. Bairstow

Printed circuits

Printed Circuits Handbook, Clyde F. Coombs, ed. (McGraw-Hill Book Co., New York), 536 pp. $15.00.

This is a "how-to-do-it" reference to printed circuits, their assembly, fabrication, design and testing. Each portion of the subject is treated by a specialist in that particular field. The book aims to be both technical enough to be of value to the engineer and practical enough for use in production.

It opens with practical discussion of layout and design and goes on to laminate selection and specification. Following this is a section on transforming the artwork into a finished image on the PC card. Both manual and automatic assembly of electronic components onto the printed-circuit board are dealt with as well as plastic encapsulating materials and conformal coatings. The volume is rounded out with soldering techniques and materials, and methods for testing, inspection and quality control.

Optimization methods

Recent Advances in Optimization Techniques, Abrahim Lavi and Thomas P. Vogl, eds. (John Wiley & Sons, New York), 656 pp. $12.50.

This collection of articles discusses recent analytical studies and presents new practical methods of optimization. The results of the application of these methods to real-life problems are presented, actual working programs are described and their operation is discussed. The articles cover two broad areas. The first involves design optimization of "static" systems, leading to nonlinear programing problems. The other involves performance optimization of dynamic systems, leading to problems in the calculus of variations and dynamic programing. An extensive bibliography of optimization techniques is included.

Introduction to transistors

Transistor Basics: A Short Course, George C. Stanley, Jr. (Hayden Book Co., New York), 102 pp. $2.75.

Beginning with the introduction of the necessary terms, and then describing diode and transistor behavior, this simplified approach to transistor circuit analysis will enable the reader to determine values to an accuracy adequate for most practical situations. In anticipation of changes in the technology, a table of exact expressions plus a set of rule-of-thumb formulas are given in appendices.

Noise measurement

Handbook of Noise Measurement, Arnold P. G. Peterson and Ervin E. Gross (General Radio Company, West Concord, Mass.), Sixth Edition, 282 pp. $1.

This revised edition contains new charts and tables, a bibliography of references on sound and vibration, and a catalog of General Radio sound instruments. It includes a detailed discussion of noise and vibration and their effect on humans, and a description of noise measuring techniques, instruments and accessories.

Introduction to engineering

Engineering: An Introduction to a Creative Profession, George C. Beakley and H. W. Leach (The Macmillan Company, New York), 548 pp. $9.95.

Beginning with a brief history of engineering developments, the authors construct an elementary text useful to the uninitiated and the new engineering student. Qualifications and basic tools for a career in engineering and the various branches of engineering are discussed, as are methods of problem-solving, analysis and design. Of particular value to the novice are a chapter on technical sketching and appendices containing a review of logarithms, trigonometry and geometric figures, and tables and formulas. Several chapters include problems and exercises; all have bibliographies.

Bridge to radio astronomy

Introduction to Radio Astronomy, R.C. Jennison (Philosophical Library, Inc., New York), 160 pp. $4.75.

Bridging the gap between comprehensive textbook and oversimplified popular treatment is this short treatise on radio astronomy. It contains a reasonable amount of detail on the techniques of the science and is directed to those who are not specialists but are interested in understanding the subject.

Some mathematics are incorporated in the text, but the substance of the book is discussed verbally so that the less mathematical should have little difficulty in grasping it.

Measurement guide

Handbook of Electronic Instruments and Measurement Techniques, Harry E. Thomas and Carole A. Clarke (Prentice-Hall, Inc., Englewood Cliffs, N. J.), 398 pp. $12.

The illustrated handbook is a ready reference to information about electronic instruments, measurements and techniques, including a rundown on transducers and readout devices. Bridge circuits, display devices and digital instrumentation are covered in detail.

Discrete physical systems

Analysis of Discrete Physical Systems, Herman E. Koenig, Yilmaz Tokad, Hiremaglur K. Kesavan and Harry G. Hedges (McGraw-Hill, New York), 447 pp. $13.75.

Electrical networks, electronic circuits, mechanical systems and control systems—all receive specialized treatment in most engineering schools. This book develops a single discipline for analyzing these and other systems. The book comprehensively explains the general theory for system modeling and presents state-space concepts and numerical solutions before introducing more conventional Laplace transform models and solutions. The problem of modeling and the problem of evaluating the performance characteristics of the system as reflected by the model are recognized as two fundamental aspects of general system theory. The modeling theory is based on generalizations of Kirchhoff's voltage and current laws and the performance characteristics are presented primarily in terms of state-space concepts. These two aspects of system theory are integrated to establish the relationship between the state model and the structure of the system.

Device physics

Large-Signal Transistor Circuits, Donald T. Comer (Prentice-Hall, Inc., Englewood Cliffs, N. J.), 268 pp. $10.50.

This treatment of device physics and equivalent circuits is divided into nine sections. These deal respectively with transistor physics, small-signal equivalent circuits, large-signal graphical techniques, miscellaneous R-C circuits, static and transient considerations in transistor switching, multivibrator circuits, time base generation and transformer-coupled pulse circuits.

The book is not intended as a reference work, but as a tutorial treatment addressed to the student. It tries to get away from the more usual "black box" piecemeal linear methods by stressing circuit analysis rather than circuit design. Thus it subordinates exact design equations to physicomathematical descriptions of circuit operation.

Microwave communications

Microwave Systems Planning, Kenneth L. Dumās and Leo G. Sands (Hayden Book Co., New York), 143 pp. $8.00.

This book defines and explains, in a semitechnical manner, the important criteria involved in the planning, engineering and installation of microwave equipment for communications purposes. The authors have confined the discussion to point-to-point FM systems. The book begins with the theoretical aspects of the field, from frequency and wave theory, including propagation, to hardware theory. Following this is a thorough investigation of the practical aspects of establishing a microwave path with a high probability of good performance.

Electron theory of solids

An Introduction to the Electron Theory of Solids, John Stringer (Pergamon Press, New York), 246 pp. $6.00, hard cover; $4.50, softbound.

This text deals with the behavior of electrons in solids, particularly in relation to semiconductors. Some knowledge of second-order differential equations and elementary crystallography is assumed. Beginning with a discussion of classical theory, the author proceeds to discuss the uncertainty principle; quantum theory, with physical models to illustrate quantum mechanical results; statistical mechanics; and the band theory of solids. Theoretical manipulations are related to real problems.

Basic industrial metrology

Handbook of Industrial Metrology, Publications Committee of the American Society of Tool and Manufacturing Engineers, eds. (Prentice-Hall, Inc., Englewood Cliffs, N. J.), 492 pp. $15.00.

This guide to ultraprecise measurement combines both theory and principles for all types of discrete measurements, with strong emphasis on applications. The introduction outlines the principles for estimating and achieving accuracy; systematic and constant errors; sensitivity and readability, and elements of a generalized measuring system. The general principles of measurement are dealt with in detail for such areas as setup and datum definition, datum deformation, stress and strain, basic units and quantities and master standards.

The book also describes the design and application of direct measuring equipment, optical projectors, radiological instruments, surface texture equipment and optical alignment devices. It concludes with a section on gauging equipment, gauge control, quality control management, test function and machine tool alignment.

Residue arithmetic

Residue Arithmetic and Its Applications to Computer Technology, Nicholas S. Szabo and Richard I. Tanaka (McGraw-Hill, New York), 236 pp. $12.50.

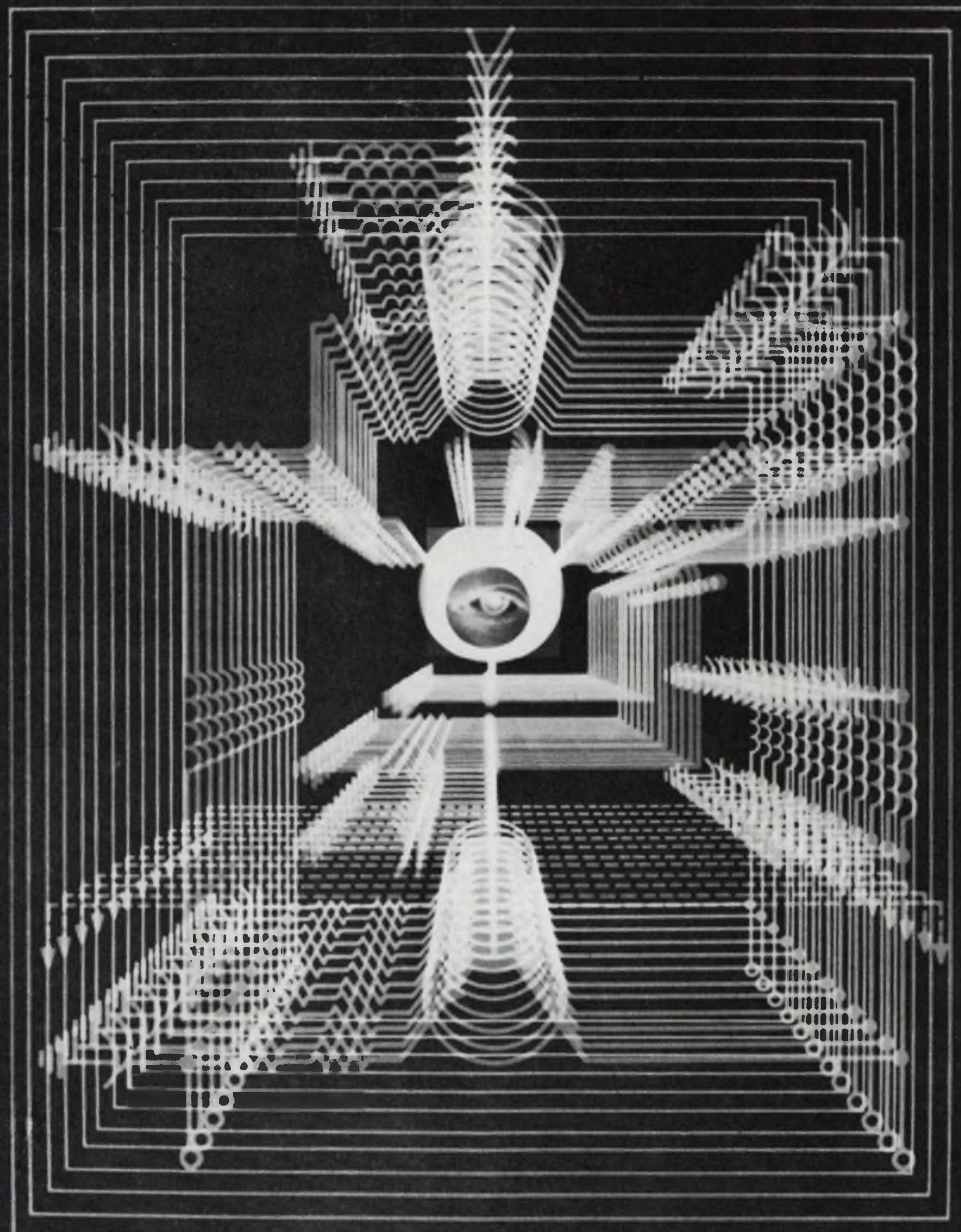
This summary of the whole field of residue arithmetic includes an annotated bibliography which lists the literature in the field, together with comments on each of the references cited.

A form of carry-free arithmetic, the residue number system permits addition, subtraction and multiplication to be performed in one step. This makes it possible to perform these operations in a digital system at a higher rate than is practical with conventional number systems. The book discusses the advantages and uses of the system, giving careful attention to the troublesome areas of determining algebraic sign dividing, and determining the magnitude of a number.

Mathematical physics

Equations of Mathematical Physics, G. N. Polozhiy (Hayden Book Co., New York), 543 pp. $14.50.

This first English edition of Polozhiy's comprehensive text (first published in the U.S.S.R. in 1964) is a valuable reference to the field of mathematical physics for those involved in engineering and physics. The author departs from the traditional by investigating the general properties of elliptical equations before dealing with parabolic and hyperbolic equations. In each case there is an introductory discussion of their physical interpretation.



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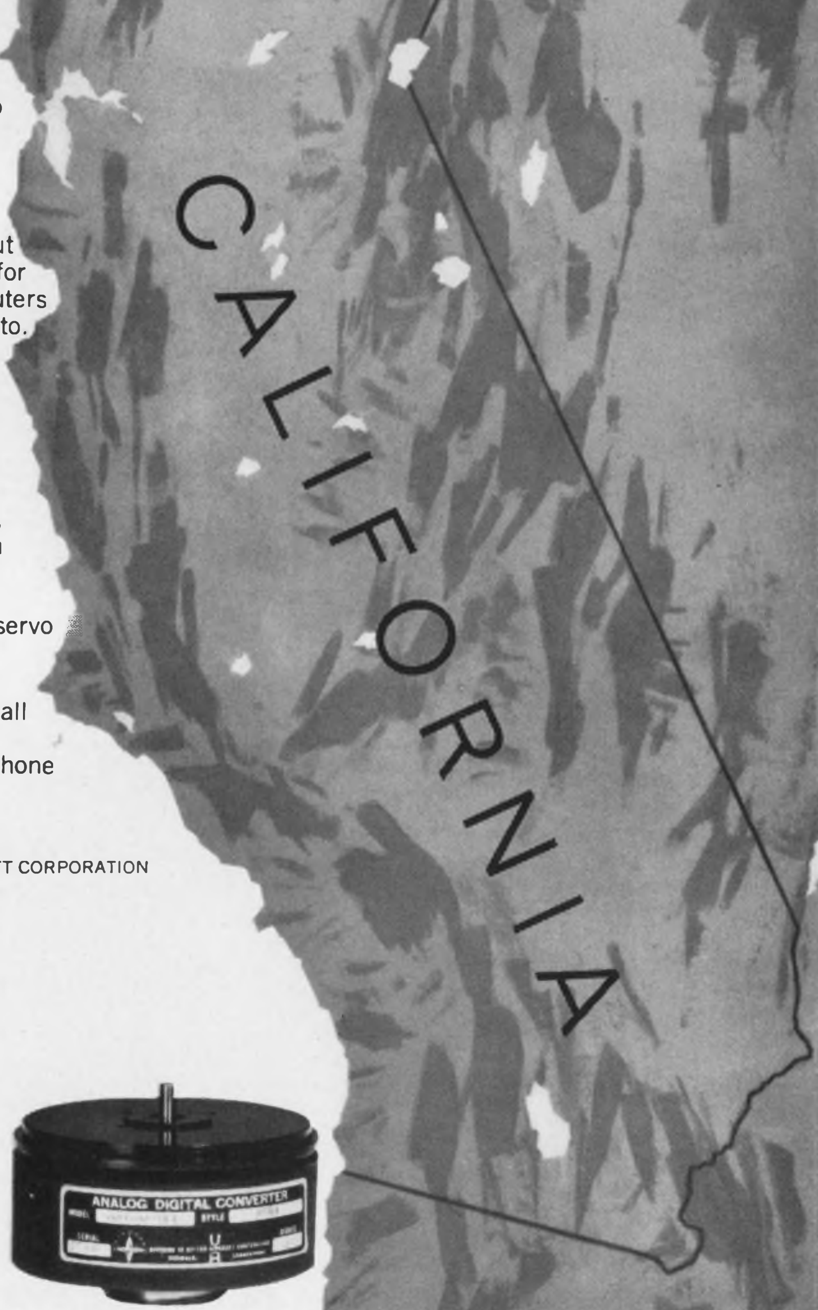

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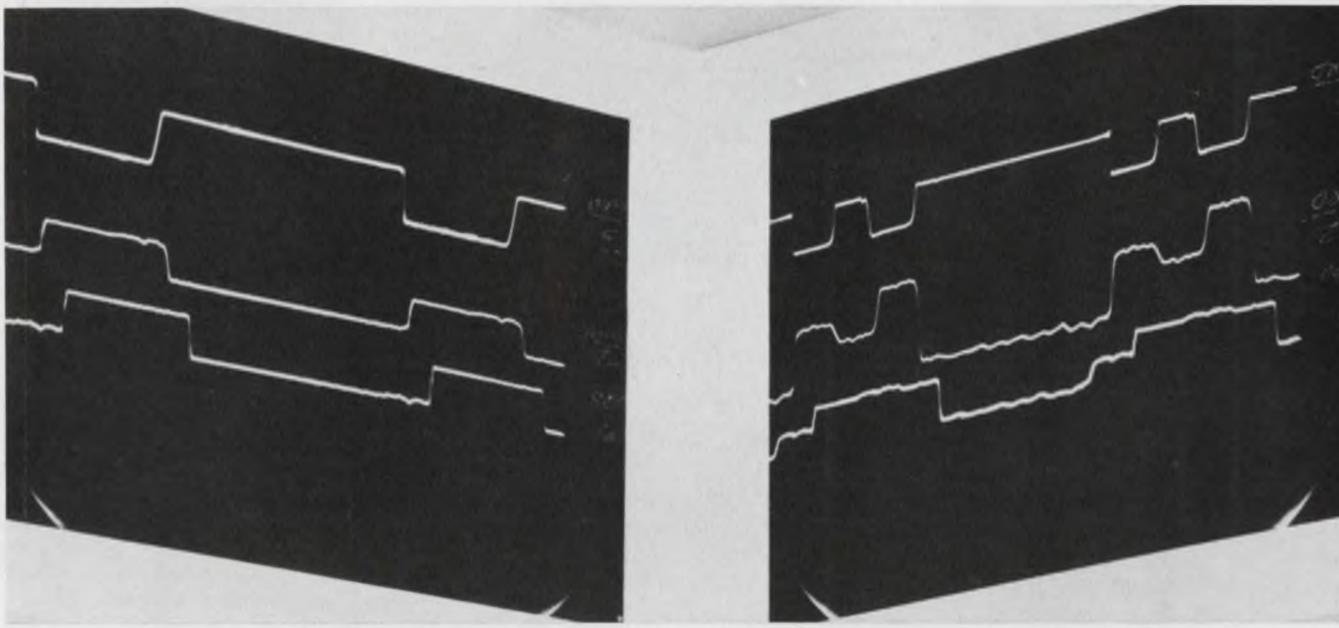
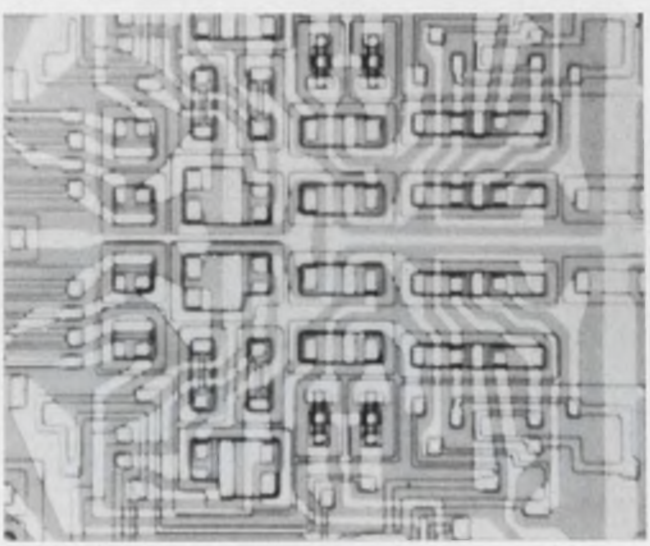
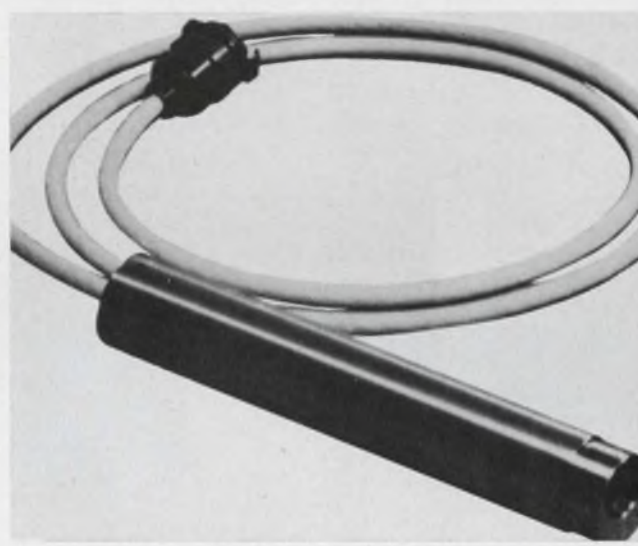


Line receiver logic card prevents reflections and standing waves caused by mismatches in long signal paths. The card has circuitry for four separate transmission lines. Page 292



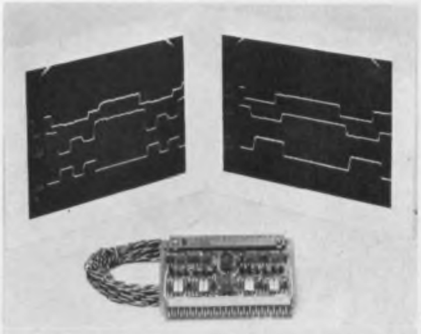
A pair of cross-coupled J-K flip-flops in a single package halves your can count. Page 310



Solid-state light pen responds in nanoseconds without fiber optics or multipliers. Page 304

Also in this section:

Line receiver card cuts reflections



Monitor Systems, Inc., Fort Washington, Pa. Phone: (215) 646-8100.

Designed for use where long signal paths cause transmission difficulties, this digital logic card eliminates reflections and standing waves brought about by impedance mismatches together with erroneous pulses generated by these reflections. The problem of reflections is particularly difficult in the case of TTL equipment. Here faster switching time gives rise to higher frequency components which cause the most trouble. Each of the cards carries line receiver circuits for four separate lines.

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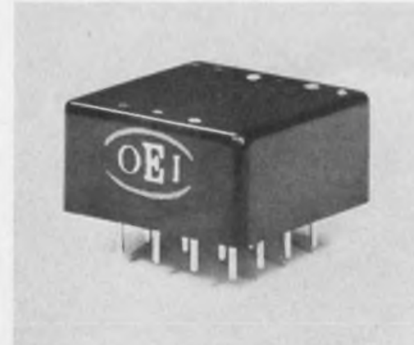
Isolated-input VCO keeps output a-m low

International Electronic Research Corp., 135 W. Magnolia Blvd., Burbank, Calif. Phone: P&A: $300; 45 days.

An isolated power supply provides a high degree of isolation from power, input and output terminals in this VCO. Common-mode rejection is 120 dB at dc and 60 dB at 1 kHz. A miniature transformer-coupled output stage provides for floating in single-ended output connections. Output distortion is less than 1% and a-m is under 1 dB.

CIRCLE NO. 394

Module detects analog coincidence



Optical Electronics, Inc., P. O. Box 11140, Tuscon, Ariz. Phone: (602) 624-3605. P&A: $50 (3 to 9); stock.

Only at the coincidence of two analoge input voltages does this detector have a digital output of 1. Regardless of the relationship of the two input voltages, the output is at 0 at noncoincidence. Using the Model 5185 and a voltage comparator, an unknown voltage may be determined to be above, equal to or below a reference voltage.

CIRCLE NO. 395

Generator calibrates scope sweeps

Accutronics, Inc., 12 South Island, Batavia, Ill. Phone: (312) 879-1000. P&A: $59.50; stock.

Used for calibrating the sweep of scopes, this 1,MHz battery-powered, time-mark generator provides an output of 1 V p-p with an output impedance of 50 Ω. The Micro/marker uses silicon transistors and provides better than ±0.01% stability over 0° to +60°C. It has connectors for both UHF or BNC type oscilloscopes.

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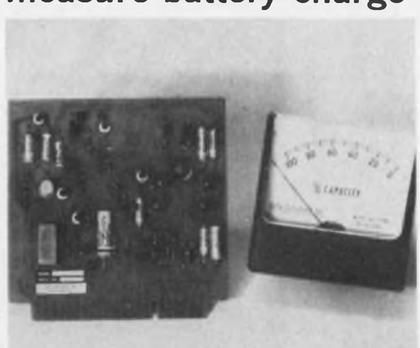
Voltage time integrators measure battery charge



Curtis Instruments, Inc., Mt. Kisco, N. Y. Phone: (914) 666-8051.

With an output scaled to provide a microampere output, this integrator is an analog of battery state-of-charge. A 100% charge is equal to 10 μA. The lightweight, solid-state unit provides a direct indication of remaining battery capacity. The unit features a linearity of 0.5%, drift of 0.2% per day powered and zero unpowered, zero input threshold and infinite storage.

Booth No. 4611 Circle No. 359

High-current op amp drifts ±10 μV/°C

Burr-Brown Research Corp., 6730 S. Tucson Blvd., Tucson, Ariz. Phone: (602) 294-1431. P&A: $65 (1 to 9); stock to 3 wks.

This unit packs a ±50-mA output current in a package 1.8 x 1.2 x 0.6 inches. The unit is useful for comparator or go/no-go applications in which the amplifier is required to drive a relay. Other specifications include a rated output voltage of ±10 V, open loop gain of 100 dB, small-signal response of 1.5 MHz and full-power response of 20 kHz.

Booth No. 3212 Circle No. 380

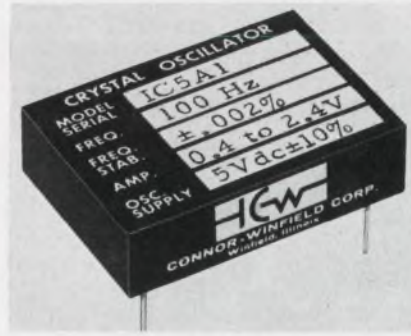
Teraohm resistors in tiny package

Pyrofilm Resistor Co., Inc., Cedar Knolls, N. J. Phone: (201) 539-7110.

Tiny enough to fit under your fingernail these resistors are operative from 10^8 to 10^{12} Ω with a normal tolerance of ±25%. The subminiature component is 0.04-inch in diameter and 0.13-inch long. It is usable at temperatures of up to 100°C and can be encapsulated. The ends of the resistor serve as terminals for soldering to boards or other components.

CIRCLE NO. 439

Crystal oscillators compatible with ICs

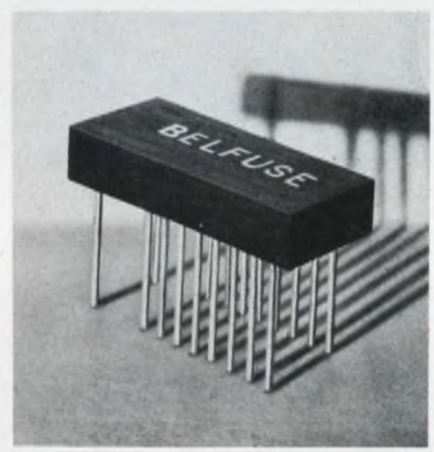


Connor-Winfield Corp., Winfield, Ill. Phone: (312) 231-5270.

Fully compatible with integrated circuitry, these oscillators span 1 Hz to 400 kHz in any of eight models. Duty cycle is 50% and output is square wave. Zero voltage is less than 0.4 and logic one is greater than 2.4 V. Power supply requirement is 5 V dc ±10%.

CIRCLE NO. 396

Tiny delay lines housed in flat pack

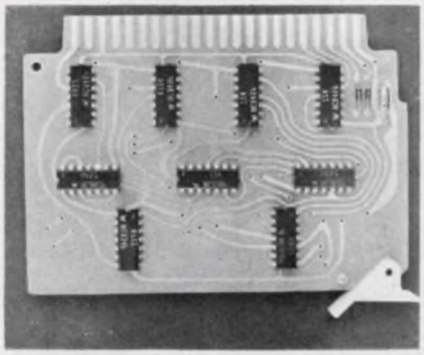


Bel Fuse, Inc., 198 Van Vorst St., Jersey City, N. J. Phone: (201) 432-0463.

Designed for flat-pack applications where compact size is required, these delay-line modules measure 0.8 by 0.35 by 0.25 inch. The delay line can be single or multisectioned with delays up to 20 ns. Characteristic impedance is 100 Ω with output rise times of less than 4 ns. The units are suitable for computer and instrumentation applications where high-density packaging is required.

Booth No. 4910 *Circle No. 250*

Reversible counter cards operable to 5 MHz



Wyle Products Div., 133 Center St., El Segundo, Calif. Phone: (213) 678-4251.

A pair of DTL counter cards are offered: Model MRC-ID contains one reversible BCD decade counter, and model MRC-1B one reversible 4-bit binary counter. Both operate at up to 5 MHz. Operating from a single counting input, the counters are equipped with "enable" gates for forward or reverse control. Carry outputs are provided for tandem connection.

CIRCLE NO. 397

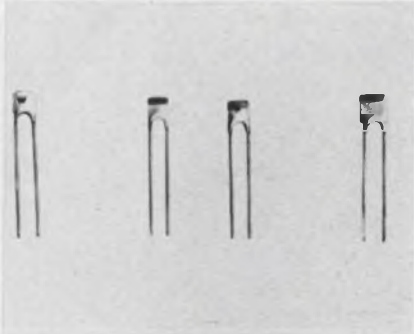
Tiny wirewound pot weighs 1/2 ounce

Duncan Electronics, Inc., 2865 Fairview Rd., Costa Mesa, Calif. Phone: (213) 754-2931. P&A: $4; stock.

Measuring 7/8-inch in diameter, 3/4-inch long, and weighing one-half ounce, Duncan's Pixie pot has ±5% tolerance over 100 Ω to 100 kΩ. Linearity is ±0.25% and resolution for a 1-kΩ unit is typically 0.022. The pot features gold-plated terminals and is rated at 2 watts at 25°C.

CIRCLE NO. 398

Ceramic plate capacitors range 1 to 150 pF

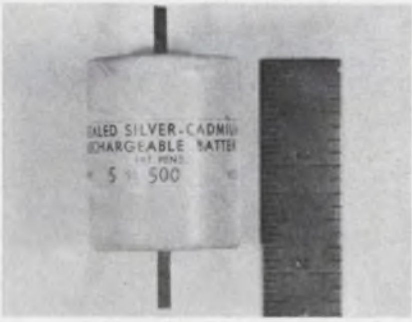


Mepco, Inc., Columbia Rd., Morristown, N. J. Phone: (201) 539-2000.

Less than 0.197 inches wide, these capacitors range from 1 to 150 pF. Class II capacitors are available in capacitances ranging from 1000 to 10,000 pF and from 18 to 1800 pF in two size configurations. Both Class I and II capacitors have a maximum working voltage of 40 V dc and are available with 0.024-inch rigid leads, or 0.016-inch flexible leads, for mounting on PC boards.

CIRCLE NO. 399

Silver-cadmium cells overpower NiCads



Electrochimica Corp., 1140 O'Brien Dr., Menlo Park, Calif. Phone: (415) 323-0283.

With about twice as large an energy density in Wh/lb and Wh/in^3, silver cadmium cells offer higher discharge rate capabilities and longer charge retention than NiCads. The S-500 (500 mA-hr) measures 1.34-inches OD and 0.25-inch high and offers twice the capacity of a NiCad cell of the same dimensions. The batteries are suitable for microelectronics, communication transceivers, test instruments, telemetry, and other commercial, space and military applications.

CIRCLE NO. 400

Sense and hold module remembers peaks

Optical Electronics Inc., P. O. Box 11150, Tucson, Ariz. Phone: (602) 624-3605. P&A: $360 to $400; 30 days.

In operation, this module stores the peak positive or negative value of an input waveform and presents it as a dc output signal. The output is changed by a higher level input signal or by a reset signal applied to the module. The modules can be used to measure the amplitude of transients, to obtain a peak noise voltage level and to measure the peak of a complex waveform.

CIRCLE NO. 401

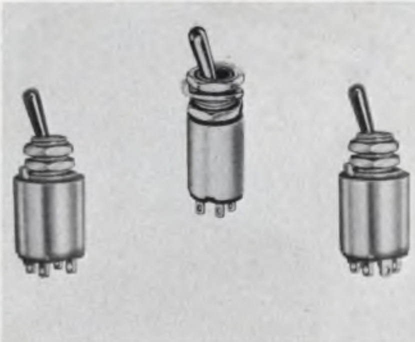
Analog multipliers keep error down

GPS Instrument Co., Inc., 188 Needham St., Newton, Mass. Phone: (617) 969-9405.

A pair of analog multipliers are offered. One accepts two signals in the range of 0 to ±5 V and delivers 1/5 their algebraic product. The other accepts signals of 0 to ±10 V and gives 1/10 the algebraic product. Error is less than 50 mV. Both are quarter-square type multipliers and use diode-shaping networks and four wide-bandwidth op amps.

CIRCLE NO. 402

Two-position toggles RFI-shielded



Control Switch Div. of Controls Company of America. 1420 Delmar Dr., Folcroft, Pa. Phone: (215) 586-7500. Price: $7.56.

With minimal RFI emission, these switches are for airborne, shipboard, military, and commercial electronic equipment that operate in shielded systems. The shielded switches attenuate conduction and radiation in the 0.14-to-200-MHz range. The switches meet MIL-I-6181D and MIL-STD-826A requirements for radiation-free components and are designed for use in radiation-free airborne equipment conforming to MIL-I-26600.

CIRCLE NO. 403

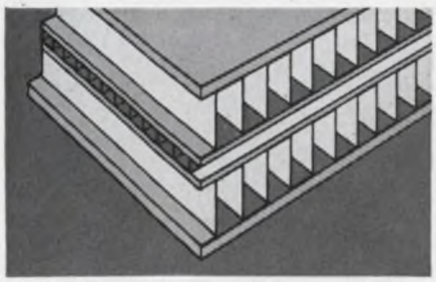
PC coil forms fully shielded

Cambridge Thermionic Corp., 445 Concord Ave., Cambridge, Mass. Phone: (617) 491-5400. P&A: 82¢ and 87¢ (100 to 249); stock.

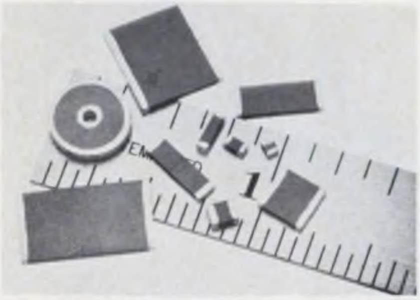
Mounting pins for these units are located on 0.2-inch grid spacing for printed circuit layout and mate with 0.025-inch jacks. Coil forms are available in six types for operating frequencies from 0.2 to 300 MHz. Inductances range from 0.022 to 1200 μH with Qs of approximately 60 and 40 respectively. The package is 0.4 inches square and offers a low profile above the printed circuit.

Booth No. 4103 Circle No. 379

For a complete listing of the technical papers at the show, see page U 112. For reprints of most of the papers, fill out the order form on page U 115.



Ceramic chip caps range 10 pF to 1.5 mF



Monolithic Dielectrics, Inc., P. O. Box 647, Burbank, Calif. Phone: (213) 848-4465.

Space-saving, high-stability monolithic ceramic chip capacitors have a high capacitance-to-volume ratio. Available in 51 models, the series ranges from 10 pF to 1.5 mF in small rectangular, large rectangular, square and disc feedthrough configurations. All models are available with dc working voltages of 50, 100 and 200. Standard tolerance is ±20%, with models also available at ±5%, ±10% and guaranteed minimum value.

CIRCLE NO. 404

Narrow-band filters cut off sharply

Bundy Electronics Corp., Fadem Rd., Springfield, N. J. Phone: (201) 376-8150.

Narrow-band active filters are offered covering 385 to 3495 Hz (20-Hz spacing) or 353 to 3503 Hz (24-Hz spacing). The 20-Hz filters can divide the frequency spectrum into 155 channels, with a bandwidth of 5 Hz and attenuation of 12 dB at crossover. The 24-Hz filter produces 131 channels, with a bandwidth of 10 Hz and 18-dB attenuation at crossover. The filters come in a hermetically sealed module with solder or plug-in termination.

CIRCLE NO. 405

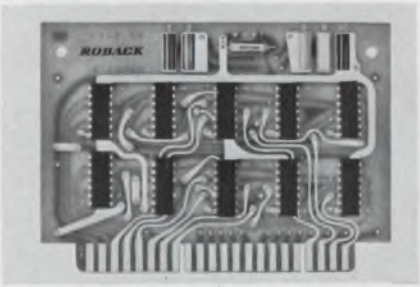
High-gain op amp gives 2 mA at 20 V

Data Device Corp., 240 Old Country Rd., Hicksville, N. Y. Phone: (516) 433-5330. P&A: $71 (10 to 24); stock.

With a gain of 200,000, this op amp has an output of 20 mA and 20 V, and stability of 5 μV/°C, 0.3 nA/°C. The unit has a current off-set of 10 nA. It provides a frequency for full output of 25 kHz. Applications include servo/resolver systems, solenoid drivers, automatic test equipment and signal conditioning systems. The all-silicon device is fully encapsulated and designed for PC board mounting.

CIRCLE NO. 406

High noise immunity in DTL cards



The Roback Corp., 601 Buck Rd., Huntingdon Valley, Pa. Phone: (215) 676-4000. P&A: $9.50 (flip-flop), $2.50 (gate); stock.

Low-cost DTL logic cards provide high noise immunity with a dc-to-5-MHz operating speed. Available in commercial and military versions, the cards combine monolithic ICs and discrete hybrids on a 4.5 by 3.25-inch glass-epoxy board. High noise immunity, typically 1.2 volts over 0° to 70°C is achieved with local power line filtering.

CIRCLE NO. 407

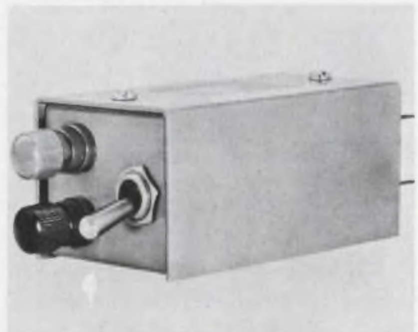
Module delays pulses up to 30 μs

MCG Electronics, 11-22 Joselson Ave., Bay Shore, N. Y. Phone: (516) 586-5125.

This module accepts a logic 0 (negative 0-V pulse from 2 to 5-Vdc level) input pulse and delays it up to 3 μs with a delay tap resolution of 50 ns. The output is a logic pulse with a fan out of 20 and with rise and fall times of approximately 30 ns. The delayed output pulse is stable, exhibiting a time delay variation of 50 ns (at the 3-μs setting) when the temperature is varied from +25° to +75°C.

CIRCLE NO. 408

Thermocouple reference converts mV recorders

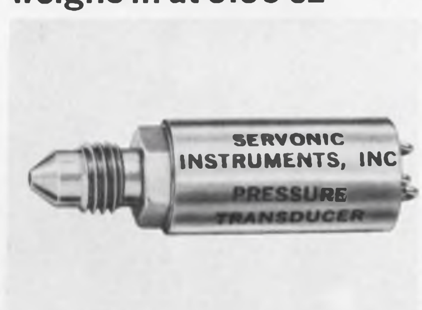


Consolidated Ohmic Devices, 115 Old Country Rd., Carle Place, N. Y. Phone: (516) 741-1500. P&A: $92.50; stock to 4 wks.

Millivolt recorders can be converted to thermocouple recorders with this plug-in thermocouple reference junction. The device has banana plugs on 3/4-inch spacing to plug in directly to the 5-way binding posts of the millivolt recorder. The device is activated by an off-on switch. The plug-in, set at 0°C reference, can measure any temperature with any thermocouple. Over the 55° to 90°F range, accuracy is guaranteed at ±1/2°F.

CIRCLE NO. 409

Tiny pressure transducer weighs in at 0.06 oz

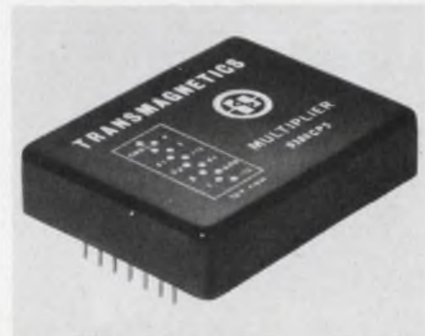


Servonic Instruments, 1644 Whittier Ave., Costa Mesa, Calif. Phone: (714) 642-2400.

The Miniducer, measuring 0.5-inch in diameter and 1-inch long, is available in pressure ranges from 0 to 500 to 0 to 10,000 psia and psig. Used for airborne telemetry and control, overall accuracy is better than ±1.75% including the combined effects of linearity, friction, hysteresis, resolution and repeatibility. It withstands 100-G shock and 50-G vibration.

Booth No. 5314 Circle No. 373

Wideband multiplier phase-controlled



Transmagnetics, Inc., 134-25 Northern Blvd., Flushing, N. Y. Phone: (212) 539-2750. P&A: $278 (1 to 9); stock to 4 wks.

Flat to 0.1 dB from dc to 25 kHz, this true analog multiplier has a phase shift not exceeding 1.5 degrees. Applications are in precision modulation or dc-to-ac compensation, variable gain control, wideband power measurement, weighted gating and signal sampling and analog multiplication. Specifications include 0.5% full-scale linearity and 0.02%/°C stability over −55° to +85°C.

CIRCLE NO. 410

Stable inverter gives ripple-free output

MIL Associates, Inc., Dracut Rd., Hudson, N. H. Phone: (603) 882-5193. P&A: $375 (1 to 9); 10 days.

For use with airborne, synchronous servo equipment where accuracy of operation is dependent upon frequency stability, this inverter gives a 400-Hz output stable to ±0.25%. A 28-V dc input provides 115 ±5 V rms output. Ability to adjust the output frequency by ±1% or ±4 Hz allows compensation for mechanical tolerances in clock or servo equipment such as airborne tape recorders.

CIRCLE NO. 411

Synchro-to-dc converter accurate to 3 minutes

Natel Engineering Co., Inc., 7129 Gerald Ave., Van Nuys, Calif. Phone: (213) 782-4161. P&A: from $250; 4 to 5 wks.

All solid-state synchro-to-dc sine/cosine converters offer ±3-minute accuracy independent of rotor excitation voltage (±10%). Sine/cosine tracking accuracy is ±0.02% of full scale and repeatability is ±0.01%. The converters accept the output of a standard 3-wire ungrounded synchro stator and provide dc voltage outputs corresponding to sine and cosine of synchro shaft angle.

CIRCLE NO. 412

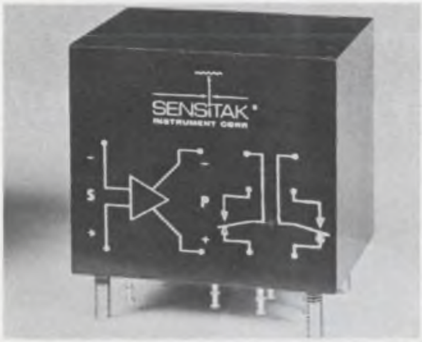
Log amplifier modules temp compensated

Burr-Brown Rsearch Corp., 6730 S. Tucson Blvd., Tucson, Ariz. Phone: (602) 294-1431. Price: $275 (1 to 9).

Temperature compensation gives this log amp an accurate log characteristic over a range of temperatures (0° to 60°C). Input signals range from 10 mV to 10 V. Applications include signal compression, analog computation, industrial and scientific instrumentation. Balancing and zeroing controls are external and optional.

Booth No. 3212 *Circle No. 370*

Five-amp logic relays take microamp inputs



Sensitak Instrument Corp., 531 Front St., Manchester, N. H. Phone: (603) 627-1432. P&A: $9.90; stock.

Microamp-sensitive dpdt logic relays consist of a silicon npn amplifier driver and a magnetic relay, epoxy encapsulated for immunity to shock and vibration. Signal input impedance of 1 MΩ and large overvoltage capability suit for sensing over a 100:1 dynamic range.

CIRCLE NO. 413

Load-absorb resistor has no self-inductance

The Carbone Corp., 400 Myrtle Ave., Boonton, N. J. Phone: (201) 334-0700.

Practically independent of applied voltage and ambient temperature, these load-absorbing resistors return to their normal ohmic values after overload if overload is not too high or too protracted. The material absorbs large transient energy impulses. The resistors are used in the same applications as wirewounds but in circuits where self-inductance must be zero or where overloading is anticipated. Uses are as surge-limiting resistors, protection resistors in dust-precipitator circuits, dummy-load resistors, surge-dampening devices in shortwave transmittors, resistors for alternator ground connections and discharge resistors for condenser banks.

Resistance values range from 2 to 40,000 Ω. Maximum energy dissipation in still air is from 175 to 250 joules per cubic centimeter, depending on discharge time. The upper limits can be raised by forced cooling with air, water or oil. Maximum voltage gradient is about 1200 V/cm. Maximum load is about 200 watts, without forced cooling.

CIRCLE NO. 414

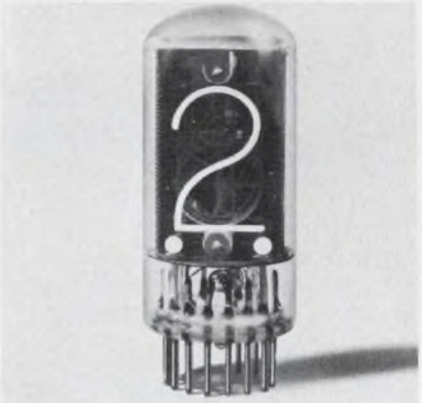
Short 5-A connectors hold 85 conductors

Matrix Science Corp., 3311 Winona Ave., Burbank, Calif. Phone: (213) 845-8434.

With six shell sizes from 8 through 18, these connectors accommodate from 7 to 85 conductors. Mated pairs meet operating requirements through a temperature range of −67° to +392°F. All contacts are rated for 5-A continuous duty, rated at 1500 V dc.

CIRCLE NO. 415

Improved Nixies shorter, faster



Burroughs Corp., Electronic Components Div., Plainfield, N. J. Phone: (201) 757-5000.

An improved version of Burroughs B-5440 Nixie is electrically and mechanically interchangeable with the old standard. The tip-off, which is at the top of the tube in the B-5440, has now been brought out in the base so that overall seated height is cut by 17%. An optional "keep alive" feature is used when rapid ionization is required, in dark environments, in photographic applications, and in time sharing or strobe applications. The "keep alive" feature enables ionization to occur in normal ambient light in less than 100 μs in contrast to 10 μs required by standard tubes.

Booth No. 2816 *Circle No. 360*

PC reeds packed for sensitivity

Automatic Electric Co., Chicago. Phone: (312) 562-7100.

This printed circuit dry reed switch is a miniature reed capsule within a relatively large bobbin for greater sensitivity. Due to its low self-inductance and high-speed operation, the Correed is reportedly an ideal output device, providing complete isolation between the coil drive and output contacts. The metallic output contacts have a low closed-circuit resistance (about 60 mΩ) and a very high open-circuit resistance (about 500,000 MΩ).

Booth No. 4221 *Circle No. 351*

Solid-state light pen responds in nanoseconds

Information Control Corp., 1320 E. Franklin Ave., El Segundo, Calif. Phone: (213) 322-6930.

Sensitive to brightness changes of 10^{-6} mW/cm², this light pen exhibits less than a 300-ns response time. Acceptance area of the pen is 1/8 inch, defined by an illuminated solid finder circle projected on the CRT phosphor. To aid the operator in positioning, the pen projects an illuminated solid finder circle on the CRT phosphor illuminating the exact area to be sampled by the detector.

CIRCLE NO. 416

Fm discriminator sits in 5-1/4-inch rack

Geotech, Div. of Teledyne, 3401 Shiloh Rd., Garland, Tex. Phone: (214) 278-8102.

For multiple-channel, low-frequency, fm data telemetering, this 14-channel demodulator system is housed in a 5-1/4-inch rack. Input signal threshold is adjustable from 0.05 to 10 V p-p. Carrier center frequency is 1500 Hz with ±45% deviation. Dynamic range is 80 dB on an rms-rms basis and provision is made for filter configurations. Noise level is 1 mV p-p.

CIRCLE NO. 417

Self-powered op amps drift-free, quiet

Julie Research Laboratories, Inc., 211 W. 61st St., N. Y. Phone: (212) 245-2727. P&A: $800; 30 days.

Designed for precision dc applications, these low-noise, drift-free op amps feature input stability of 0.1 μV and typical gains from 10^6 (120 dB) to 10^8 (160 dB). They are suited for driving and control elements in high-stability and high-linearity current and voltage generating (feedback) systems and as standard cell emf buffers and amplifiers and as drive units for dialable voltage current sources. Overall noise (short-term) is ±100 nV p-p, stability is less than 1 μV/wk.

CIRCLE NO. 418

Calibration standards span wide ranges

RFL Industries, Boonton, N. J. Phone: (201) 334-3100. Price: $9000.

Solid-state calibration standards offer wide ranges of current, voltage, power and frequency output. Accuracy is 0.1% dc, 0.15% ac. Go-no-go logic circuitry protects against misoperation and overloads. Automatic operation senses the dialed quantity and corrects for any deviation. The output deviation control facilitates direct percent calibration. Voltage ranges from 0.01 mV to 1000 V ac and dc, currents from 0.02 μA to 20A, dc watts from 0.01 to 4000 and dc resistance from 0.01 Ω to 11.11 MΩ.

Booth No. 2307 Circle No. 290

Comparator-converter NBS-accurate

Engelhard Industries, Inc., 113 Astor St., Newark, N. J. Phone: (201) 242-2700.

A comparator and companion coax thermal converter set offer high accuracy for electronic and aerospace metrology. The comparator is a stable, accurate transfer standard with an ac/dc differential of 10 ppm or less, which can be certified by NBS to an accuracy of 50 ppm in the audio range. The converter set determines the ac/dc difference of the comparator for complete calibration accuracy.

Booth No. 1671 Circle No. 369

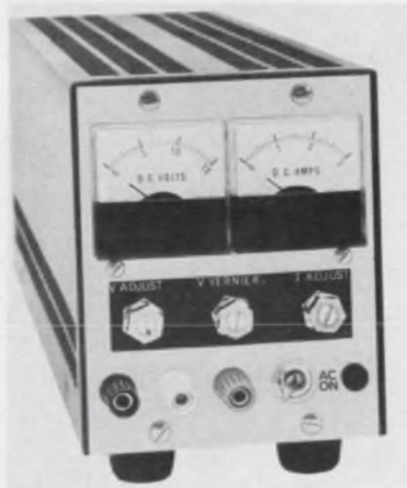
Volt/frequency meters have digital readout

Wavetek, 8159 Engineer Rd., San Diego, Calif. Phone: (714) 279-2200. Price: $1095.

With a 5-digit readout, this unit measures dc voltages from 0 to 1000, and frequency from 5 Hz to 100 MHz. A null meter with full-scale deflection sensitivity of 100 μV provides a voltage accuracy of 0.01%. Frequency can be measured to 0.01% of reading $\pm$0.001% of full scale. A recorder connector provides for continuous analog output of either frequency or voltage.

Booth No. 2417 Circle No. 368

Slot supply system mixed and matched



Trygon Electronics, Inc., 111 Pleasant Ave., Roosevelt, N. Y. Phone: (516) 378-2800.

Sub-rack slot power supplies offer combinations of half-rack and quarter-rack, modules and metered models. The power supplies in the series feature slot voltage ranges from 2.5 to 4.5 V dc at 3.6 A to 24 to 32 V dc at 8 A. Versatility is achieved with a series of rack adapters permitting the designer to mix and match units to obtain up to eight different outputs in a 19-inch wide rack configuration.

Booth No. 2618 Circle No. 298

MIL-spec DVM environment-resistant

Dana Laboratories, Inc., 2401 Campus Drive, Irvine, Calif. Phone: (714) 833-1234.

Designed to meet all of the significant requirements of MIL-T-21200F, class 2 and 3, this DVM is a 5-digit (with sixth-digit overrange) null-balance instrument with a dc accuracy of ±0.005% of reading ±0.001% of full scale, and a minimum measuring speed of 12 ms. The unit meets MIL-temperature requirements with continuous operation from −40° to +55°C, storage temperature from −62° to +85°C and intermittent operation possible at +71°C. Humidity may run to 100%, with condensation in and on the equipment. The rack-mount unit also meets shock, sand, fungus, salt, explosion and vibration requirements.

Booth No. 2406 Circle No. 289

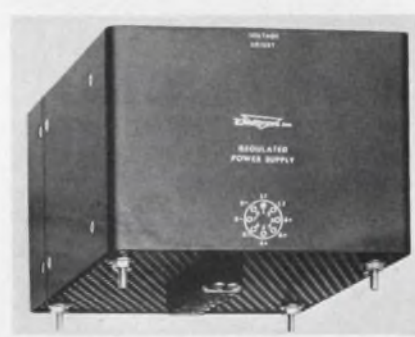
Portable counters for ac or dc

Amark Corp., 31 Commercial St., Plainview, N. Y. Phone: (516) 938-3322. P&A: $595 to $890; 2 to 4 wks.

Ability to operate from 12 V dc gives these counters a field service capability. Model TSA-3334 has a four-digit readout, model TSA 3436 a six-digit readout. Frequency ranges are 15 Hz to 1.2 MHz and dc to 1.2 MHz. The counters function with inputs ranging from 100 mV to '250 V with accuracy of ±1 count. The counters are self checking and have an automatic reset.

CIRCLE NO. 419

MIL power modules range 3 to 250 V



Deltron, Inc., Wissahickon Ave., North Wales, Pa. Phone: (215) 699-9261. P&A: $65 to $470; stock.

There are 299 units in this line ranging from 3 volts, 36 A to 250 volts, 2.1 A. Units provide an MTBF of to 100,000 hours, and meet military shock, vibration, humidity, altitude, RFI, marking, and component standards. The units have 0.02% regulation, convection cooling to 71°C, thermal cutout with automatic reset, remote sensing and programing and automatic series and parallel operation.

CIRCLE NO. 420

Digital voltage source fully programable

Electronic Development Corp., 423 W. Broadway, Boston. Phone: (617) 268-9696. P&A: $1650; stock.

The sign and each decade of this voltage source are independently selected. Outputs are 0 to 111.11 Vdc. Programing is either serial by decimal digit, 8421 code or full parallel entry. The memory feature will preserve the contents of the internal register after the transfer busses have been de-energized. Punch tape, punch card, incremental magnetic tape readers, or pin board, programer drum, stepping switch programing may be used.

CIRCLE NO. 421

Prescaler plug-in ups counter specs

Hewlett-Packard, 1501 Page Mill Rd., Palo Alto, Calif. Phone: (415) 326-7000. P&A: $825; 10 wks.

For use in HP plug-in counters, this prescaler extends the direct counting rate to 200 MHz. At the same time, the plug-in increases counter sensitivity, enabling counter operation with signals as small as 1 mV rms at frequencies between 1 and 200 MHz. The prescaler works with HP models 5245L, 5245M, 5246L and 5247M. The plug-in's digital circuits divide input sine waves or pulse trains by a factor of four, bringing signal frequencies as high as 200 MHz within the basic counting rate.

Booth No. 2909 Circle No. 367

Photomultiplier supply delivers 15 kv

Venus Scientific Inc., 25 Bloomingdale Rd., Hicksville, N. Y. Phone: (212) 867-6062. P&A: $178; stock.

Using all silicon components, the K15 is a dc-dc converter capable of delivering up to 1 mA with ripple of 0.1% or less for inputs ranging from ±3 to 15 V dc. Output voltages vary from ±300 to 1500 V. Input and output circuits are fully isolated from each other. The unit provides complete protection against damage from shorts or reversal of polarity. Measuring 1 inch in diameter and 2-1/4 inches long, the unit can be incorporated into closed-loop systems.

CIRCLE NO. 427

Rear-projection readout weighs 1-1/2 ounces

Shelly Associates, Inc., 111 Eucalyptus Dr., El Segundo, Calif. Phone: (213) 322-2374.

Smaller than a roll of pennies, this readout contains 12 separate message projection systems. Each of the optical systems will project anything that can be put on film into images as large as 0.45 inches. The design permits messages to be displayed vertically or horizontally with minimum blank areas or image blockages. It will readout symbols, characters or up to four-line messages 0.1-inch high. The front dimensions are 0.65 x 0.46 inch. The SRO-90 uses an unbased, replaceable lamp unit, easily replaced.

CIRCLE NO. 428

Digital frequency meter measures to 12.4 GHz

Hewlett-Packard, 1501 Page Mill Rd., Palo Alto, Calif. Phone: (415) 326-7000. P&A: $4750; Sept.

This unit measures microwave frequencies between 0.3 and 12.4 GHz with 8-digit resolution. Other than selection of the appropriate one of two frequency ranges, the operator needs to make no tuning adjustments or calculations. The correct readout is obtained automatically. A "no-lock" monitor causes the display to read all zeroes until the instrument is locked onto an input signal.

CIRCLE NO. 429

Guidance receiver all-solid-state

Electronic Specialty Co., Colorado Blvd., Los Angeles. Phone: (213) 246-6761.

Intended for use in pilotless target aircraft and missiles, this command guidance receiver uses all-solid-state circuitry and operates in the 406-to-550-MHz band. It operates from the aircraft's 28-V dc power source and contains its own voltage regulator and line filter. A low-impedance audio output is provided to drive an external decoder.

CIRCLE NO. 430

Generator synthesizes low-frequency noise

Hewlett-Packard, 1501 Page Mill Rd., Palo Alto, Calif. Phone: (415) 326-7000. P&A: $2650; stock.

Gaussian noise waveforms whose power density is exactly known are generated by this instrument. Maximum amplitude is 3.16 V rms with an upper cutoff frequency selectable in 18 steps from a high of 50 kHz to a low of 0.00015 Hz. Output power remains constant regardless of bandwidth selected. An advantage of the synthesizing technique is that noise waveforms can be repeated exactly as they occurred at an earlier time.

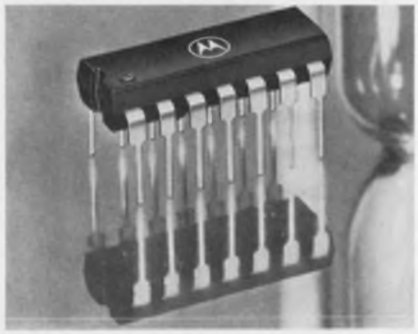
Since the amplitude of the binary waveform can be controlled precisely, the noise output of the generator is known precisely and is highly stable in amplitude (dc drift is less than 5 mV per 10°C change between 0 and 55°C). An attenuator provides 30 steps down to 0.1 V rms output. The instrument's output impedance is matched to 600 Ω when the attenuator is used (a second output supplies a fixed-level 3.16-V output from a 1-Ω source).

The instrument generates a sync pulse, for triggering an oscilloscope or other equipment, each time the noise pattern repeats. When desired, the patterns can be gated and set to run once, twice, four or eight times and then stop. The gating waveform is available at rear panel connectors for operating any external equipment.

CIRCLE NO. 431

For a complete listing of the technical papers at the show, see page U 112. For reprints of most of the papers, fill out the order form on page U 115.

ECL flip-flops toggle at 120 MHz



Motorola Semiconductor Products, Inc., P. O. Box 955, Phoenix. Phone: (602) 273-6900. P&A: $6.50 and $7.40 (over 1000); stock.

Flip-flops keep getting faster. Designed for high-frequency counters, frequency synthesizers and extremely high-speed registers, Motorola's J-K flip-flop features a typical toggle frequency of 120 MHz. Known as the MC1027P, it is an ac-coupled J-K flip-flop with 4 J and 4 K inputs as well as direct set and reset inputs. The unit operates with the same logic levels and is fully compatible with other members of Motorola's emitter-coupled logic series. The 120-MHz toggle frequency of the MC1027P is reportedly more than twice as fast as any saturated logic flip-flop. The MC1027P offers a typical propagation delay of 4 ns. Dc fan out is 25 minimum with maximum recommended ac fan out of 15 for high speed operation. Both the companion high-speed clock driver and the flip-flop are packaged in a 14-lead plastic package.

CIRCLE NO. 422

Ferrite circulator completely integrated

Texas Instruments, 13500 N. Central Expwy., Dallas. Phone: (214) 238-3741.

These symmetric-junction integrated circulators operate in the X-band frequencies, from 8.7 to 9.9 GHz. Isolation is 20 dB and insertion loss is 0.4 to 0.6 dB. With a 450-MHz bandwidth centered at 9.2 GHz, the unit exhibits 25 to 37-dB isolation and 0.4-dB insertion loss. The integrated circulator is intended for stripline circuitry, but it is also adaptable to coaxial packaging.

Booth No. 4105 Circle No. 366

Dual J-K flip-flop cuts external wiring

Stewart-Warner Microcircuits, Inc. 730 E. Evelyn Ave., Sunnyvale, Calif. Phone: (408) 245-9200. P&A: $10.10 (100 to 999); stock.

Dual J-K flip-flops are now available consisting of two cross-coupled, J-K flip-flops in a single package. The circuits are built as a single passivated die measuring 56 x 56 mils. Two DTL 948 flip-flops are offered in two logic configurations, one with separate clock inputs, and the other with common clock and common reset in temperature ranges from −55° to +125°C or 0° to 75°C.

The circuits meet dc and dynamic specs of the DTL 930 series logic elements and with TTL logic elements. Their use can cut the package count in half in counters and shift registers; and since they are already J-K connected, the required external wiring is reduced significantly. All circuits are available in ceramic flat or dual in-line packages.

CIRCLE NO. 423

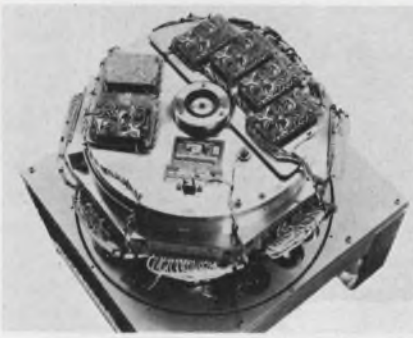
Core driver assemblies give 1-A pulses

Microsemiconductor Corp., 11250 Playa Court, Culver City, Calif. Phone: (213) 870-2974. P&A: 25¢ to 50¢ per junction; stock.

Core driver assemblies are offered in 1 x 4, 2 x 4, 1 x 8 and 2 x 8 silicon diode matrices. They are produced on 0.025-inch centers. Electrical characteristics of individual silicon diode junctions are compatible with microsecond read and write mass memories. Trapozoidal pulses with amplitude in excess of 1 A driving current can be achieved.

CIRCLE NO. 424

Disc drum memories hold 15 megabits

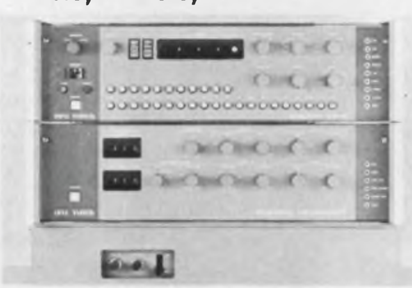


Digital Development Corp., 5575 Kearny Villa Rd., San Diego, Calif. Phone: (714) 278-9920.

Capacity of this system is 15.36 million bits with an access time of 8.5 ms. Each disc has a capacity of 3.84 million bits on its 128 data tracks of recording surface. With four discs, 512 data tracks are available in a single unit. Recording heads are organized into groups and each group services one disc surface.

CIRCLE NO. 425

Simulators generate PCM, PDM, PAM

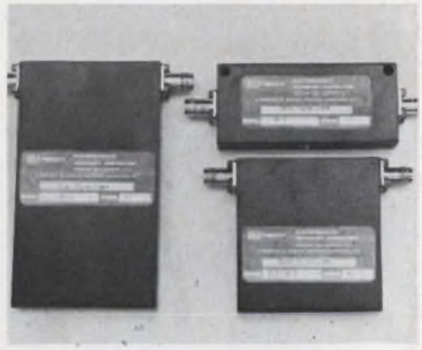


Electro-Mechanical Research, Inc., Box 3041, Sarasota, Fla. Phone: (813) 958-0811.

Serial PAM, PDM, and PCM telemetry signals and parallel computer words are generated by these simulators. Format content and signal characteristics are programed and can be instantly changed under computer, paper tape or manual control. To simulate distortion occurring in the transmission system, they will insert selectable blanking, noise, bit-rate jitter, baseline offset and wow. The core memory has 2-μs cycle time, and is capable of storing 1024 16-bit words. Up to seven instantly addressable complex formats can be stored in memory and modified in real time.

CIRCLE NO. 426

Equalize gain in broadband TWT amps

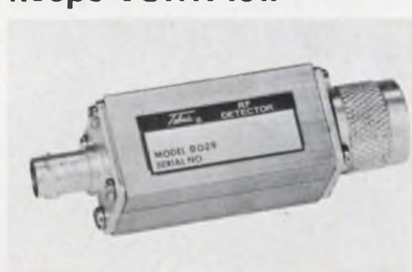


American Electronic Laboratories, Inc., P. O. Box 552, Lansdale, Pa. Phone: (215) 822-2929.

A passive, self-contained gain equalizer provides a method for removing undesirable gain variations in broadband TWT amplifiers. Either terminal can serve as the input, and the band-edge loss can be limited to 1/2 dB. A peak attenuation of 6 dB is normal at the center of the frequency band, but can be shifted as much as ±10%. Units are available in ranges of 1 through 5 GHz to accommodate power levels up to 10 watts.

CIRCLE NO. 432

Rf voltage detector keeps VSWR low



Telonic Instruments, 60 N. First Ave., Beech Grove, Ind. Phone: (317) 787-3231. P&A: $95; 45 to 60 days.

Designed for cw and swept applications as well as general-purpose use, this voltage detector covers 10 kHz to 3000 MHz. In addition to its low VSWR and the broadband characteristics, the model 8029 is a sensitive detector; square-law sensitivity is 0.3 mV/μW. It also exhibits flatness of ±0.5 dB over its operating range. Input impedance is 50 Ω.

Booth No. 3126 Circle No. 365

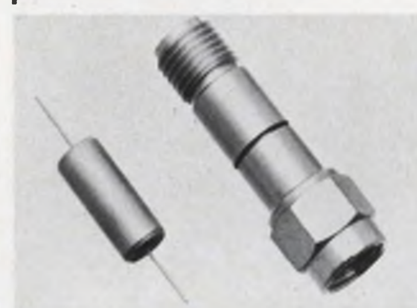
Water-cooled load dissipates 25 kW

Aetronic Research Corp., 13710 Aspinwall Ave., Cleveland. Phone: (216) 851-3220. Price: $875.

Designed to terminate 50-Ω coax lines, this dummy load handles 25 kW from 60 Hz to 2.2 GHz. Maximum VSWR is 1.1 to 1 GHZ; 1.15 to 1.5 GHz; and, 1.2 to 2.2 GHz. This unit uses water both as a dielectric and as a coolant. It may be operated in any condition. Construction is brass and aluminum, finished in nickel plate.

CIRCLE NO. 433

Passive limiters protect detectors



Hewlett Packard, 1501 Page Mill Rd., Palo Alto, Calif. Phone: (415) 326-7000. P&A: $100 to $125; stock.

Passive limiters reflect excess microwave power on coax transmission lines. The limiters protect detectors and other sensitive elements by attenuating power at levels above 10 mW. Signals with lower power levels pass with little attenuation. Frequency range of the limiters is 0.4 to 12.4 GHz. Maximum cw power input can be 1 W, derated linearly above 25°C to 0 watts at 150°C. Maximum permitted pulse power input is 75 W for 1-μs pulses with a 0.001 duty factor. The limiters consist of two silicon pin diodes in parallel between the center and outer conductors of a coax line. The limiters are supplied in two forms. One, type 3701, is a short section of coax line that can be mounted directly into semirigid 0.141-inch OD or 0.188-inch OD coax line by brazing or soldering. The other limiter, type 3711, has miniature 3-mm coaxial connectors.

CIRCLE NO. 434

Insertion loss tester sweeps 0.05 to 12.4 GHz

Weinschel Engineering Co., Inc., Clopper Rd., Gaithersburg, Md. Phone: (301) 948-3434.

With accuracy the same as that of a single-frequency dual-channel system, this swept insertion loss test set has resolution of 0.01 dB up to 20 dB. A single sweep of the components under test provides a permanent record of insertion loss vs frequency over the band. Stability of reference lines is better than 0.01 dB. In application, twenty unknown items having nearly the same value and frequency sensitivity can be readily tested using the same set of reference lines. A choice of insertion loss measurement heads are available in ranges of 0.05 to 2 GHz, 1.7 to 4.2 GHz, 3.7 to 8.2 GHz and 7 to 12.4 GHz.

Booth No. 4606 Circle No. 278

Coherent transponder ups radar resolution

Control Science Corporation, 4810 Beauregard St., Alexandria, Va. Phone: (703) 354-1500.

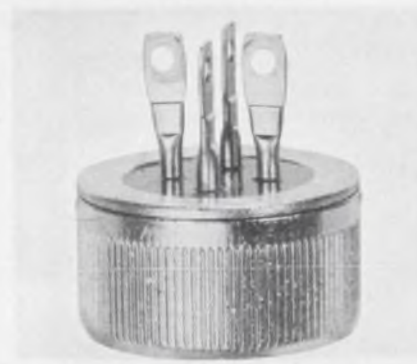
For missile or aircraft applications where precise velocity measurements are required, this C-band, pulse coherent transponder is used in conjunction with such radars as the AN/FPS-16, AN/FPQ-6 or AN/TPQ-18 which have been modified for coherent signal processing. The resolution of target velocity can be improved by two orders of magnitude in comparison with conventional transponder tracking. Receiver sensitivity is −65 dBm with the 100-watt peak minimum transmitted response pulse identical in frequency and coherent with the received signal. Frequency is 5.4 GHz to 5.9 GHz.

CIRCLE NO. 435

If you are attending WESCON, and we hope you are, please be sure to pick-up your free copy of Electronic Design's WESCON EXTRA at booth 3622 in the Cow Palace's South Exhibit Hall. The EXTRA contains all the Show news you need to know.

The Editors

Integrated rectifier recovers in 200 ns

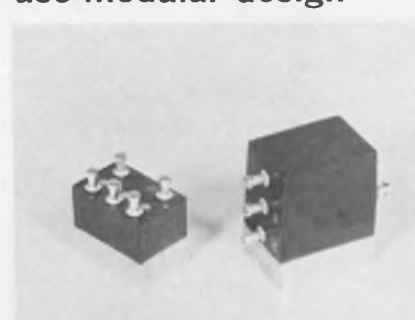


Varo, Inc., 2203 Walnut St., Garland, Tex. Phone: (214) 272-3561. P&A: $5.05 to $6.85 (100); stock to 3 wks.

Peak reverse voltage ratings of this rectifier are 100, 200 and 400 volts. The full-wave bridge output current is 10 A at 75°C case temperature. The package is 0.75-inch diameter by 0.8-inch high and has a hermetic seal. The circuit is electrically insulated from the base for direct mounting to chassis or heat sink.

Booth No. 5342 *Circle No. 371*

Power rectifiers use modular design

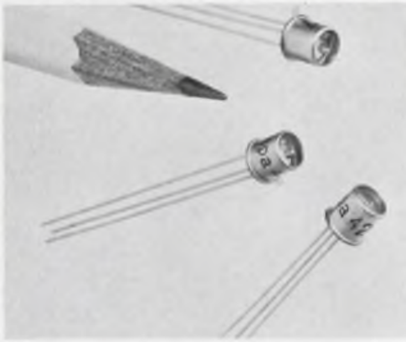


Solitron Devices, Inc., 256 Oak Tree Rd., Tappan, N. Y. Phone: (914) 359-5050.

Mounted on an insulated aluminum heat sink, these rectifiers overcome insulation problems. The rigid metal substrate provides a low thermal resistance path to the heat sink. Units available are a center tap, doubler, single-phase half or full-wave bridges and three phase half or full-wave bridges.

CIRCLE NO. 436

Photodiode detector sees the light

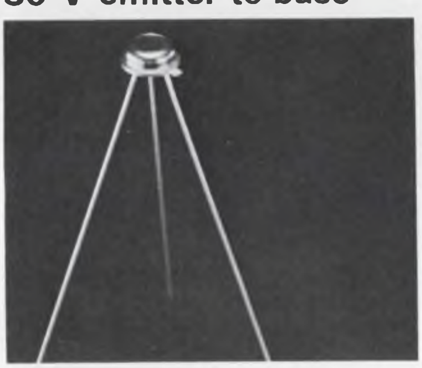


Hewlett Packard, 1501 Page Mill Rd., Palo Alto, Calif. Phone: (415) 326-7000. P&A: $35 (1 to 9); stock.

When these pin diodes are reverse-biased, usually at 10 volts, changes in illumination intensity modulate the diode current. One of the advantages is the extremely fast response to changes in illumination—less than 1 ns with a 50-Ω load resistance. Dark current is 1 nA at 10 V reverse bias and at 25°C. Typical response is 0.5 μA/μW into 1-MΩ load at a wavelength of 0.77 micron and reverse bias of 10 volts.

CIRCLE NO. 437

Npn switches rated 30 V emitter-to-base

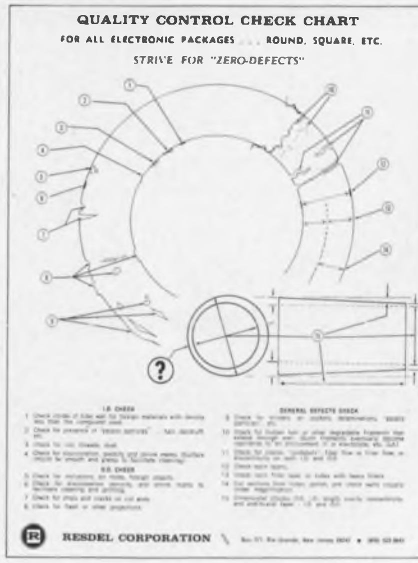


Crystalonics, Div. of Teledyne, 147 Sherman St., Cambridge, Mass. Phone: (617) 499-9156. P&A: $10.80; stock.

Emitter-to-base voltage of the 2N5066 silicon npn switching transistors is a healthy 30 volts. Offset voltage is 1 mV and saturation voltage is a maximum of 8 Ω. The 2N5066 is a direct complement of the 2N3677 and the pair can be used in high-accuracy ac switching applications.

CIRCLE NO. 438

Application Notes



Epoxy package checklist

A two-part data sheet and checklist on electronic packages aims at "at-a-glance" quality control. The front of the sheet shows two photomicrographs of cross sections of epoxy tube walls. The reverse side is a thorough checklist which describes the various defects which occur in packages. Resdel Corp.

CIRCLE NO. 441

Switching speed up

This note describes an application of the 2N2580 transistor to a switching circuit with improved decay time, without the use of a despiking diode. Delco Radio.

CIRCLE NO. 442

Power amplifier design

Delco's audio power amplifier design exhibits ±1 dB flatness from 20 Hz to 20 kHz. One application is in a commercial home entertainment system. Schematics and specifications are available in a 4-page guide. Delco Semiconductors.

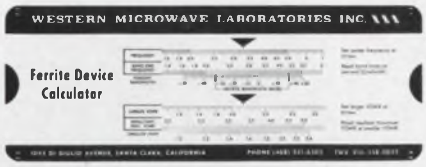
CIRCLE NO. 443

Integrated DTL circuits

In twelve pages of notes on the Signetics 600 series of integrated DTL circuits, NAND gates and their uses are described. Design considerations are mentioned, and schematics and graphs are given. Signetics Corp.

CIRCLE NO. 444

Design Aids



Ferrite device calculator

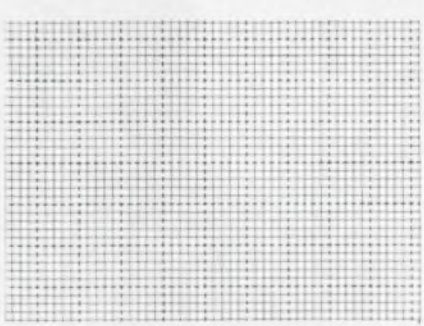
This pocket-sized calculator aids in the specification of ferrite components. In addition, the calculator is a handy aid to systems designers in solving commonly encountered transmission line problems. The rule gives band limits given center frequency, resultant max VSWR given larger and smaller VSWR and isolation given the VSWR of the terminated port. Western Microwave Labs, Inc.

CIRCLE NO. 445

Mold release chart

Molders of epoxy resins will find helpful information in this chart describing parting agents for castings and laminates. It describes application, surface of the finished part, method of applying, temperature resistance and film thickness. Also included are step-by-step instructions for the preparation of porous and nonporous surfaces prior to casting or lamination. Marblette Corp.

CIRCLE NO. 446



Designer's Mylar grid

Samples of a five-line designer's grid in Mylar are offered. Every fifth line is broken to allow for easier interpretation of dimensions. The grid is accurate to ± 0.001 and is offered in black-line or nonreproducible blue line in a range of sizes. Capitol Reproductions, Inc.

CIRCLE NO. 447

New Literature

Logic modules manual

A 24-page illustrated booklet, "Logic Modules: Make? Buy?" identifies and analyzes factors management should consider in making decisions. Long and short-range production costs, effects of time loss or gain on competitive position, risk involved with short market life or possible obsoleted performance, and optimum utilization of capital investment (both human and financial resources) are considered. These factors and others are related to each other in the framework of present trends and past experience in the IC logic module field. Charts, graphs and worksheets included in the report are structured so that individual ccompanies can "plug in" pertinent information for analysis. Data Technology Corp.

CIRCLE NO. 448

Components compendium

A reference manual entitled "Essential Characteristics" contains 360 pages of data on receiving tubes, five-star tubes, special-purpose tubes, picture tubes, capacitors, photoconductive cells, photoconductive cell-lamp combinations and reed switches. This single-source reference has been updated and includes 300 receiving and television picture tubes. It is directed at helping technicians, design engineers and hobbyists.

Available for $2 from General Electric, 2100 Gardiner Lane, Louisville, Ky.

For a complete listing of the technical papers at the show, see page U 112. For reprints of most of the papers, fill out the order form on page U 115.

Electrolytic capacitor guide

A 32-page cross reference covers electrolytic capacitors used in color TV chassis. The listing is intended to aid interchangeability of high-quality electrolytic capacitors. Included in the presentation is a section on printed-circuit replacements by capacity/voltage for single, double, triple and quadruple section units. Cornell-Dubilier Electronics.

CIRCLE NO. 450

Microelectronics manual

A product reference guide of Philco/Ford microelectronic products lists such products as bipolar linear and digital ICs, MOS ICs, epoxy transistors and MOSFETs. The brochure contains instructions for logic diagrams and packaging. Basic parameters are given for all ICs. Additional information is given on LSI, hybrids, microwave components and devises and infrared components. Philco-Ford Corp.

CIRCLE NO. 451

Monolithic subsystems

The second edition of "MOS Monolithic Subsystems: A Revolution in Microelectronics," is an introduction to MOS ICs. Included in the presentation are a historical sketch of the individual MOS transistor, descriptions of the arrays now in production, explanations of the fundamentals of device and circuit operation, circuit advantages and descriptions of the basic digital and analog circuit design techniques developed at Philco-Ford. Philco-Ford Corp.

CIRCLE NO. 452

DTL/TTL modules

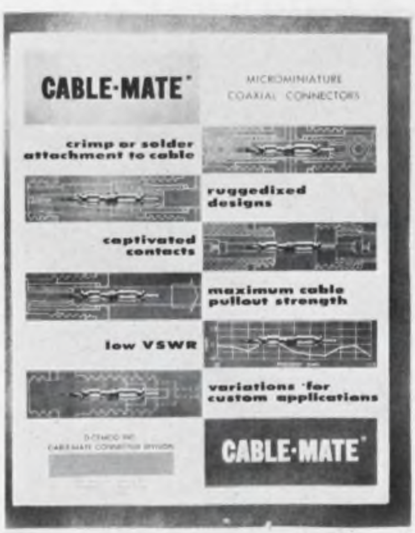
Compatibility, interfacing and performance characteristics of DTL and TTL integrated circuit logic modules are discussed in a reference chart. The table lists propagation time, power dissipation (maximum and typical), fan in, fan out, and other operating parameters including interfaces. The 4-page chart folds into an 8-1/2 by 11 booklet for easy notebook filing. Data Technology Corp.

CIRCLE NO. 453

Instrumentation applications

The Spectrum Scanner, published bi-monthly, describes the manufacturers instrumentation and their various applications. Covered in the booklet are emission spectroscopy, atomic absorption spectroscopy, instrumentation for research in the physical sciences and X-ray diffraction. The bulletin is fully illustrated with photos and schematics. Jarrell-Ash Co.

CIRCLE NO. 454



Coax connector catalog

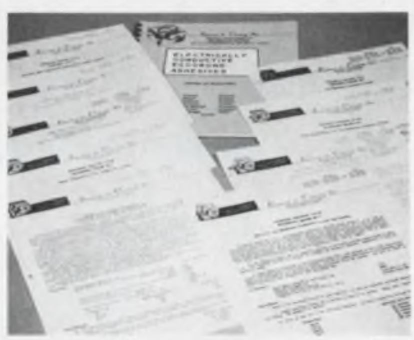
A 32-page volume provides engineering data for standard and custom designed microminiature coaxial connectors, including plugs, jacks, adaptors and PC receptacles. Many of the designs described are interchangeable with other nationally available microminiature, subminiature and ultraminiature coax connectors. D-Cemco, Inc.

CIRCLE NO. 455

Relay contamination

The paper that won first prize at the 1967 NARM (National Association of Relay Manufacturers) Conference is offered in reprint form. It describes contact resistance as the principal parameter for determining the reliability of relay operation and applies this concept directly to the influencing and affecting internal and external causes of instabilities. The paper describes the various sources of contamination and their alleviation. Part of the report focuses on the residual gas analyzer, a device which permits the relay manufacturer to locate and localize the sources of residual gas within the relay package for removal. Another section discusses intermediate contact life which describes some of the relays which exhibit high and erratic contact resistance only after a period of service life. The 14-page paper is illustrated with photos, graphs and schematics. Filtors, Inc.

CIRCLE NO. 456



Conductive adhesives

A new brochure describes in detail the use and performance characteristics of electrically conductive adhesives, and coatings. Their volume resistivity varies from 0.0002 to 50 Ω-cm. One-part systems requiring elevated temperature curves are described, as well as two-part room temperature curing systems. Emerson & Cuming, Inc., Dielectric Materials Div.

CIRCLE NO. 457

For a complete listing of the technical papers at the show, see page U 112. For reprints of most of the papers, fill out the order form on page U 115.

Rf instrumentation

Jerrold's new short form catalog gives capsule information on their line of rf test equipment, including sweep systems. Also included is detailed information on amplifiers, measurement comparators, marker generators, precision attenuators, tuned rf voltmeters, and general-purpose test sets. Accessory equipment in the form of detectors, bridges, matching pads and rotary coaxial transfer switches is also included. Jerrold Electronics Corp.

CIRCLE NO. 458

Solder-plated wire

A technical information bulletin covers tin and solder-plated wire and ribbon. The brochure describes wires capable of being plated, the range of plating thickness, the types of baths available, spooling sizes and the ability of plated wire to retain its uniformity after curing. It shows how to analyze the thickness, continuity, solderability and the tin lead ratio of solder-plated copper. Sylvania Products Inc.

CIRCLE NO. 459

Core wire optimization

"How to Determine Optimum Wire Sizes" is a two-page data sheet which describes a graphic technique to determine the optimum wire size for a given ferrite core. Electronic Memories, Inc.

CIRCLE NO. 462

Trimmer cap selection

A 4-page brochure, "Eighteen Things to Look For in Precision Trimmer Capacitors" shows pictorially how the internal construction of precision trimmers affects their performance. It shows how typical trimmers are made, how rotating and non-rotating piston designs work. It demonstrates how linearity, Q, rf current capacity, life and self-resonance are affected by the internal mechanism. The bulletin graphically indicates the differences in resolution, seal integrity, size and performance under vibration. Voltronics, Inc.

CIRCLE NO. 460

Reliability evaluation

A 67-page booklet describing methods for evaluating contractor reliability programs describes the key factors which make a reliability assurance program effective. It gives specific criteria for evaluating each of fourteen reliability program areas. The description of criteria for evaluating each reliability task is directed toward fundamentals and should be of use to contractors and subcontractors in aerospace and other industries which employ reliability assurance programs.

Available for $3 (NASA SP-6501) from Clearinghouse, Springfield, Va. 22151.

Radar standards

Minimum performance standards for airborne weather and ground mapping pulsed radar are set forth in this report by the Radio Technical Commission for Aeronautics. The recommended standards were coordinated internationally with the European Organization for Civil Aviation Electronics and an RTCA group. The 40-page document, RTCA DO-134, meets the international standardization needs of users and manufacturers of airborne electronic equipment.

Available for $2.50 from RTCA Secretariat, 2000 K Street, N. W., Washington, D. C.

For a complete listing of the technical papers at the show, see page U 112. For reprints of most of the papers, fill out the order form on page U 115.

Reprints Available

The following reprints are available free and in limited quantities. To obtain single copies, circle the number of the article you want on the Reader-Service card.

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BPA

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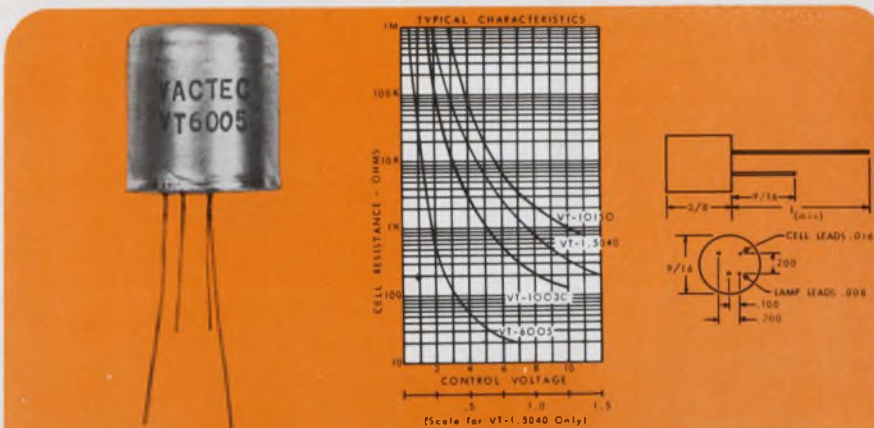

Now 1.5v, 6v, and two 10-volt Vactrols are available for electronic amplifier applications. Combines a dependable Vactec photocell with the proper long-life incandescent lamp in a complete low-cost module.

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See Vactec's listing in EBG under "Semi-Conductors," and in EEM, Sec. 3700.

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Designer's Datebook

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Technical Conference on Electronic Materials (New York City) Sponsor: AIME; L. R. Weisberg, Electronic Materials Committee, The Metallurgical Society of AIME, 345 E. 47 St., New York, N. Y. 10017

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Aug. 29-31
Association for Computing Machinery Conference (Washington, D. C.) Sponsor: ACM; M. J. Healy, c/o Association for Computing Machinery, Box 6, Annandale, Va. 22003

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Sept. 6-8
IEEE Computer Conference (Chicago) Sponsor: IEEE; S. S. Yau, Northwestern University, Dept. of Electrical Engineering, Evanston, Ill. 60201

CIRCLE NO. 496

Sept. 11-14
ISA Conference and Exhibit (Chicago) Sponsor: ISA; Instrument Society of America, 530 William Penn Place, Pittsburgh, Penn. 15219

CIRCLE NO. 497

Sept. 11-16
International Congress on Magnetism (Cambridge, Mass.) Sponsor: American Institute of Physics; Dr. J. S. Smart, Secretary, 1967 ICM, IBM Watson Research Center, Yorktown Heights, N. Y. 10598

CIRCLE NO. 498

Sept. 21-22
Microelectronics Applications Symposium (Garden City, N. Y.) Sponsor: IEEE; L. I. Kent, Executive Secretary, c/o Airborne Instruments Laboratory, Commack Road, Deer Park, N. Y. 11729

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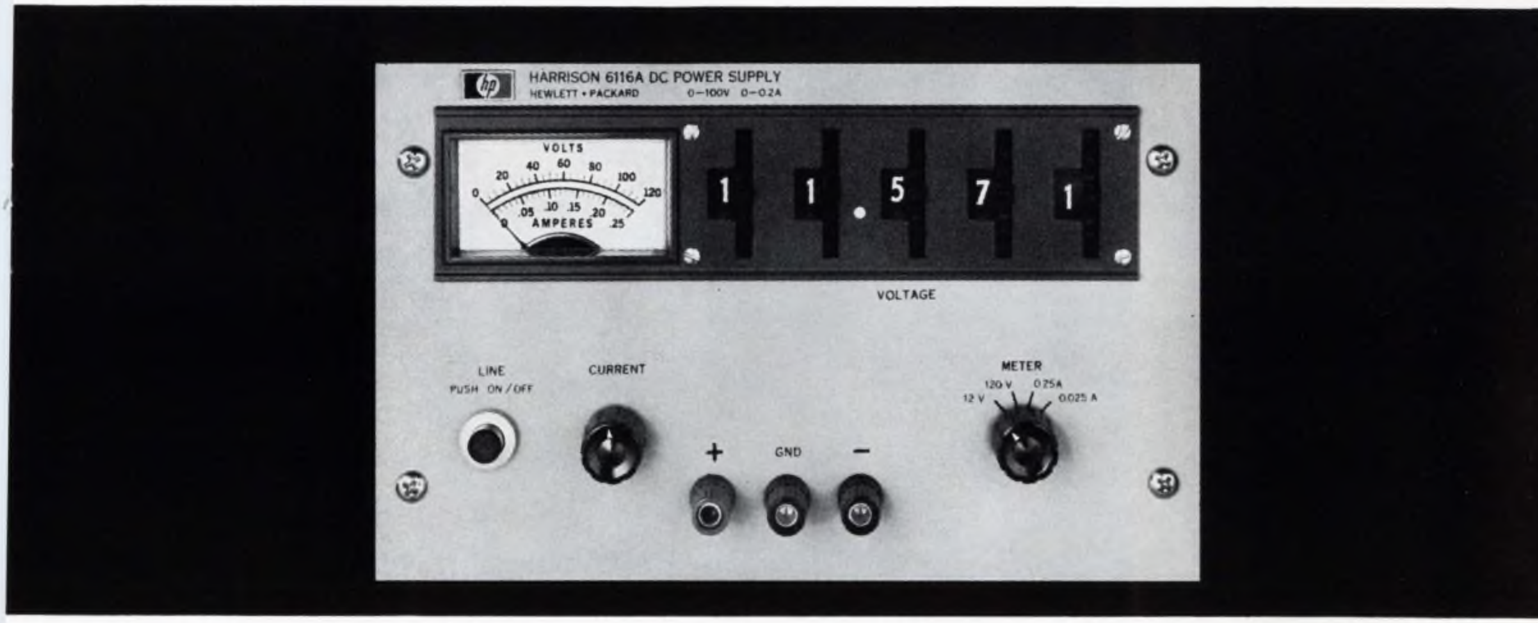

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3½" H, Half Rack Width

DC OUTPUT	MODEL	PRICE
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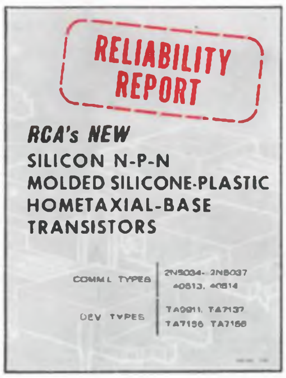
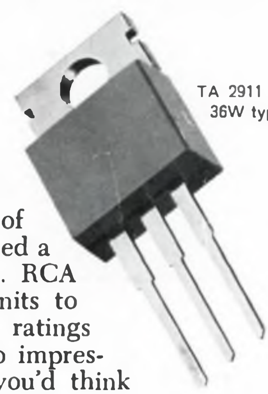
The "non-plastic" plastic transistors



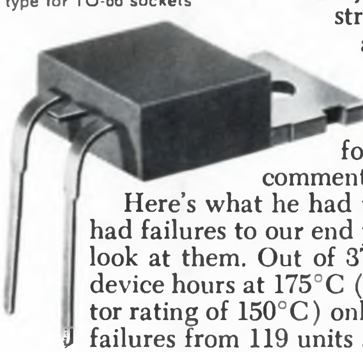
So reliable you'd think they were hermetic



TA 2911
36W type for printed-circuit boards

We're big enough to realize that with any plastic transistor, you're bound to have questions concerning reliability.

So...long before RCA announced this family of "Hometaxial-Base" silicon power plastic devices (10 transistors with ratings of 36W or 83W), our reliability engineers devised a most rigorous new-product testing program. RCA subjected hundreds of units to stresses beyond device ratings and the results are so impressive that, frankly, you'd think the transistors were hermetic.



TA 7155
36W type for TO-66 sockets

We thought it would be appropriate for you to see our reliability manager's comment on the tests to date.

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2N 5035
83W type for printed-circuit boards

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2N 5034
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